



MONASH University

Understanding ways of knowing: A mixed methods approach

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Abstract

Epistemic cognition, the research area which explores the ways people acquire, justify, and use knowledge, has long been studied and debated by philosophers and educational psychologists. It has implications for both academic and non-academic realms and is a key predictor of vital 21st century skills including digital literacy, critical thinking, and scientific literacy. However, the issue of how to name, define, conceptualise, and measure this construct has also been the subject of much research and debate. In order to overcome the limitations of current models and measures, there is a need to explore the ways of knowing and meaning of that knowing from the perspective of the layperson, that is, the individual knower. The purpose of this doctoral research is therefore to understand how people know what they know, in order to build on current understandings and ultimately aid the development of a more comprehensive model and measure of epistemic cognition. This thesis reports on the use of an exploratory, sequential mixed methods approach to understanding, modelling, and testing a psychological construct. In the first stage, a qualitative study was used to explore how adults know what they know and what knowing means to them. Six Australian adults each participated in a semi-structured interview that explored their experiences of knowing in relation to topics such as work, environmental and social concerns, and personal interests. The interview data were analysed using thematic analysis. Five themes were identified: (a) justification for knowing; (b) sources of knowledge; (c) influences on knowing; (d) knowing about knowing; and (e) personal meaning of knowing. These results add further detail to current understandings of epistemic cognition and were subsequently used to develop a preliminary model of ways of knowing (i.e., the means of justifications used by adults). In the second stage, this preliminary model of ways of knowing was tested. Adult participants from Australia ($N = 345$) indicated their agreement with various statements and then justified how they know each of these. The justification options for endorsement were created utilising the themes and quotes from the interview data. Results indicated that all of the justifications were used to varying degrees across the various topics. Cluster analysis was also used to identify three distinct profiles of knowing based on the participants'

endorsement of the justifications across several topics. These were labelled *justifiers through formal processes* ($n = 200$), *undifferentiated justifiers* ($n = 87$), and *multiple justifiers* ($n = 58$). Participants in these clusters not only differed in the means of justification they used, but also with regards to how many justifications they used, their responses to the topic questions, and their backgrounds. The findings add finer-grained detail to dimensions of justification in current models as well as additional areas of relevance to consider when assessing epistemic cognition. The identification of distinct profiles of knowing also raises the possibility that interventions focussed on promoting adaptive ways of knowing can be developed for different types of knowers.

Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Comment on Formatting

This thesis has been formatted following the guidelines of the Publication Manual of the American Psychological Association (APA), Sixth Edition. In a departure from APA convention, blank lines have been added before and after block quotations from participants in the qualitative study. This is to aid readability.

Chapter 1: Introduction

What does it mean “to know” something? And how do you know that you know it? For instance, what would you say if you were asked how you know that climate change is real (or not)? Or that vaccinations do (not) cause autism? That the moon landing was real (or not)? How would you justify your knowledge on these questions? Would you say you know these because you have seen evidence for them yourself, you read about them, or because someone told you? Or because of the science or that scientists or other experts have said they are true? Many of us have never even questioned how we know these things or where this knowledge came from. Regardless, these questions regarding how we know what we know stem from study in the area of epistemic cognition.

Epistemology is the discipline of philosophy which considers and debates the questions of what it means to know something, and how we come to know it. More recently, as educational psychologists have become interested in the psychology of knowing, specifically the ways in which an individual’s perspectives on the nature, sources, justification, and limits of knowledge influence various outcomes (Franco et al., 2012), they have labelled this area of research as *epistemic cognition*. Of particular relevance is that the ways in which people acquire, justify, and use knowledge has long been claimed to have implications in both academic and non-academic realms (Hofer, 2016). These include how an individual approaches learning tasks (Schommer, 1990) such as in psychology (Hofer, 2000), mathematics (Muis, 2004; Schommer, Crouse, & Rhodes, 1992), history (Maggioni, VanSledright, & Alexander, 2009), and science (Barzilai & Weinstock, 2015; Hammer, 1994; Sandoval, 2005), as well as reading comprehension (Bråten, Britt, Strømsø, & Rouet, 2011). In addition, epistemic cognition is positively correlated with academic achievement (Greene, Cartiff, & Duke, 2018) and has implications for teaching (Lunn Brownlee, Ferguson, & Ryan, 2017), lifelong learning (Bath & Smith, 2009), and out-of-school learning (Bricker & Bell, 2016).

Beyond the classroom, epistemic cognition relates to how one searches for (Kammerer, Amann, & Gerjets, 2015), and evaluates, information online (Bråten, Strømsø, & Samuelstuen,

2005), makes political decisions (Hofer, 2004a), juror reasoning (Kuhn, 2001), and public understanding of science (Greene, Yu, & Copeland, 2014; Sinatra, Kienhues, & Hofer, 2014). It plays a role in health decision making (Hofer, 2004a), and is enacted when 'Googling' medical information (Kienhues & Bromme, 2012) or turning to one's doctor to understand what is known about a medical condition (Greene & Yu, 2016). Epistemic cognition also influences the evaluation of contradictory claims and reasoning about complex socio-scientific issues, such as climate change, vaccination, evolution (Sinatra et al., 2014), the potential health risks of mobile phones (Ferguson, Bråten, & Strømsø, 2012), and genetically modified organisms (Muis, Chevrier, Denton & Losenno, 2021; Sinatra & Lombardi, 2020).

Epistemic cognition is also a key predictor of 21st century skills of digital literacy (Greene et al., 2014), critical thinking (Greene & Yu, 2016), and scientific literacy (Greene, Cartiff, & Duke, 2018). These skills are vital in this post-truth, digital era; a time in which misinformation and fake news abound and individual decision-making is argued to rely more on personal beliefs and feelings than on objective standards for truth (Prado, 2018; Sinatra & Lombardi, 2020). To succeed and thrive in this rapidly changing world, individuals must therefore be able to discern accurate and useful contributions to human knowledge from opinion, speculation, dogma, questionable assertions, and unsubstantiated or maliciously intended deceptions (Cartiff, Duke, & Greene, 2021; Greene, Chinn, & Deekens, 2021; Greene, Sandoval, & Bråten, 2016b; Sandoval, Greene, & Bråten, 2016; Sinatra & Lombardi, 2020).

Given its importance, researchers have recently turned their attention to developing epistemic cognition interventions (Cartiff et al., 2021; Greene & Yu, 2016). The purpose of such interventions is to foster the development of adaptive or competent epistemic cognition, generally defined as the ability to flexibly adjust one's epistemic cognition "to match the norms of the context in which they enact their thinking" (Greene et al., 2016b, p. 498) and perform successfully. While showing promising results (Cartiff et al., 2021), research on interventions is currently limited by serious issues plaguing the field, particularly regarding the conceptualisation and measurement of

epistemic cognition (Bråten, 2016; Mason, 2016). In particular, there is a need for robust measures that can track the effectiveness of these interventions (Mason, 2016). Such measures are necessary to assess accurately and reliably one's epistemic cognition pre- and post-intervention in order to determine the extent to which one's epistemic cognition is changed by such interventions and how these changes effect various outcomes (Cartiff et al., 2021; Greene, Cartiff, & Duke, 2018; Mason, 2016). These measures, in turn, need to be based on appropriate models grounded in a comprehensive understanding and a clear agreement about what is being measured.

The issue of how to name, conceptualise, delimit, and measure this construct has however long been the subject of research and debate in the field (Alexander, 2016; Sandoval et al., 2016; Sinatra, 2016). The use of instruments with significant psychometric problems (Buehl, 2008) has further added to the field's issues and raises fundamental questions regarding associations purported between scores on epistemic cognition measures and various outcome variables (Greene & Yu, 2014; Mason, 2016). These issues have undoubtedly hindered progress in the field and led to repeated calls specifying the need for conceptual unification (Greene, Azevedo, & Torney-Purta, 2008) and refinement of measures (Greene, Cartiff, & Duke, 2018).

The purpose of this research, therefore, is to further the understanding of epistemic cognition with the aim of ultimately contributing to its conceptualisation and measurement. It seeks to do this from a psychological perspective and by seeking the voice of the layperson, that is, the everyday person who is not a philosopher, epistemologist, or researcher interested in epistemic cognition. The rationale behind this is that current models and measures (to be reviewed in chapter two) are based on theories from philosophers, psychologists, and educational researchers. While making valuable contributions to the field, such research is based on assumptions regarding how the everyday person knows what they know and seeks to confirm these preconceptions through that research. What has been missing though has been a consideration of how the everyday person knows what they know, and how these insights can inform and extend current models and measures.

Thesis structure

This thesis begins with a literature review (chapter two) which aims to survey the field and critique key models, measures, and related issues. There is a review of terminology before various types and specific models of epistemic cognition are reviewed. This includes developmental models, multidimensional beliefs models, and newer models informed by disciplinary education, empirical findings, and philosophy. Various definitions and conceptualisations of epistemic cognition are subsequently reviewed before a consideration of measurement and measurement issues in the field. The chapter ends with a summary of key themes and issues in the field before presenting suggestions for moving forward.

Chapter three then provides the methodological approach taken to this research. It presents the exploratory, sequential mixed methods approach that was taken, in which a preliminary qualitative phase was followed up with a quantitative one. The rationale for taking this approach is highlighted and the underpinning epistemological foundations of this work articulated.

In chapter four, the method for the qualitative study is detailed. This includes the recruitment and interviewing of six Australian adults to explore how they know what they know and what knowing means to them. The development of the semi-structured interview guide, including a rationale for focussing on a variety of areas to provide context for knowing, is outlined. Ethical considerations and practices to ensure research rigour and data trustworthiness are also discussed. Lastly, the iterative process of inductive data analysis, specifically thematic analysis, is presented.

Each of the five resulting themes from the qualitative study is then reported and discussed in an individual chapter (chapters five to nine). A narrative account is presented of each theme and associated subthemes along with quotes to illustrate these. Consideration is then given to the meaning of each of these themes in turn. A general discussion (chapter ten) then wraps up the qualitative study, summarising key results as well as the implications of these results. Strengths and limitations of this study are identified before future directions for further research are explored.

The research then shifts to the quantitative phase, in which a quantitative study was used to follow up particular results from the qualitative study. In chapter eleven, the method for this quantitative study is detailed. This includes the social media recruitment of 345 Australian adults and the development of a survey to explore how the participants justified their knowledge regarding various topics. Of note is the use of quotes from the qualitative study to create the justification options in the survey. The procedures for data collection and hierarchical cluster analysis of the data are then provided.

In chapter twelve, the results from this quantitative study are reported. The three educated profiles of justification are detailed alongside a consideration of profile differences in response to the topic questions and demographic variables. Chapter thirteen then discusses the meaning and implications of the results, alongside the strengths, limitations, and considerations for future research.

In the final chapter (chapter fourteen), a summary of key findings is presented in light of the overarching research question. An integration of the findings from both studies is also provided before the recommended next steps are discussed. The implications and contributions of this research are considered before closing with concluding remarks.

Chapter 2: Literature Review

The intent of this chapter is to review the development of the conceptualisation and measurement of epistemic cognition. This review traces the development of the field in terms of the various models and measures of epistemology which have arisen, with associated methodologies and construct definitions also reviewed. The aim is to highlight key issues associated with the conceptualisation and measurement of epistemic cognition that point to a need to revisit this construct. In particular, it should become apparent that what has been missing is a consideration of how the everyday person knows what they know, and that such insights can inform and extend current models and measures.

The review begins with an overview of terminology in use before considering the various conceptualisations of epistemic cognition over time. Of these, the earlier developmental models which spawned research in this field are firstly discussed. This early research on ways of knowing tended to utilise interviews with homogeneous groups of college students. From these, developmental models were posited that outlined the stages an individual passes through in relationship to making meaning of their experiences, such as with education, in their relationships, their self-concept, and in their adult lives.

Next, later models which conceptualised personal epistemology as comprising several multidimensional “beliefs” or “theories” are considered. These included beliefs about the nature of knowledge, including how certain or simple it is, and the nature of knowing, which includes where knowledge comes from and how it can be justified. With these models came the development of self-report questionnaires which led to a plethora of studies linking epistemic cognition to academic outcomes such as achievement, motivation, self-regulation, text comprehension, conceptual change, and strategy use (summarised in Hofer & Bendixen, 2012; Schraw, 2013). Next, models which were informed by disciplinary education will be briefly reviewed. Following that will be a review of models which expanded on earlier ones through greater consideration and integration of empirical findings and the field’s philosophical underpinnings. After that, long-standing issues around the domain-

generality and -specificity of epistemic cognition and the categorisation of epistemic cognition as naïve or sophisticated will be considered.

The latter half of this review is concerned with the measurement of epistemic cognition. In particular, the measurement of epistemic cognition has been closely linked to its conceptualisation. Generally, those subscribing to a developmental approach have used interviews to assign individuals to different levels (e.g., absolutist or multiplist) of the respective models. In contrast, dimensional approaches and recent models informed by philosophy tend to be associated with the use of self-report scales. Several of these measures in use today will be summarised and details presented regarding the dimensions or levels measured and types of questions asked. Key issues related to these measures will also be detailed, including questions about factor structures, sampling, item wording, and what is actually being measured (i.e., beliefs or actual practices). Lastly, the use of alternative forms of measurement, including think-aloud studies and task-based observation, which aim to overcome some of the limitations of previous measures will briefly be reviewed.

This review finishes with a consideration of key issues and research gaps in the field. These particularly relate to the poor psychometric properties of many of the self-report questionnaires currently in use which have, consequently, led to questions regarding the conceptualisation of epistemic cognition itself as well as about the operationalisation of the construct in these measures. This has also cast doubt on the accuracy of claims linking particular ways of knowing with academic outcomes (Greene & Yu, 2014). Further adding to the confusion and hindering conceptual clarity is the fact that the field is “plagued by terminology that is undefined, poorly specified or variably defined” (Alexander & Sinatra, 2007, p. 223), so that articles on epistemic cognition often do not explicitly define the construct under study (Briell, Elen, Verschaffel, & Clarebout, 2011; Southerland, Sinatra, & Matthews, 2001).

Throughout the years there have also been repeated calls for the development of a unified conceptual framework and better measurement of epistemic cognition, with as yet little resolution of these key issues (Alexander, 2016; Briell et al., 2011; Greene et al., 2008; Greene, Sandoval, &

Bråten, 2016a; Hofer, 2004b; Hofer, 2016; Mason, 2016; Schraw & Olafson, 2008; Sinatra, 2016).

Several solutions to address some of these issues are proposed, including the use of exploratory, mixed methods, and person-centred approaches. In particular, it is suggested that taking an approach unconstrained by current theory can enable insights gained from the experiences of the everyday person regarding how they know what they know to inform the refinement of current models.

Terminology

Regarding terminology, the construct related to the nature and justification of human knowledge has variously been called “personal epistemology,” “epistemological beliefs,” “epistemic cognition,” “epistemological understanding,” and “ways of knowing,” as well as other terms (Briell et al., 2011; Hofer & Pintrich, 1997; Schraw, 2013). A plethora of terms has been utilised, although not always in reference to the same construct; at times one term is used for different constructs while at other times different names have been given to the same construct (Alexander, 2016; Briell et al., 2011). Notably, variations on the word “epistemology” were used to describe earlier research in the field, including “epistemological beliefs” (Schommer, 1990), “epistemological theories” and “personal epistemology” (Hofer & Pintrich, 1997), and “epistemological resources” (Hammer & Elby, 2002). However, given the term *epistemology* refers to a theory of knowledge (Greene et al., 2016a; Hofer, 2016), it was argued that *epistemological beliefs* meant “the study of theoretical and definitional matters of knowledge in a philosophical sense (i.e., the study of knowledge and, specifically, how claims of knowledge can be justified”; Ferguson, 2014, p. 731). A more accurate term, then, is *epistemic*, which comes from the Greek term *episteme* (meaning knowledge, what is known, or the way of knowing; Kitchener, 2011).

There was hence a shift in the field towards referring to “epistemic” beliefs, to highlight the focus on individuals’ beliefs about knowledge and knowing. More recently, however, the use of the term “beliefs” has received criticism with researchers arguing instead that the construct needs to be understood as a process (Hofer, 2016). That is, it has been suggested that

cognitive processes aimed at defining, verifying, or justifying knowledge should be regarded as aspects of personal epistemology and that the term epistemic cognition, including both beliefs and the application and influence of those beliefs, may be a more accurate term than just epistemic beliefs (Strømsø & Kammerer, 2016, p. 231).

The field has thus come to be most commonly and most appropriately labelled *epistemic cognition* these days, with this term used as it “emphasizes knowledge and the processes involved in its definition, acquisition, and use” (Greene et al., 2008, p. 143). That is, epistemic cognition “translates to cognition of or relating to knowledge” (Greene et al., 2016a, p. 2). A commonly accepted definition, and the one guiding this work, then, is that epistemic cognition relates to “how people acquire, understand, justify, change, and use knowledge in formal and informal settings” (Greene et al., 2016a, p. 1).

As a convention, when referring to a particular model, the terminology specified by those author(s) will be used. However, when referring to the field in general (specifically psychological approaches, rather than philosophical ones), the terms *epistemic cognition* and *ways of knowing* will be used interchangeably. Although the term “beliefs” has been used regularly in this field, the use of this term will be minimised where possible due to the “messy” nature of this construct (Pajares, 1992).

It is also necessary to highlight definitions of key terms in the literature, particularly to distinguish between the meanings of these terms in philosophy and psychology. In particular, within philosophy, to answer the question of “*what is knowledge?*” requires considering how knowledge is distinguished from beliefs. This entails determining how one knows what they know. In particular, knowing is said to occur when one has evaluated the evidence for a claim and determined the claim to be true and justified and therefore sufficient to treat as knowledge (Greene et al., 2016a). In contrast, believing refers to holding a claim as true without having evidence for it (Greene et al., 2016a). In a nutshell, then, epistemology “deals with how one can be *justified* in claiming something

as knowledge, as opposed to belief” (Greene, 2007, p. 69, emphasis in the original). Of note, though, is that philosophy is normative, meaning its focus is on how things *ought* to be (Kitchener, 2011).

Science, on the other hand, is empirical and focussed on describing how things *are*. In their everyday lives, individuals often use the phrase “I know” to indicate confidence that the claim is an accurate take on the world, compared to using “I think,” “I believe,” or “I guess” (Greene et al., 2016a). Claims of knowing by the everyday person, who is not a philosopher, therefore, may not meet philosophical standards for knowing. Arguably though, as will later be discussed, it is one's epistemic practices of reasoning about and justifying knowledge claims they come across in their lives that are most relevant for researchers in the field to consider. The everyday person may also take as knowledge claims that have not been evaluated or justified, as is seen in the rising spread and acceptance of fake news and perspectives on climate change and vaccines that contradict the scientific knowledge on these topics (Barzilai & Chinn, 2020; Chinn, Barzilai, & Duncan, 2021; Lewandowsky, Ecker, & Cook, 2017). In order to make sense of how individuals reason about various issues, researchers must instead consider what counts as knowledge to individuals, alongside whether, and how, they evaluate the claims they encounter. In summary, psychologists and researchers studying epistemic cognition must concern themselves with how individuals actually justify knowledge, whether these are the “proper” ways specified by philosophy or not (Greene et al., 2008).

Developmental models

Perry's Scheme of Intellectual and Ethical Development. In what is often regarded as seminal research in the field of personal epistemology, Perry (1970) set out to understand the intellectual and ethical development of liberal arts students at Harvard in the 1950s and 1960s. He was particularly interested in understanding their responses to the pluralistic intellectual atmosphere of university, and the progression in the forms or structures with which they construe their experience with the nature and origins of knowledge, values, and responsibility. Perry's longitudinal approach consisted of phenomenological interviews in which students were simply

asked to describe what had stood out for them during that year. This resulted in a scheme with nine sequential positions of development that were further clustered into four stages. It was proposed that individuals develop through these sequential stages which are characterised by evolving views about knowledge and knowing, regardless of domain or discipline (Greene, Cartiff, & Duke, 2018; Sandoval et al., 2016).

The stages of Perry's scheme range on a continuum from dualism to commitment within relativism. In *dualism*, the learner sees the world in black and white (Greene, 2007), unquestionably viewing knowledge as factual, unchanging, and transmitted by an authority. In the next stage, *multiplism*, students do not believe in the possibility of true knowledge, instead believing in a plurality of perspectives; that is, there are no right or wrong perspectives, no objective standards for knowledge, and no transmission of knowledge from authorities. *Relativists*, in the next stage, see knowledge as conditional on context and therefore understand the need to evaluate judgments through the use of logical rules or reasoning.

Finally, in the fourth stage, *commitment within relativism*, knowing is seen as relative in time and the student has developed a commitment to the experience of 'who he is.' There is an integration of knowledge learned from others with personal experience and reflection in this stage, with individuals choosing a set of criteria to judge knowledge claims, while acknowledging that others might utilise different criteria. This stage is also defined by a shift from intellectual to ethical development, with a focus on the individual committing to their values and identity. It was argued that individuals progress and can stagnate or even regress through these stages, with change thought to be brought about through reorganisation of the meaning of experience, either by assimilating an experience to existing cognitive frameworks or by modifying their frameworks to accommodate the experience (Hofer & Pintrich, 1997). Experiences from education were seen as playing a key role in the cognitive disequilibrium which initiates such change.

There are several limitations of this scheme, including its development from a relatively homogenous sample of mostly males from a single college, the data being validated using data from

which the scheme evolved, and the investigators who abstracted the scheme having also served as the interviewers. Moreover, the later positions of the scheme have a more rudimentary description of how knowledge is construed; this was likely influenced by the unstructured focus of the interviews and the fact that these positions were not commonly observed among the sample (Hofer & Pintrich, 1997). Research from a developmental psychology perspective has also contradicted Perry's model, by showing that children and college freshmen do not only see the world in an objective way (Greene, 2007).

Operationalising the scheme has also been difficult; although self-report measures based on the scheme have been developed, such as the Measure of Epistemological Reflection (Baxter Magolda, 1992), these have been limited by confounding epistemology with educational preferences (Hofer & Pintrich, 1997). Generally, measurement using Perry's scheme has focussed on the use of lengthy, semi-structured interviews, with coding schemes being used to categorise participants' responses. Despite these limitations and not originally being conceptualised as the study of students' epistemologies (Buehl & Alexander, 2001), Perry's influential scheme arguably laid the foundation for subsequent research and developmental models in the field (e.g., Baxter Magolda, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994).

Women's ways of knowing. In response to the dominant male-oriented views on knowledge and truth at the time, including Perry's predominantly male-based model, Belenky et al. (1986) concentrated on developing a model of women's ways of knowing. These researchers proposed that epistemological views influence a woman's definition of self, sense of control over life events, views of teaching and learning, and conceptions of morality. To test this, women of different ages and diverse ethnic and educational backgrounds were interviewed about their experiences as learners and knowers, as well as their changing self-concept and relationships with others. Perry's key question of what had stood out for them that year was also asked with the aim of mapping the women's experiences to Perry's scheme. However, when this was not achieved, they developed a new scheme of five epistemological positions which summarise the "perspectives from which

women view reality and come to understand truth, knowledge, and authority” (Belenky et al., 1986, p. 3). Whereas Perry’s model focussed on the nature of knowledge and truth, Belenky and colleagues’ model focussed more on the source of knowledge and truth and highlights the interconnected role of self and identity in this area.

In earlier positions in the model (*silence* and *received knowledge*), women see knowledge as received from an authority originating outside the self, while in *subjective knowledge* the source is within the individual. In *procedural knowledge*, women are invested in learning and using objective ways to obtain and share knowledge. This position takes two forms: *separate knowing*, a critical, detached, and impersonal knowing; and *connected knowing*, a mode of knowing with more emphasis on understanding, empathy, and the personal. Lastly, in *constructed knowledge*, knowledge is seen as contextual wherein both subjective and objective strategies for knowing are valued. While the researchers concluded that women’s ways of knowing are intertwined with self-concept, participants may have been primed by questions about relationships prior to questions on education and ways of knowing (Hofer & Pintrich, 1997). The questions on ways of knowing were also almost exclusively focussed on the role of experts, thereby limiting consideration of one’s ways of knowing to these sources instead of other salient factors. In addition, despite using a diverse sample, the questions on ways of knowing differed between groups based on whether the woman was in higher education or a recent graduate or not. This therefore limited comparisons between the groups and the chance to elucidate the role of education in the development of one’s epistemology.

Epistemological reflection model. Countering previous research on the separate genders, Baxter Magolda (1992) sought to explore gender-related patterns in student’s intellectual development. A random sample of 101 students from an American university, although “not exactly representative of the larger student body” (Baxter Magolda, 1992, p. 25), was followed over the course of their years at college. Qualitative, in-depth interviews revealed four patterns of ways of knowing as students reflected on their experiences with learning at college. Each of these ways of

knowing was characterised by a core set of epistemic assumptions about the nature, limits, and certainty of knowledge, and led to expectations regarding the learner, peers, teachers, and learning process in educational settings.

These ways of knowing included *absolute knowing*, in which knowledge is viewed as certain or absolute and transmitted from an authority; *transitional knowing*, where knowledge is more tentative and there is a focus on understanding; *independent knowing*, where knowledge is uncertain, everyone has their own beliefs, and the learner thinks for themselves; and finally *contextual knowing* where knowledge is contextual, different perspectives are compared, and knowledge is judged on the evidence in context. From these categories, it can be seen that there is an emphasis in this model on the nature of learning as situated in the college classroom context and less on assumptions about knowledge itself (Hofer & Pintrich, 1997). Moreover, despite setting out to study the role of gender, Baxter Magolda (1992) concluded that there were actually more similarities than differences between women's and men's ways of knowing.

Many participants continued to be interviewed annually, and Baxter Magolda was able to document post-college experiences with learning and coming to know, as well as their experiences with making meaning of the demands of adult life, their sense of self, and how they decided what to believe. She documented a transition from the start of college, when knowledge was generally viewed as certain and transmitted by authorities, to a growing awareness of multiple perspectives, less reliance on authority and more personal responsibility for adopting knowledge claims, to post-college when most viewed knowledge as contextual and individuals tended to construct their own perspectives to become the "authors of their own lives" (Baxter Magolda, 2008 p. 53). Now subsumed under research on self-authorship, this model is context-bounded (Limón, 2006), the most academically focussed of the developmental models, and includes aspects such as the role of the learner, instructors, and evaluation, which are not purely epistemological (i.e., focussed on knowledge and knowing; Buehl & Alexander, 2001).

Reflective Judgement Model. Around the same time, King and Kitchener (1994) developed an extensive model of the epistemic assumptions that underlie reasoning, that is, reflective thinking. Their seven-stage model of epistemic cognition outlines the developmental progression that occurs from late adolescence to mid-adulthood (King & Kitchener, 2004) in the ways that people understand the process of knowing and how they justify their beliefs; that is, there is a focus on how people develop their understanding of the limits, certainty, and criteria for knowing (Greene, 2007). The model was built on the work of Perry and other developmental psychological models, such as Dewey's work on reflective thinking (Hofer & Pintrich, 1997), and consists of qualitatively different stages that outline how individuals reason about ill-structured problems which cannot be solved with a high degree of certainty, such as the safety of additives in food (Hofer & Pintrich, 1997).

The model was refined through large-scale cross-sectional and longitudinal studies using the Reflective Judgement Interview. This one-hour, semi-structured interview consists of standard ill-structured problems such as how the pyramids were built and the objectivity of news reporting. These problems are explored and probed before being transcribed and scored by trained, certified raters who assign scores within the two areas of nature of knowledge and nature of justification. A complex rating system eventually sees a score assigned that reflects the stage of reflective judgement evident in the transcripts (King & Kitchener, 2004). Each stage in the model has a clearly defined set of assumptions about knowledge and how it is acquired, with successive stages representing a more complex and effective form of justification and associated with a different strategy for solving open-ended problems.

The model, with three overarching levels, begins with *pre-reflective thinking* (stages 1-3) in which individuals do not acknowledge that knowledge is uncertain and do not use evidence to reason towards a conclusion. In the next stages of *quasi-reflective thinking* (stages 4 and 5) knowledge is seen as uncertain, subjective, and contextual; justification is idiosyncratic or context specific. In the final stages, labelled *reflective thinking* (stages 6 and 7), knowledge is seen as actively constructed or the outcome of a process of inquiry and beliefs are justified by considering evidence

from different perspectives and evaluating them against various criteria. It is proposed that individuals progress through these stages by the acquisition of certain skills at each stage.

The authors assert that an individual's assumptions about knowledge change over the course of their lifetimes, and these changes are facilitated by being in an educational setting (King & Kitchener, 1994, 2004), although little is known or proposed about how these changes specifically occur. Their work made a valuable contribution to the field by expanding upon the upper positions of Perry's scheme (Hofer & Pintrich, 1997). Research with the reflective judgement model is also notable for including a broad range of traditional- and non-traditional-age students as well as non-student adults, eliciting an individual's responses at a functional level rather than at the optimal level, and for considering reasoning in non-academic contexts (Buehl & Alexander, 2001; King & Kitchener, 2004). The focus on justification, a central aspect of epistemology in philosophy, is a notable strength of this model over other developmental ones. However, it can also be argued that epistemological beliefs are activated beyond simply reasoning about ill-structured problems (Hofer & Pintrich, 1997). That is, it is also enacted in everyday contexts such as when searching for and evaluating knowledge online, as well as reading and engaging in text comprehension.

Argumentative reasoning and epistemological understanding. A similar model was that of Kuhn (1991). Kuhn evaluated participants' reasoning and justification in relation to ill-structured, real-world problems, such as "What causes prisoners to return to crime after they're released?" Participants were required to state and justify their position, generate an opposing position and rebut it, propose solutions, and discuss their epistemological reasoning. Notably, participants were interviewed from four diverse age groups, including 14-15-year-olds, and participants in their 20s, 40s, and 60s. In addition to participants who had attended college, the study also included equal numbers of participants who had not attended college. A separate group with presumed expertise in the topics (e.g., parole officers, teachers, and philosophers) was included.

Although the aim of the study was to explore argumentative reasoning skills, Kuhn found responses to a number of the questions reflective of various forms of epistemological thinking, such

as the certainty, proof, and origins of knowledge, the role of expertise, and the possibility of multiple viewpoints. Moreover, the model paralleled the progressive development through objective and subjective views of knowledge detailed in Perry's work (Sandoval et al., 2016). Despite these findings, this model, defining three broad epistemological views, was only based on the responses to questions about expertise. In this developmental model, *absolutists* see knowledge as coming from an external source; the experts' knowledge is regarded as certain and absolute; and they express high certainty with their own beliefs. Further, absolutists see knowledge claims as black and white facts and representative of an objective reality that is directly knowable (Kuhn, Cheney, & Weinstock, 2000). Individuals at this level use critical thinking for assessing knowledge claims to determine whether they match reality, or not.

In contrast, a *multiplist* denies the certainty of experts, has a sceptical view of expertise, and gives more weight to ideas and emotions than facts. Critical thinking is not relevant at this stage, as reality is not directly knowable. For multiplists, knowledge is subjective; constructed by human minds and therefore tentative (Kuhn et al., 2000). Lastly, *evaluative epistemologists* also deny the possibility of certain knowledge, but instead recognise expertise and varying viewpoints that can be evaluated, through the use of critical thinking, regarding their merit or adequacy. In this final stage, the objective and subjective dimensions are integrated and coordinated (Mason, 2016).

More recently, Kuhn and colleagues (2000) added a pre-absolutist level, labelled "realism," said to be characteristic of epistemological understanding during early childhood. In this stage, knowledge claims are seen as copies of an external reality which is directly knowable. Knowledge at this stage is seen as certain and coming from an external source, therefore making critical thinking unnecessary. Like King and Kitchener's model, Kuhn's model focussed on an individual's views on knowledge as a general construct, outside of the classroom, and also used a broad sample. This work has also made an important contribution to the field through study of the relationship between epistemology and juror reasoning (Weinstock, 2016). Despite such strengths, little information is provided as to its empirical validation (Hofer & Pintrich, 1997).

While the measurement of epistemological understanding was initially through the use of detailed interviews, Kuhn et al. (2000) developed a briefer, more efficient self-report instrument to assess epistemological understanding. The Epistemological Understanding Instrument (EUI) was developed to capture the transitions from the absolutist to multiplist stage, and from the multiplist to evaluativist stage. Specifically, respondents are assessed through the presentation of discrepant claims. That is, they are presented with two conflicting statements (e.g., “Robin thinks lying is wrong. Chris thinks lying is permissible in certain situations”) across the five domains and are asked whether only one statement is right, both could have some rightness, or one is “more right” than the other (Kuhn et al., 2000).

The authors posited that the coordination of the subjective and objective dimensions of knowing develops in a systematic way across various judgement domains (i.e., personal taste, aesthetics, value, and truth). Importantly, Kuhn et al. (2000) found that the positions differ substantially as a function of education level with participants having more education ‘outperforming’ those of lesser educational levels. That is, participants from the higher education group were more likely to be in the evaluative category and less likely to be in the absolutist one, as well as more likely to generate successful counterarguments and rebuttals, offer genuine evidence, or show more complex forms of thinking. Moreover, they found consistent age-related patterns in the progression of judgement across the different domains. Further, there were domain differences in the acknowledgement of subjective thinking, with it being more readily acknowledged in judgements of personal taste and aesthetics and less readily regarding judgements of truth (Kuhn et al., 2000). While a useful model which has influenced other models (e.g., Greene et al.'s [2008] model), questions however have been raised about the non-epistemic nature of the personal taste and values domains (Greene et al., 2008; Mason, 2016) and the assignment to a level of epistemic cognition based on only one question (Mason, 2016)

More recently Barzilai and Weinstock (2015) developed a scenario-based assessment based on Kuhn and colleagues’ conceptualisation. In creating the Epistemic Thinking Assessment (ETA),

they aimed to overcome some of the limitations associated with the EUI, including questions regarding its accuracy in assigning individuals to epistemic levels and validity, as the focus is not on specific knowledge claims (Barzilai & Weinstock, 2015). Further, they aimed to improve the reliability of measurement of epistemic thinking, to account for multiple dimensions of epistemic perspectives (including the certainty, source, and justification of knowledge), and to explore various topics in more depth.

Of note is that a comprehensive process of instrument development was detailed, including formulating a definition of the model to be assessed; developing items; reviewing and refining items through cognitive interviewing; a pilot study to further explore the items followed by item revisions; and a large-scale study to provide a confirmatory test of the instrument. Questions were designed to tap into epistemic thinking at a metacognitive level, that is, understanding of the nature of knowledge and knowing at a reflective, meta-level, instead of asking participants to self-report their beliefs about knowledge and knowing. Instead of being asked to judge the 'rightness' of a claim, participants are asked to consider the nature and limits of knowledge and knowing, such as whether one can ever know something with certainty or how competing accounts should be evaluated.

To provide context, a history scenario and biology scenario were adapted, with each containing conflicting expert accounts regarding a historic event or biological phenomenon. Statements were developed to represent each level; for instance, absolutism – "One can know for certain what happened to the frogs" and for evaluativism – "There is never full certainty what happened to the frogs, but it is possible to improve the degree of certainty." Exploratory and confirmatory factor analyses generally supported the expected structure of the three epistemic levels, although validity and reliability were found to be better in the biology scenario than in the history one (Barzilai & Weinstock, 2015). An important conclusion raised by the authors was that topic or domain differences have a clear impact on the assessment of epistemic thinking.

Summary of developmental models. These developmental models generally posit that an individual's views on knowledge and knowing change over time in qualitatively different ways. They

tend to suggest a similar progression from dualism through multiplism to evaluativism: from views of knowledge as being certain and concrete, right or wrong, and transmitted by an authority; to a mid-point perspective in which everyone is seen to have their own beliefs which are evaluated based on the knower's position; to a final recognition that knowledge is actively constructed by the knower and evidence is critically evaluated and judged in context (Hofer & Bendixen, 2012; West, 2004).

Table 1 compares these progressions across the models. Of note, individuals are said to advance from a stage of objectivity, through subjectivity, to finally a reconciliation of the two (Kuhn et al., 2000). Inclusion of broader populations outside the typical focus on college students may be needed to see the extension and refinement of this coarse, three-level heuristic (Hofer, 2016).

While each model includes various aspects at each stage or position, it is assumed these domain-general cognitive structures are coherent and consequently develop simultaneously (Hofer & Bendixen, 2012; Mason, 2016). In addition, thinking plays a key role in these models, as evidenced by their naming and components, for example reflection, reflective judgement, reasoning, and understanding (Mason, 2016). The inclusion of thinking may however introduce construct-irrelevant variance to these models (Messick, 1995). Greater conceptual clarity about the nature of these constructs may therefore be achieved by removing thinking and reasoning from conceptions of epistemic cognition (Hofer & Pintrich, 1997). There is also consensus that the progressions proposed are associated with education, with increasing educational level associated with more "advanced" levels. Notably, in many models the latter stages only tended to be reached by advanced graduate students (King & Kitchener, 1994), graduate trained philosophers (Kuhn, 1991), individuals post college (Baxter Magolda, 1992), and rarely by college seniors (Perry, 1970). Questions have thus been raised as to whether the developmental trajectories captured in these landmark models might rather be an artifact of a Western liberal arts education (Hofer & Pintrich, 1997). Indeed, with an overrepresentation of White, middle class, college students in studies and minimal inclusion of those from different ethnic or educational backgrounds (Hofer & Pintrich, 1997), it is hard not to rule out this possibility.

Table 1

Comparison of Models of Personal Epistemology

Intellectual and Ethical Development (Perry, 1970)	Women's ways of knowing (Belenky et al., 1986)	Epistemological Reflection (Baxter Magolda, 1992)	Reflective Judgment (King & Kitchener, 1994)	Argumentative Reasoning (Kuhn et al., 2000)
<i>Positions</i>	<i>Epistemological perspectives</i>	<i>Ways of knowing</i>	<i>Reflective judgment stages</i>	<i>Epistemological views</i>
Dualism	Silence/ Received knowing	Absolute knowing	Pre-reflective thinking	Realist
Dualism	Silence/ Received knowing	Absolute knowing	Pre-reflective thinking	Absolutist
Dualism	Silence/ Received knowing	Absolute knowing	Pre-reflective thinking	Multiplist
Multiplicity	Subjective knowledge	Transitional knowing	Quasi-reflective thinking	Multiplist
Relativism	Procedural knowledge (a) Connected knowing (b) Separate knowing	Independent knowing	Quasi-reflective thinking	Evaluativist
Commitment within relativism	Constructed knowledge	Contextual knowing	Reflective thinking	Evaluativist

Note. Stages and positions are aligned to indicate similarity across the five models. Adapted from "The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning," by B. K. Hofer & P. R. Pintrich, 1997, *Review of Educational Research*, 67, p. 92. Copyright 2021 by American Educational Research Association.

Conceptual clarity or consensus, however, was not reached, with these models including various components abstracted from interviews that were framed by the researchers' interests and understandings of the underlying construct (Greene & Yu, 2014). Leading questions about relationships, experts, and evidence may have therefore primed respondents to answer in certain ways (Hofer & Pintrich, 1997). Moreover, while generally focussing on individuals making meaning of their experiences or using controversial problems as a way to capture the views individuals have about their knowledge and knowing (Greene & Yu, 2014), the models seem to have also included construct irrelevance (Messick, 1995) through the inclusion of such aspects as how individuals construe responsibility, values, learning and instruction, the nature of intelligence, and the role of peers and instructors.

With particular regards to epistemology, the foci of these models includes the nature of knowledge and truth (Perry, 1970); the source of knowledge and truth (Belenky et al., 1986); the nature, limits, and certainty of knowledge (Baxter Magolda, 1992); the limits, certainty, and criteria (i.e., justification) for knowing (King & Kitchener, 1994); and the nature of assertions, whether reality is knowable or not, the source and certainty of knowledge, and the role of critical thinking for establishing justification (Kuhn et al., 2000). These various definitions and conceptual frameworks thus raise questions regarding the construct at hand, particularly as to whether these models refer to the same or a similar construct as well as what the core components of personal epistemology might be.

Dimensional models

Epistemological beliefs. A shift in how epistemic cognition was conceptualised occurred following the work of Schommer (1990), who proposed a dimensional model of epistemological beliefs. Schommer was particularly interested in the impact a student's views about the general nature of knowledge, or their personal epistemology, may have on text comprehension. However, after noticing the inconsistent results of others using Perry's scheme, Schommer critiqued the conception that personal epistemology develops in stages. Instead, Schommer postulated that

personal epistemology is a belief system made up of 'more or less' independent, or asynchronous, dimensions. Schommer proposed a set of five dimensions from Perry's work and the work of others focusing on the nature of intelligence and beliefs about mathematics: the structure, certainty, and source of knowledge, and control and speed of knowledge acquisition. Each belief in the model is assumed to lie on a continuum from "naïve" at one end to "sophisticated" on the other and it is argued that more sophisticated beliefs are associated with better performance on measures of learning (Sandoval et al., 2016).

To test her conceptualisation, Schommer developed a 63-item questionnaire which included two or more subsets of items for each of the five proposed dimensions. College and university students rated the statements on the questionnaire, such as "When I study I look for specific facts," "People who challenge authority are overconfident," and "Scientists can ultimately get to the truth," on a 5-point Likert scale. Factor analysis was used to extract the explanatory epistemological dimensions from the responses. Of note is that the factor analysis was performed on 12 pre-defined subsets of items, with no empirical or theoretical rationale provided for pre-assigning the items to subsets (Clarebout, Elen, Luyten, & Bamps, 2001; DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008; Hofer & Pintrich, 1997). Only four factors emerged from the analysis with the proposed source of knowledge factor not emerging. Although based on a continuum, the resulting factors are stated from the naïve perspective: *Innate Ability* (the ability to learn is fixed at birth), *Simple Knowledge* (knowledge is discrete and unambiguous), *Quick Learning* (learning is quick or not at all), and *Certain Knowledge* (knowledge is unchanging; Schommer, 1990).

Since its development, Schommer's epistemological questionnaire (SEQ) has made it possible to conduct large-scale studies in an attempt to assess the relations between the components of epistemological beliefs and various academic outcomes, including academic achievement, academic motivation, text comprehension (Hofer & Bendixen, 2012), cognitive and metacognitive strategy use, and conceptual change (Sandoval et al., 2016). The SEQ has been used extensively and paved the way for the development of other paper-and-pencil measurement of

personal epistemology (Buehl, Alexander, & Murphy, 2002; Schraw, 2013), including related instruments that are partly based on the SEQ, such as the Epistemic Beliefs Inventory (EBI; Schraw, Bendixen, & Dunkle, 2002), the Epistemological Beliefs Survey (EBS; Wood & Kardash, 2002), Jehng's Epistemological Questionnaire (JEQ; Jehng, Johnson, & Anderson, 1993), and the Domain-Specific Beliefs Questionnaire (DSBQ; Buehl & Alexander, 2001; Buehl et al., 2002).

However, despite its popularity and extensive use (Buehl, 2008; Schraw, 2013), the SEQ is arguably fundamentally flawed. Theoretically, the conceptualisation has been questioned, with researchers arguing that beliefs about intelligence and learning, while related, are not genuinely epistemic (DeBacker et al., 2008; Sandoval et al., 2016; Schraw, 2013) and therefore add irrelevance to the construct (Hofer & Pintrich, 1997). Empirically, there have also been issues with the proposed factor structure with analyses yielding factor loadings inconsistent with the hypothesised structure (Clarebout et al., 2001; Schraw, 2013). Considerable variation in the numbers of factors identified has also been observed when attempting to replicate the factor structure (Buehl, 2008; DeBacker et al., 2008).

The SEQ has also been critiqued for having broadly stated items (Hofer & Pintrich, 1997) and less than ideal psychometric properties, including persistently low internal consistency (DeBacker et al., 2008; Schraw, 2013), low correlations between epistemological beliefs and various learning outcomes such as academic achievement (Schraw & Olafson, 2008), and for explaining only a small proportion of sample variance (e.g., 20-35%; Schraw, 2013). This therefore raises questions about the validity of inferences when used in studies relating epistemological beliefs to academic outcomes. Hence, it can be seen that the utility of the SEQ lies more with its convenience and unquestioned popularity than by its solid theoretical foundations and construct validity. Schommer's model is therefore unlikely to provide an accurate representation of the construct, pointing to the need for further mapping of this construct. Casting personal epistemology as beliefs is also questionable given the messy nature of beliefs (Pajares, 1992). Of concern, too, is that Schommer used the term 'beliefs' to signify the nonconscious or tacit nature of this field (Greene et al., 2016a);

this thus raises questions though as to how such beliefs can be accessed via self-report questionnaires.

Epistemological theories model. As a compromise between stage-like developmental schemes and Schommer's asynchronous, multidimensional beliefs, Hofer and Pintrich (1997) proposed that epistemic beliefs should instead be seen as coherent epistemic theories (Hofer & Bendixen, 2012). Their framework came about after an extensive review of the literature and comparison of extant models. In particular, Hofer and Pintrich (1997) noticed that while most models have different foci, definitions, boundaries, and explanations for change, there were consistencies among the dimensions proposed, even across paradigmatic approaches (Hofer & Bendixen, 2012; Sandoval et al., 2016). Many of these dimensions were hence integrated into Hofer and Pintrich's (1997) seminal model of epistemological theories, a multidimensional model in which epistemological beliefs are conceptualised as the personal theory individuals have about what knowledge is and how one comes to know.

This influential model encompasses four dimensions further broken down into two areas representing the core of individuals' epistemological theories. These are the nature of knowledge, which includes the certainty of knowledge and simplicity of knowledge, and the nature of knowing, including the source of knowledge and justification for knowing. A key addition in this model, that was not included in Schommer's model, was the dimension of *justification of knowledge*, although it is noteworthy that only basic detail is provided to describe this narrow dimension (Greene et al., 2008). Noteworthy is that a dimension related to the nature of learning (such as that proposed in Schommer's model) was not included; while seen as related to beliefs about knowledge, beliefs about learning were not seen to be epistemic. Further, while Schommer conceived a system of independent dimensions, in Hofer and Pintrich's model the individual's views on knowledge and knowing are seen as a coherent integration of compatible perspectives (Mason, 2016). The definitions of these dimensions can be found in Table 2.

Table 2

Hofer and Pintrich's (1997) Dimensions of Epistemological Theories

Area	Dimension	Description
Nature of knowledge	Certainty of knowledge	This dimension concerns the degree to which one sees knowledge as fixed or more fluid. It ranges from viewing knowledge existing as absolute truth with certainty to viewing it as being more tentative and evolving.
	Simplicity of knowledge	Knowledge is viewed on a continuum from consisting of discrete, unrelated, concrete facts to being relative and contextual.
Nature of knowing	Source of knowledge	This ranges from conceiving knowledge as something that originates outside of the self and is transmitted by an authority, such as a teacher, to viewing it as a process that resides within the knower who constructs knowledge in interaction with others (e.g., experts, texts, or experiences).
	Justification for knowing	This dimension includes how individuals evaluate knowledge claims, including the use of evidence, the use they make of authority and expertise, and their evaluation of experts. As individuals learn to evaluate evidence and to substantiate and justify their beliefs, they move through a continuum of dualistic beliefs, to the multiplistic acceptance of opinions, and to reasoned justification for beliefs.

Hofer (2000) developed a questionnaire, the discipline-focussed epistemological beliefs questionnaire (DEBQ), to assess these proposed dimensions. Questions were adapted from existing instruments, including Perry's Checklist of Educational Values and the SEQ, with additional items written to ensure coverage of the four dimensions extrapolated from Hofer and Pintrich's (1997) review. There was also a focus on ensuring that questions captured the dimensionality of personal epistemology and to ensure questions focussed on domain-specific knowledge. First year college

students enrolled in an introductory psychology course completed the questionnaire, rating each of the 27 items on a 5-point scale. A four-factor model emerged although not all of the factors emerged as predicted and some items cross-loaded onto other factors. Specifically, certainty of knowledge and simplicity of knowledge did not emerge as separate factors, an additional scale related to the perceived attainability of truth emerged, and not all aspects of both the justification for knowing and source of knowledge dimensions emerged. It is possible that some of the justification items were poor measures of the construct or that these students had difficulty interpreting the meaning of those items (Hofer, 2000).

Another aim of that study was to design a measure that could explore whether there are disciplinary differences in epistemological beliefs (Hofer, 2000). That is, there was interest in whether the dimensions of epistemological beliefs are consistent across academic disciplines or whether students hold different beliefs about different disciplines. In this study, the students were given two versions of the DEBQ; the questions on each were identical and the forms differed only by having headings of either "psychology" or "science." Students were asked to keep the relevant discipline in mind when answering the questions; these included "In this field, knowledge is certain" and "All experts in this field understand the field in the same way." Results indicated that while the underlying model was consistent across disciplines, students' specific views about knowledge differed by discipline. For instance, students reportedly saw knowledge in science as more certain and unchanging than in psychology, while they were more likely to consider personal knowledge and experience as a basis for justification in psychology than in science. Hofer concluded that these results provided evidence supporting the domain-specificity of epistemological beliefs. These results, however, were limited by the use of first year students who would arguably have had varying levels of exposure to psychology and science (Buehl & Alexander, 2001). Questions have also been raised as to whether students were keeping the specified domain in mind, particularly when the item was very generic, for instance, "Most words have one clear meaning" (Mason, 2016).

Overall, despite the limitations of the DEBQ, Hofer and Pintrich's framework is a highly influential model that has been the basis for the development of other models and measures. This includes the Internet-Specific Epistemological Questionnaire (ISEQ; Bråten et al., 2005), the Topic-Specific Epistemic Beliefs Questionnaire (TSEBQ; Bråten, Gil, Strømsø, & Vidal-Abarca, 2009) and Conley and colleagues' epistemological beliefs in science questionnaire (Conley, Pintrich, Vekiri, & Harrison, 2004).

Summary of dimensional models. These models of Schommer (1990) and Hofer and Pintrich (1997), which reconceptualised the construct as either beliefs or theories, have been particularly influential due to the development of questionnaires to measure such beliefs. These self-report measures allowed for the proliferation of research, including research exploring correlations between epistemic cognition and variables related to learning. As briefly noted, though, there have been several limitations of these measures; these will be discussed in more detail in the measurement section. In addition, both models also assume that beliefs about knowledge and knowing are static, internal entities that reside in, and are the product of, individual minds (Tafreshi & Racine, 2015). This is a cognitive view that has been critiqued by researchers for failing to account for the social, interactive, and situated nature of epistemology (Tafreshi & Racine, 2015) and that knowledge and justification occurs in the relation between the individual and the external world (Kitchener, 2011).

The epistemic nature of some of these dimensions are also in question. In particular, it has been argued that the nature of knowledge (i.e., its simplicity or certainty) is not related to epistemology and may be more accurately deemed ontological (Greene et al., 2008). Questions about the empirical overlap between the simplicity and certainty dimensions further suggests the need to refine this framework (Hofer, 2000). Moreover, the dimensions related to learning in Schommer's (1990) model are also deemed to be outside the scope of epistemology (Hofer & Pintrich, 1997; Kitchener, 2011). It has also been suggested that expansion of Hofer and Pintrich's

framework might be warranted, given the dimensions extracted from earlier models may not form an exhaustive list (Hofer & Bendixen, 2012).

Theoretical and philosophical expansion

Since the earlier developmental and dimensional models, alternative conceptions of epistemic cognition have been developed. Some of these have been influenced by disciplinary education, including the epistemological resources model of Hammer and Elby (2002, 2003). Researchers have also returned to the philosophical foundations of this field to consider how it can inform the refinement and expansion of models of epistemic cognition. Several models have been influenced by philosophy, including the epistemic and ontological cognitive development model (EOCD; Greene et al., 2008), the trichotomous justification belief framework (Ferguson, Bråten, & Strømsø 2012; Ferguson, Bråten, Strømsø, & Anmarkrud, 2013), and the successive models of Chinn and colleagues (Chinn, Buckland, & Samarapungavan, 2011; Chinn & Rinehart, 2016; Chinn, Rinehart, & Buckland, 2014). These will now be reviewed in turn.

Disciplinary education. Scholars from the fields of disciplinary education and the learning sciences have also been interested in how learners come to know and think about knowledge (Sandoval et al., 2016). This has particularly included focus on the epistemological aspects of the disciplines of mathematics, science, and history (Sandoval et al., 2016) and the recognition that, in addition to the discipline's content and theories, students must also learn the epistemology of that discipline. For example, research in the area of nature of science focusses on students' views about the tentativeness of science knowledge, its construction and subjectivity, and whether they differentiate evidence from inference. Research taking a disciplinary perspective has also shown that students' epistemologies vary both within and across disciplines in response to situational demands (Elby, Macrander, & Hammer, 2016).

Epistemological resources. A model with a strong disciplinary foundation is the resources approach of Hammer and colleagues (Hammer & Elby 2002, 2003; Louca, Elby, Hammer, & Kagey, 2004). In contrast to developmental stage models or the cognitivist approach of beliefs models, the

authors conceived personal epistemology as being made up of a range of fine-grained, situated, and highly context-specific cognitive resources (Louca et al., 2004). These knowledge elements are said to be activated in specific contexts and used by individuals “to understand and reflect on their epistemic knowledge, activities, forms, and stances” (Barzilai & Zohar, 2014, p. 15). Implicit in this framework is the claim that personal epistemology needs to be studied in context; such a conceptualisation has so far led to exploration and explanation of the impact that personal epistemology has in specific lessons in the classroom. This approach also highlights the need to consider epistemology in greater detail than other models and measures currently have. In line with their conceptualisation, scholars of this approach do not typically utilise a quantitative approach to measurement, instead preferring to study these resources in situ and opting for naturalistic observations, case studies, and interviews (Mason, 2016).

Epistemic and ontological cognitive development model. In response to the continuing debates and disagreements in the field about the conceptualisation, construct definition, boundaries, generality/specificity, and measurement of personal epistemology, Greene and colleagues (2008) advocated for the role philosophical epistemology should play in addressing these concerns and informing epistemic cognition research. Firstly, they suggested that, as justification is central to philosophical conceptions of epistemology, it should play a larger, more expanded role in models of personal epistemology and its multidimensional nature should also be recognised. Consequently, they proposed distinguishing between the internal and external sources of knowledge by separating the justification dimension into one of personal justification (i.e., experience and reasoning) and one of justification by authority (e.g., teachers and experts; Mason, 2016). They also argued that it needs to be outlined how the different qualitative positions in developmental models might be measured quantitatively. Finally, they suggested that it would be more accurate to regard factors relating to the simplicity and certainty of knowledge as ontological (i.e., related to categories of reality and what is said to exist) instead of epistemic, with only Hofer and Pintrich’s justification for knowing dimension argued to be epistemic (Greene et al., 2008).

Greene and his colleagues (2008) subsequently developed a model of epistemic and ontological cognitive development (EOCD) which integrated developmental and dimensional systems of personal epistemology models while being informed by philosophy. The typical progression outlined in previous developmental models is extended in their model with a dogmatist position that was proposed following a review of research on adolescents' epistemic cognition. Specifically, dogmatists see knowledge as constructed and believe it can only come from authority figures. Greene and colleagues' model therefore proposes four sequential positions of *realism*, *dogmatism*, *scepticism*, and *rationalism*, as well as three dimensions of ontological and epistemological cognition. Ontological cognition is captured using a simple and certain knowledge dimension, and epistemic cognition by two justification dimensions of justification by authority and personal justification. Specifically, those having a strong belief in justification by authority would say they "know" something if it came from an expert, teacher, or other reputable source, while those having a strong belief in personal justification are said to accept knowledge claims based on personal experience or logic (Greene, Torney-Purta, & Azevedo, 2010).

Each position in their model (Table 3) represents a pattern, or profile, of ontological and epistemic beliefs, with individuals in the four positions differentiated by the extent of their beliefs with respect to the three dimensions (Greene, Torney-Purta, & Azevedo, 2010). For instance, realists are proposed to have a strong belief in all three dimensions while rationalists are proposed to have a weak belief in certain and simple knowledge but a moderate belief in the dimension of justification by authority and personal justification. The authors posit that individuals progress through the positions in a predictable, developmental manner but at different times depending on whether the domain is well-structured, such as maths or physics, or ill-structured, such as history or literature.

Greene, Torney-Purta, and Azevedo (2010) also developed the epistemic and ontological cognition questionnaire (EOCQ) to measure the proposed relations among the dimensions and positions in the model. An example item for the justification by authority dimension is: "If a [mathematician/historian] says something is a fact, I believe it."

Table 3

Model of Epistemic and Ontological Cognitive Development

Educational level		Ill-structured domains			Well-structured domains			
		Belief in			Belief in			
	Position	SC	JA	SC	Position	SC	JA	PJ
Early elementary school	Realism	Strong	Strong	Strong	Realism	Strong	Strong	Strong
Late elementary school to early college	Dogmatism or skepticism	Weak	Strong	Weak	Realism	Strong	Strong	Strong
Middle to late college	Rationalism	Weak	Weak	Strong	Dogmatism or skepticism	Weak	Strong	Weak
Post-undergraduate education	Rationalism	Weak	Moderate	Moderate		Weak	Weak	Strong
			Moderate	Moderate	Rationalism	Weak	Moderate	Moderate

Note. SC = Simple and Certain Knowledge dimension; JA = Justification by Authority dimension; PJ = Personal Justification dimension.

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For personal justification, an example item is “[Mathematical/Historical] knowledge is all factual and there are no opinions.” The authors planned to iterate between model and instrument development in order to develop an adequate conceptual model of personal epistemology together with an instrument with strong psychometric qualities that produces scores that are reliable and valid indicators of personal epistemology. Factor mixture analysis, a combination of confirmatory factor analysis and latent profile analysis, was used to test the model with results generally supporting the model’s dimensional and positional aspects and the hypothesised relations between these. In addition, acceptable reliability scores were observed for all factors except for Mathematics Simple and Certain Knowledge. The authors noted that both the model and measure need further refinement and the addition of further ontological or epistemic dimensions, including other forms of justification, may be required. As yet, it does not appear that this refinement has been attempted.

Integrated model: Multiple text comprehension and the trichotomous justification

framework. An alternative approach to those taken by previous researchers is the one taken by Bråten, Strømsø, and Salmeron (2011) who developed an integrated model specifying the relationship between dimensions of epistemic beliefs and comprehension of multiple textual resources. The epistemic beliefs component of their framework was based on the one proposed by Hofer and Pintrich (1997). Further, following Greene and colleagues’ (2008) argument of the centrality of justification in philosophical epistemology, and based on their own earlier research (Bråten & Strømsø, 2010; Strømsø & Bråten, 2010), they expanded the justification for knowing dimension. Specifically, this dimension included “opinion, firsthand experience, and common sense at one end of the continuum, and beliefs in justification through reason (i.e., critical thinking), prior domain knowledge, scientific inquiry, and cross-checking of sources at the other end of the continuum” (Bråten, Britt, et al., 2011, p. 56). A program of research ensued which, among other aims, sought to further explore the dimensionality of epistemic beliefs, in particular justification beliefs (Ferguson, 2014).

This led to a study by Ferguson et al. (2012), who aimed to explore students' epistemic cognition while reading conflicting texts about the potential health risks of mobile phones. Of note is the use of think-aloud methodology to assess epistemic cognition, as it was argued that self-report measures do not assess how people enact their epistemic cognition to deal with a topic. Ferguson et al. (2012) also aimed to explore the dimensionality of students' epistemic cognition and were particularly inspired by the dimensionality proposed by Greene et al.'s (2008) model. They utilised Greene's two dimensions of justification for knowing (justification by authority and personal justification) and included Hofer and Pintrich's source of knowledge dimension under justification for knowing. Thus, their work evolved to explore three dimensions of justification: justification by authority, personal justification, and justification by multiple sources. The final dimension they utilised in their research was the certainty/simplicity of knowledge, which they specified as epistemic (in contrast to Greene et al. [2008] who proposed it as ontological). Evidence for all dimensions was found in their analysis of think-aloud protocols; however, coding the protocols based on a pre-specified model arguably constrained their results to confirming such models and not to revealing additional dimensions or forms of justification.

Later, Ferguson and colleagues (Ferguson et al., 2013) developed the Justification for Knowing Questionnaire (JFK-Q), based on Greene and colleagues' (2008) multidimensional conceptualisation of justification for knowing. In addition, they also included justification by multiple sources, as identified in their previous think-aloud study (Ferguson et al., 2012). Their final instrument consisted of three dimensions with 14 questions. Justification by authority (six items e.g., "I believe in claims that are based on scientific research"), concerns the reliability of statements or claims based on scientific research and conveyed by teachers, textbooks, and scientists. Personal justification (three items e.g., "What is a fact in natural science depends on one's personal views"), focusses on the use of personal views and opinions as a basis for judging what to trust in natural science. Lastly, justification by multiple sources (five items e.g., "To be able to trust knowledge claims in natural science texts, I have to check various knowledge sources") involves the cross-

checking, comparison, and corroboration of claims across several sources of information. The resulting measure demonstrated adequate psychometric properties with satisfactory internal consistency and the three factors explaining 53.7% of sample variance, an improvement on previous models. More recently, the Internet-Specific Epistemic Justification Inventory (ISEJ), designed to measure beliefs concerning the justification of knowledge claims on the Internet, was also developed based on this trichotomous justification belief framework (Bråten, Brandmo, & Kammerer, 2018).

Chinn and colleagues' philosophical expansion. In a similar effort to improve the conceptualisation and measurement of epistemic cognition, Chinn et al. (2011) proposed a philosophically grounded, widely expanded framework of epistemic cognition with five components. Their framework extended previous models, including Hofer and Pintrich's model, not only in terms of breadth through the addition of several components but also by depth with their arguments for more specific, fine-grained analysis of epistemic cognition. In contrast to Greene et al. (2008) who focussed on justification in their model, Chinn et al. (2011) suggested that justification is no longer a core focus for philosophers. Their framework thus includes components of epistemic aims and epistemic value; the structure of knowledge and other epistemic achievements; the sources and justification of knowledge and other epistemic achievements, together with related epistemic stances; epistemic virtues and vices; and reliable and unreliable processes for achieving epistemic aims.

Notably, some of these components resemble dimensions found in other models, such as the structure, sources, and justification of knowledge. However, Chinn and colleagues (2011) particularly expound the further detail missing from previous models that needs to be considered and may lead to better understanding of the links between epistemic cognition and the ways people approach learning tasks. For instance, with regards to the structure of knowledge, Chinn and colleagues add other dimensions such as the universality versus particularity of knowledge. Such a

distinction, they argue, should differentiate between an individual who attends to the general details of a knowledge claim from one who focusses on the context and specific details.

Likewise, their framework incorporates additional sources of knowledge including perception, introspection, memory, reasoning, and testimony as well as considering how these interact, instead of assuming they function in isolation. This is further extended by including considerations about the grounds for trusting various sources. For example, an individual may decide a science textbook is to be trusted because of a belief in its 'smart' authors or alternatively through an understanding of the process the authors take in gathering and evaluating the evidence to support the claims made in the book. These varying grounds for trusting the same source are postulated to lead to different approaches to learning and reasoning, and even how the individual will deal with conflicting information. Conceptualising and thus measuring sources of knowledge at a more fine-grained level may therefore improve understanding and prediction of different learning approaches.

Extending on previous conceptualisations of justification in models of personal epistemology, Chinn and colleagues (2011) also outlined the need for more specific types of justification that may better explain differences in people's epistemic behaviour. This includes needing to understand what individuals consider as good evidence, their standards for that evidence, and how they use evidence to evaluate a knowledge claim. Other, non-evidential approaches to justifying knowledge claims need also be considered. A related consideration included in their model is the stances individuals take towards knowledge claims; this ranges from viewing a knowledge claim as certain, to partly true or a working assumption, to doubting it, seeing it as uncertain, or withholding judgement.

This framework also includes several components new to models of epistemic cognition. These include the epistemic goals individuals take towards inquiry and finding things out and the value they attach to attaining different knowledge. Whether one is cautious or open to adopting new beliefs, for example, is likely to influence their learning approaches as is the value they place on

different types of knowledge, such as practical versus theoretical knowledge. This has been seen in qualitative interviews with experts and novices in the areas of biology and history which revealed, for instance, that experts and novices differ in the kinds of knowledge they value in a field (Greene & Yu, 2014). That is, history experts were found to value conceptual or principled knowledge more, while novices valued factual knowledge more. Finally, the dispositions that aid or hinder the achievement of epistemic aims are also included in their framework as are the cognitions related to the reliable or unreliable processes by which knowledge is achieved.

Despite proposing a comprehensive model, no instrument to test this model has yet been developed. This vast expansion may also add unnecessary complexity that precludes the development of useful, accessible, and interpretable measures. Moreover, some of the proposed dimensions might also be better treated and measured as correlates of epistemic cognition rather than as cognitions central to the construct. In sum, though, Chinn et al.'s (2011) model does provide useful suggestions of areas that may need to be considered in the development or revision of models. Importantly, the authors point to a need to better understand what people do and why they do it, with regards to knowing, as well as what different terms (e.g., experience, expert, or evidence) mean to them.

AIR model. More recently, Chinn and colleagues (2014, 2016) reorganised their earlier (2011) epistemic cognition framework into the AIR model of epistemic thinking. This model was developed to address the normative aspects and situativity of epistemic cognition (Barzilai & Chinn, 2018), and, compared to other models, focusses on the processes of epistemic cognition. It has three components: *Aims* and value, epistemic *Ideals*, and *Reliable* processes for achieving epistemic aims. In addition, this model emphasises that epistemic cognition is social, centred in practices (i.e., not formal beliefs), situated and contextual, and ethical (Chinn & Rinehart, 2016).

The first component considers an individuals' aims, and the value placed on those aims, regarding the intended goals of cognition. These goals include, for example, knowledge, understanding, wisdom, explanation, models, avoiding false beliefs, or true beliefs. It is argued that

the value an individual places on obtaining knowledge about various topics will affect how they process and seek out information on those topics. As an example, they discuss a mother whose practical goal is to enhance her children's health; this mother may therefore have as an epistemic aim the goal of finding out the truth about the safety of vaccines for children (Chinn et al., 2014). Moreover, she may value accurate information about vaccines but not value knowledge about kidney disorders (as she thinks her family are not at risk of suffering from kidney disorders). Further, Chinn and colleagues articulate that different communities value different kinds of knowledge. For example, a community may value knowledge about cloning as more valuable than knowledge of an animal's anatomy, because of the practical, medical implications of the former knowledge (Chinn & Rinehart, 2016). It is argued that the more an individual values an epistemic end, the more likely they will be to set epistemic aims to achieve that end (Greene, Cartiff, & Duke, 2018).

Next, epistemic ideals are the criteria or standards used to evaluate an epistemic product (e.g., knowledge, understanding, or explanations) and determine whether one's epistemic goals have been achieved, or not. For instance, a scientific knowledge claim may only be accepted if it fits with evidence or existing theories. Others might only count a belief as knowledge if standards are met that the belief is true and justified. The mother noted above may be guided by the ideal that a true explanation of vaccine safety will not have any strong counterevidence. Chinn and colleagues (2014) further elaborate five broad categories of epistemic ideals: the internal structure of an explanation; connections to, or coherence with, other knowledge; present and future connections to empirical evidence; standards regarding the evaluation of testimony from others; and ideals of good communication, that is, explanations that are clearly presented and understandable. Notably, they argue that epistemic ideals are dependent upon situation and topic.

The final component relates to the schemas, or cognitions, stipulating the processes by which epistemic products are reliably produced. More specifically, a reliable process is a method or procedure that produces a relatively high proportion of the end product, whether that be true beliefs, knowledge, theories, understanding and so on, compared to an unreliable process.

Moreover, the reliability of the processes is dependent on certain conditions. Examples of reliable processes include visual perception under typical conditions (i.e., close distances of the object under investigation and good lighting, as opposed to poor conditions such as long distances and dim lighting), replication of results in the production of scientific knowledge, asking an expert about a topic in their area of expertise, and reasoned argumentation. Unreliable processes, for instance reading tea leaves or horoscopes to produce knowledge about a person's personality, are more likely to produce false beliefs than true ones. Further, reliable processes relate to both the creation of epistemic products and the evaluation of others' epistemic products. Chinn et al. (2014) also acknowledge that these schemas may manifest as tacit beliefs (i.e., a belief that one is unable to verbalise but can be inferred through their actions). As with their earlier model, no measure has yet been developed to test this model.

Yet more recently, this descriptive model has been used as a framework to inform analysis of why post-truth thinking challenges occur and how education can both aggravate and mitigate these (Barzilai & Chinn, 2020; Chinn et al., 2021). Barzilai and Chinn (2018) also built on the AIR model and virtue epistemology to develop the Apt-AIR framework. This framework has been used for generating goals for, and components of, epistemic education targeted at promoting apt epistemic performance (Barzilai & Chinn, 2018). It has also been used to make sense of deep epistemic disagreements and propose instructional recommendations to address these (Chinn, Barzilai, & Duncan, 2020). While useful frameworks for expanding understandings of epistemic cognition and explicating goals for epistemic education, the AIR and Apt-AIR models would ultimately benefit from empirical validation.

Summary of model development and expansion. These models have added to earlier understandings of epistemic cognition, particularly highlighting its contextual and situated nature and a focus on processes and enacted practices; that is, what individuals actually do instead of their self-reported beliefs about knowledge and knowing. Alternative methodologies for measurement have been proposed, including latent profile analysis and the need to collect online data while

individuals engage in authentic tasks, such as through the use of think-aloud protocols, observations, and case studies.

In addition, justification has been a key feature in several of these models (e.g., the EOCD and trichotomous justification framework). While these particular justification dimensions have been informed by philosophy and supported by empirical data, there remains a need to explore whether additional means of justification are used by individuals beyond these current broad dimensions of authority, personal justification, and multiple sources. Further, following the suggestions of Chinn and colleagues (2011), these dimensions could be elaborated with specific, finer-grained detail, which would arguably increase the predictive validity of such dimensions. The models proposed by Chinn and colleagues (2011, 2014, 2016) particularly demonstrate how philosophical conceptions of epistemology can add to psychological ones, potentially leading to clearer construct definition and measurement.

The vastness of the expansion of epistemic cognition by Chinn and colleagues, however, may be too broad in that it acts as a barrier to, rather than a facilitator of, further research (Hofer & Bendixen, 2012). Indeed, given the normative focus of philosophical conceptions of epistemology (i.e., how one ought to justify knowledge; Kitchener, 2011), such expansions may not reflect how the layperson actually justifies what they know. Consequently, there needs to be a balance in which philosophical epistemology informs research, yet educational researchers and psychologists are ultimately focussed on empirical analyses of epistemic practices. Understandings from philosophy might also be more useful for informing epistemic education aimed at developing lay epistemic performance (Barzilai & Chinn, 2018).

Having reviewed various models and types of models over time, this review now turns to consider other issues associated with epistemic cognition. In particular, the first section deals with construct definitions and dimensions, before turning to issues of contextuality and sophistication implicit in the various models and debated over the years. Following that is a critique of the various

ways that epistemic cognition has been measured from interviews to self-report measures and alternative forms of measurement.

Domain-general, domain-specific, and topic-specific conceptualisations of epistemic cognition. Whether individuals have general views about knowledge and knowing (domain-general beliefs) or ones that vary by discipline, such as mathematics, physics, or psychology (domain-specific beliefs), was a central debate earlier in the field and influenced the conceptualisation and measurement of personal epistemology (Hofer & Bendixen, 2012). Earlier developmental models and Schommer's epistemological beliefs model assumed domain generality in which beliefs were seen as independent of specific domains of knowledge (Buehl & Alexander, 2001). Such assumptions carried through into the way interview questions were asked and instruments were developed (Hofer & Bendixen, 2012). There was then a shift towards viewing personal epistemology as domain-specific and studies and measures were subsequently designed to capture these, including Hofer's (2000) study described earlier.

However, Buehl and Alexander (2001) critiqued previous studies in support of domain-specificity for using between-subject analyses based on various groupings of students and different assessments of beliefs, thus making direct comparisons difficult. Other within-subject studies supporting either domain-specificity or domain-generality were likewise criticised for the domains chosen and comparisons made as well as the instruments used. For instance, some measures purporting to be domain-specific are arguably only surface adaptations of domain-general measures or use the same measure but ask respondents to consider different domains on subsequent administrations (e.g., Hofer, 2000). Further, studies suggesting students in different disciplines have different views on knowledge may have been limited by the use of domain-general instruments and the fact the students may have kept different domains and topics in mind while answering the questions (Bråten et al., 2009). While think-aloud studies have also found evidence of different levels of specificity (Ferguson et al., 2012; Mason, Ariasi, & Boldrin, 2011), these have also been critiqued for their deductive coding of protocols based on pre-defined dimensions, instead of

inductively exploring any differences across topics or domains (Greene & Yu, 2014; Sandoval et al., 2016). Moreover, Greene and Yu (2014) argued that there is a need to explore assumptions made by researchers that each dimension in models is equally relevant across domains and topics. They also suggested the need to consider the possibility of dimensions that are unique to specific disciplines. As a result, they advocated for the use of qualitative research to explore these assumptions and the conceptual foundations of current measures.

The critique of measures used at the time also led Buehl and colleagues (Buehl & Alexander, 2001; Buehl et al., 2002) to develop their own measure to test for domain-specific beliefs, the Domain-Specific Belief Questionnaire (DSBQ). This was based on Schommer's multidimensional conception of epistemological beliefs, with questions written to elicit beliefs about knowledge in the disciplines of mathematics and history. The results, based on data from undergraduate students, showed that a domain-specific model fit the data better than a domain-general one. From their study and review of the literature they concluded that epistemological beliefs are multidimensional and multilayered; individuals were said to possess both general beliefs about knowledge and beliefs about more finely specified forms of knowledge, such as academic knowledge, which could differ depending on the domain (Buehl & Alexander, 2006). Since then, assessment of epistemological beliefs in specific academic disciplines has included the disciplines of science, maths, psychology, and history (Buehl, 2008).

Around the same time, Muis, Bendixen, and Haerle (2006) developed an integrated model of both domain-general and domain-specific beliefs. Called the theory of integrated domains in epistemology (TIDE) framework, it was developed following a review of previous empirical studies and with a consideration of philosophical perspectives on epistemology. In this model, Muis and colleagues take an integrative perspective, with multidimensional epistemic beliefs regarding the certainty, simplicity, source, and justification of knowledge following a developmental progression (as in the developmental models; Merk, Rosman, Muis, Kelava, & Bohl, 2018). Outlined in this framework is a hierarchically structured model of the interplay between general epistemic beliefs,

academic epistemic beliefs, and domain-specific epistemic beliefs. Specifically, Muis et al. (2006) defined general epistemic beliefs as those beliefs about knowledge and knowing that develop in non-academic contexts (e.g., at home, work, in conversations with peers). Academic beliefs are those which develop in educational contexts, while domain-specific epistemic beliefs are “beliefs about knowledge and knowing that can be articulated in reference to any domain to which students have been exposed” (Muis et al., 2006, p. 36).

These days it is generally accepted that individuals do not have either domain-general or domain-specific beliefs, but that they hold both beliefs about knowledge and knowing in general as well as about specific domains or disciplines (Bråten, Britt, et al., 2011). More recently, it has also been argued that an individual’s epistemic beliefs can also vary by topic (Bråten, Strømsø, & Samuelstuen, 2008; Bråten et al., 2009; Bråten, Britt, et al., 2011). For instance, an individual might perceive knowledge about algebra to be simple and certain, while viewing knowledge about geometry as complex and dynamic (Greene, Cartiff, & Duke, 2018). This extends on domain-specific beliefs by adding further contextualisation of these beliefs and has led to research on epistemic beliefs regarding topics such as the Internet (Bråten et al., 2018) and climate change (Bråten et al., 2009; Strømsø, Bråten, & Samuelstuen, 2008). Measures have also been developed to assess such beliefs, including the ISEJ (Bråten et al., 2018) and the TSEBQ (about the topic of climate change; Bråten et al., 2009); both of these measures were developed based on Hofer and Pintrich’s (1997) framework. Beliefs at the topic-specific level have recently been added to the TIDE framework, with evidence found for a reciprocal relationship between topic-specific and general epistemic beliefs (Merk et al., 2018).

Importantly, this issue has implications for measurement. In particular, understandings and representations of knowledge and knowing are argued to be dependent on whether the items focus on knowing in general or about a specific topic or domain (Mason, 2016). More recently, a meta-analysis explored the effects of alignment between epistemic cognition measures and achievement measures (Greene et al., 2018). Findings revealed that studies in which the measures were aligned,

that is, both measures were at the same level of focus (e.g., domain-specific, domain-general, or topic-specific), had higher effect sizes than those where the measures were not aligned.

Developing expertise and naïve and sophisticated beliefs. The related argument that students' beliefs about knowledge within disciplines develop from more general beliefs and become more differentiated with exposure to a discipline and with developing expertise (Buehl & Alexander, 2006) has also been challenged and needs further support (Hofer & Bendixen, 2012). Specifically, implicit in most developmental and dimensional models of personal epistemology is the view that as expertise develops, individuals progress from naïve, unproductive views of knowledge as discrete, certain facts that originate outside the self and are justified by observation, authority, or rules to "sophisticated," "availing" views of knowledge as connected, tentative, evolving, and originating within, and justified by, the individual (Chinn & Rinehart, 2016; Greene, 2016; Greene & Yu, 2014). This assumption that certain ways of knowing are more sophisticated than others and thus lead to improved understanding and more knowledge has been challenged for neglecting to consider the division of cognitive labour (Bromme, Kienhues, & Stahl, 2008; Chinn et al., 2011; Greene & Yu, 2014).

This idea acknowledges the fact that most of our knowledge comes from others and not from personal experience. Invariably, individuals make judgments about knowledge claims based on information from external sources such as textbooks, teachers, experts, and scientists, with even experts themselves utilising such sources (Greene & Yu, 2014). Further, philosophers also see other people and their testimony as acceptable, productive sources of knowledge (Chinn et al., 2011; Chinn & Rinehart, 2016; Greene, 2016). There is recognition now that labelling such ways of knowing as 'naïve' is inappropriate and an unreliable indicator of expertise (Greene & Yu, 2014), and that justification by authority or experts is often availing and appropriate given the vast amount of knowledge claims individuals encounter these days (Bromme et al., 2008; Chinn et al., 2011; Greene & Yu, 2014). Indeed, it would be more fruitful to understand how and in which contexts individuals privilege various experts and sources as well as their grounds for these.

The idea of epistemic sophistication has also been criticised for implying the desirability or superior effectiveness of certain ways of knowing over others, and the implication that one's beliefs need to fit or match their discipline (Hofer & Sinatra, 2010), without a complete understanding of how various beliefs are a help or hindrance in different contexts. Bromme, Pieschl, and Stahl (2010) argue instead that one's flexibility to differentially enact epistemological criteria to suit different domains and contexts is more appropriate. This thus leads to a need to better understand whether individuals can or do transfer ways of knowing related to areas they have or are developing expertise into another area of less expertise (Greene et al., 2021; Hofer, 2004a). There is now a shift away from the idea of epistemic beliefs being universally sophisticated or not and instead a move towards the idea of epistemic competence (Murphy & Alexander, 2016) or adaptiveness; that is, acknowledging that individuals adapt their epistemic cognition to match the norms of the context (Chinn et al., 2014; Greene et al., 2016b). More recently, researchers have argued that the goal of epistemic education is to promote apt epistemic performance. This is defined as successfully achieving valuable epistemic aims (e.g., an accurate belief), through epistemic competence (e.g., the accurate belief is formed through applying appropriate epistemic ideals and the most reliable epistemic processes) across various contexts (Barzilai & Chinn 2018; Chinn et al., 2020, 2021; Greene et al., 2021). Therefore, judgement of a way of knowing's sophistication is more complex than has been implied in beliefs models, and vitally includes a consideration of the context in which it is being used.

Construct definitions. There are numerous ways that the construct of epistemic cognition has been named, defined, and conceptualised (Greene et al., 2016ab; Hofer & Bendixen, 2012; Hofer & Pintrich, 1997; Mason, 2016; Sandoval et al., 2016). Terms have varied by researchers and discipline (Hofer, 2016), with labelling often indicative of different methodologies and underlying theoretical assumptions about the nature and function of the construct (Alexander, 2016; Hofer & Pintrich, 1997; Kienhues, Ferguson, & Stahl, 2016). In particular, the construct has been conceived of as (a) a highly integrated, domain-general cognitive developmental structure, (b) a set of beliefs or

theories about the nature of knowledge and knowing, (c) fine-grained, contextually situated epistemological resources, (d) frameworks, or (e) a cognitive process (Hofer, 2016; Hofer & Pintrich, 1997; Mason, 2016). Notably, differences in naming and conceptualisations raise questions such as whether researchers are talking about the same or a distinct, yet related, construct or whether they are instead all describing different parts of the same whole (Hofer, 2016). Model refinement, theoretical synthesis, integration of approaches, and the development of congruent models are therefore needed to advance the field (Hofer, 2016, Sandoval et al., 2016).

As noted earlier, the general term epistemic cognition has been favoured recently to reflect that the construct is best described as “a broad set of cognitive processes” that include other elements such as beliefs, resources, aims, and theories (Hofer, 2016, p. 30). To reiterate, this term, as defined by Greene et al. (2008, p. 143), includes the processes involved in the definition, acquisition, and use of knowledge. This term and definition have been advanced in an attempt to promote clarity, facilitate communication between researchers, and enable unified research to understand the processes regarding how the various proposed elements work together within this overarching construct (Hofer, 2016). At the same time, though, using an overarching term could be argued to disregard subtle distinctions among the constructs it encompasses (Alexander, 2016; Hofer, 2016) and ignore the important methodological and theoretical differences that have led to these (Kienhues et al., 2016). Moreover, despite these attempts at clarifying terminology, epistemic beliefs and epistemic cognition are still conflated in the literature (Sinatra, 2016). To distinguish between these, Sinatra (2016) highlighted that beliefs and knowledge are the contents of cognition, upon which epistemic cognition, which is fundamentally a process, acts.

Sinatra (2016) further argued for the need to determine the components of this process and to define and measure these. Relatedly, some researchers have argued for a move towards focussing on *epistemic practices* (Barzilai & Zohar, 2016; Chinn & Rinehart, 2016; Kelly, 2016; Sinatra, 2016). These processes are said to include how individuals enact their epistemic beliefs and conceptions of knowledge to reason, justify claims, problem solve, make decisions (Sinatra, 2016), and define what

counts as knowledge (Kelly, 2016). A focus on practices, therefore, would examine *what people do*, not what they say about knowledge in general or what they think they would do (Sinatra & Chinn, 2012). This is especially needed given low correlations between espoused beliefs and enacted cognition (Chinn et al., 2011). Exploring epistemic practices could particularly consider the practice of knowledge justification, such as how an individual reasons about evidence to draw conclusions about knowledge claims, evaluates the claims of others, and determines which sources to trust (Sinatra, 2016). A focus on epistemic practices, therefore, is arguably more useful and has more ecological validity than an individual's self-report of their beliefs or thoughts about knowledge and knowing.

Dimensions of epistemic cognition. Another area of debate over the years has focused on which components or dimensions should or should not be included in models of epistemic cognition. Numerous dimensions have been proposed, with varying levels of agreement. In developmental models, these have included the nature, limits, certainty, proof, and source of knowledge. Multidimensional models have included the simplicity, certainty, source, and justification of knowledge as well as two questionable dimensions of fixed ability and quick learning. More recently, models informed by philosophy have either narrowed or substantially broadened the focus of their models. Specifically, the justification of knowledge is the focus of the trichotomous justification belief framework and has been split into three dimensions of justification (by authority, multiple sources, and personal justification). Chinn et al. (2014, 2016), on the other hand, vastly expanded epistemic cognition to include epistemic aims, ideals, and reliable processes. Agreement on a core set of dimensions relevant to psychological studies on epistemic cognition is therefore pertinent.

Questions have also been raised regarding whether beliefs about learning belong in models of epistemic cognition. Generally, it has been suggested that learning and personal epistemology should be kept separate for parsimony, clarity, and philosophical integrity (Hofer & Bendixen, 2012). Moreover, to include learning in the epistemic cognition construct introduces construct-irrelevant variance that contaminates assessment scores (Messick, 1995). Greene et al.'s (2008) definition,

however, includes the acquisition of knowledge, suggesting the centrality of learning to epistemic cognition. In addition, epistemology includes the acquisition of knowledge (i.e., learning) and studying knowing and learning separately may overlook the rich detail and practical implications that can be garnered when the two, and their relationship, are studied together (Hofer & Bendixen, 2012). Agreement, then, is also needed on which dimensions are epistemic, and which are not and might be better regarded as correlates of epistemic cognition instead (Alexander, 2016).

Assessment of epistemic cognition

Interviews. Assessment of personal epistemology has been closely linked to its conceptualisation. Specifically, developmental models have tended to utilise long, semi-structured interviews or scenario-based problem solving to assign respondents to a particular level or stage. While allowing for a rich, in-depth consideration of an individual's representations and understandings about knowledge and knowing, interviews often have time consuming and complex scoring requiring the use of trained interviewers and scorers, thus adding to their expense (Mason, 2016). Individuals may also be assigned to a general epistemic level or stage despite evidence of varying levels of epistemic reasoning across the questions used to assess them (Mason, 2016). Notably, developers of these earlier, developmental models did not always set out to study epistemic cognition, with studies instead focussed on intellectual and ethical development, reflective thinking, and argumentative reasoning. This undoubtedly influenced the interview questions that were asked and the resulting components. Moreover, while scenario-based interviews are an alternative to traditional question-and-answer formats, thus allowing researchers to explore concurrent reasoning about epistemic issues, the insights gained are limited by such interviews often being conducted outside the contexts where such reasoning would typically be applied (Sandoval et al., 2016).

Self-report measures. In contrast, those grounding their research in multidimensional models have tended to utilise Likert scale questionnaires at different levels of specificity. Table 4 provides an overview of these measures and associated models.

Table 4

Summary of Epistemic Cognition Instruments and Associated Models

Measure	Model based on	Dimensions or positions	Example item(s)	Question type and Focus
Epistemological Questionnaire (Schommer, 1990)	Epistemological beliefs (Schommer, 1990)	Certain knowledge Simple knowledge Omniscient authority Quick learning Innate ability	When I study I look for specific facts People who challenge authority are overconfident	<i>Likert scale</i> General beliefs about knowledge
Discipline-Focused Epistemic Belief Questionnaire (Hofer, 2000)	Epistemological theories (Hofer & Pintrich, 1997)	Certainty/simplicity of knowledge Justification for knowing: personal Source of knowledge: authority Attainment of truth	In this field, knowledge is certain All experts in this field understand the field in the same way	<i>Likert scale</i> Knowledge in disciplines of psychology and science
Epistemological Understanding Instrument (Kuhn et al., 2000)	Epistemological understanding (Kuhn et al., 2000)	Realist Absolutist Multiplist Evaluativist	“Robin thinks lying is wrong. Chris thinks lying is permissible in certain situations” Can only one of their views be right, or could both have some rightness? IF BOTH COULD BE RIGHT: Could one view be better or more right than the other?	<i>Judging rightness of a pair of statements</i> Judgement domains: Personal taste Aesthetic Value Truth (social world) Truth (physical world)

Measure	Model based on	Dimensions or positions	Example item(s)	Question type and Focus
Epistemic Thinking Assessment (Barzilai & Weinstock, 2015)	Epistemological understanding (Kuhn et al., 2000)	Absolutism Multiplism Evaluativism	Can there be certainty about the deformed frogs? One can know for certain what happened to the frogs One can never know for certain what happened in the Livian war/to the frogs	<i>Scenario-based assessment with Likert scale</i> (history and biology) Metacognitive focus Epistemic perspectives assessed through epistemic dimensions: certainty, nature, and source of knowledge; attainability of truth; justification, reliability, multiple perspectives, and expertise
Epistemic and ontological cognition questionnaire (Greene, Torney-Purta, & Azevedo, 2010)	Epistemic and ontological cognitive development (Greene et al., 2008)	<i>Positions</i> Realism Dogmatism Scepticism Rationalism <i>Ontological dimensions</i> Simple and certain knowledge <i>Epistemic dimensions</i> Justification by authority Personal justification	If a [mathematician/historian] says something is a fact, I believe it In [math/history], what's a fact depends upon a person's point of view	<i>Likert scale</i> Ill-structured domain (history) Well-structured domain (mathematics)
Conley et al.'s epistemological beliefs in science	Epistemological theories (Hofer & Pintrich, 1997)	<i>Nature of knowledge</i> Source of knowledge Certainty of knowledge	Some ideas in science today are different than what scientists used to think.	<i>Likert scale</i> Science

Measure	Model based on	Dimensions or positions	Example item(s)	Question type and Focus
questionnaire (Conley et al., 2004)		<i>Nature of knowing</i> Development of knowledge Justification of knowledge	In science, there can be more than one way for scientists to test their ideas.	
Justification for Knowing Questionnaire (Ferguson et al., 2013)	Trichotomous justification belief framework (Ferguson et al., 2012, 2013)	Justification by authority Personal Justification Justification by multiple sources	If a natural science teacher says something is correct, then I believe it To be able to trust knowledge claims in natural science texts, I have to check various knowledge sources	<i>Likert scale</i> Justification of knowing in science
Internet-Specific Epistemic Justification Inventory (Bråten et al., 2018)	Trichotomous justification belief framework (Ferguson et al., 2012, 2013)	Justification by authority Personal justification Justification by multiple sources	When I find information about an educational topic on the Internet, I evaluate whether this information is consistent with my own understanding of the topic	<i>Likert scale</i> Justification of knowledge claims on the Internet
Topic-Specific Epistemic Beliefs Questionnaire (Bråten et al., 2009)	Epistemological theories (Hofer & Pintrich, 1997)	Certainty of knowledge Simplicity of knowledge Source of knowledge Justification for knowing	Certain knowledge about climate is rare I understand issues related to climate better when I think through them myself, and not only read about them	Likert scale Topic-specific epistemic beliefs (climate change)

These days, a great deal of measurement of epistemic cognition uses such questionnaires, often using or based on Schommer's Epistemological Questionnaire or Hofer and Pintrich's (1997) framework. These numerous self-report measures include various dimensions. Those based on Schommer's model or on adaptations of the SEQ assess certain knowledge, simple knowledge, omniscient authority (equivalent to source of knowledge), quick learning, and innate ability, while those based on Hofer and Pintrich's framework cover the certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing.

More recent measures have been developed to account for the philosophical expansion of recent models, including the greater focus on justification in the EOCD (Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010) and the trichotomous justification framework (Ferguson et al., 2012, 2013). Specifically, Greene, Torney-Purta, and Azevedo's (2010) integrated epistemic and ontological cognition questionnaire (EOCQ) includes dimensions of simple and certain knowledge (deemed ontological), justification by authority, and personal justification, alongside positions of realism, dogmatism, scepticism, and rationalism. Similarly, the JFK-Q, based on the trichotomous justification framework, assesses justification by authority, personal justification, and justification by multiple sources.

Self-report measures have allowed for large-scale studies to be conducted with relative ease and have often been used in studies aiming to assess the link between epistemic cognition and performance in various contexts, including academic achievement, achievement motivation, comprehension of single and multiple texts (Bråten & Strømsø, 2010; Bråten, Britt, et al., 2011; Schommer, 1990), conceptual change (Qian & Alvermann, 1995; Qian & Pan, 2002), self-regulated learning (Schraw, 2013), online learning (Bråten, 2008; Mason, Boldrin, & Ariasi, 2010a, 2010b), Internet search and evaluation skills (Bråten et al., 2005, Strømsø & Bråten, 2010; Strømsø & Kammerer, 2016), public understanding of science (Bromme & Goldman, 2014), and juror decision making (Weinstock, 2016). Such research has shown, for instance, that beliefs that knowledge is simple and certain (sometimes described as more 'naïve' beliefs) are related to less adaptive

academic cognitions and poorer performance on outcome measures (Bråten et al., 2005). Similarly, research has revealed that higher scores on dimensions of certainty, simplicity, source of knowledge, and justification for knowing predict higher levels of self-reported self-regulation strategies and Internet search and evaluation skills (Bråten et al., 2005; Strømsø & Bråten, 2010).

With regards to the trichotomous justification framework, research has generally shown that beliefs in personal justification are negatively related to outcomes while strong beliefs in justification by multiple sources are positively related to outcomes (for a review, see Brandmo & Bråten, 2018). These outcomes include multiple text comprehension, conceptual change learning, science achievement, adaptive strategy use online, and Internet-based learning. The relationship between beliefs in justification by authority and outcomes has been less consistent. Additionally, a recent meta-analysis by Greene and colleagues (2018) revealed the overall correlation between epistemic cognition, measured predominantly in terms of beliefs, and academic achievement, to be .162. Cohen's *d* of .328 indicated a small to medium effect, that is, a small but meaningful relationship.

However, despite their extensive use and popularity, there have been serious critiques levelled at the self-report measures in use, leading to questions about their construction and utility. Firstly, there are numerous issues with the factor structure and stability of measures, suggesting issues with construct validity and item design (Briell et al., 2011; Clarebout et al., 2001; DeBacker et al., 2008; Greene, Torney-Purta, & Azevedo, 2010; Schraw, 2013; Wood & Kardash, 2002). Various factor structures have been proposed in the different instruments, with little comparison of the instruments, while studies using the same instrument (e.g., the SEQ) have failed to replicate the proposed factor structure, variously extracting from two to four structures (Buehl, 2008; Clarebout et al., 2001; DeBacker et al., 2008; Schraw, 2013). For example, dimensions relating to the simplicity and certainty of knowledge have at times emerged as one combined factor in some studies (Qian & Alvermann, 1995; Schommer-Aikins, Mau, Brookhart, & Hutter, 2000), while items proposed to load on specific dimensions have often loaded on dimensions other than those to which they were proposed (e.g., Bråten et al., 2009; Hofer, 2000).

Moreover, each factor extracted in studies often explains only a small proportion of the variance, with the overall instrument similarly explaining only a small proportion of sample variance, usually from 20-45% (Schraw, 2013). Low predictive validity between epistemological factors used in research and various outcome variables such as academic achievement has also been observed (e.g., usually .05 to .15; Schraw, 2013). Studies have also often failed to use or report results of confirmatory factor analyses (CFA) to establish the factorial structure of scales; arguably, employing CFA, on separate samples, as well as testing alternative plausible models, would provide stronger evidence regarding construct validity than simply using only exploratory factor analyses, as many of the studies currently do (Buehl, 2008; Greene, Torney-Purta, & Azevedo, 2010; Muis et al., 2006). Finally, the use of homogeneous samples such as college students or, more specifically, undergraduate college students from the USA, further threatens the reliability and generalisability of such measures (Buehl, 2008; Greene et al., 2008).

Moreover, the linear progression suggested by the use of Likert scales is also argued to run counter to developmental perspectives which propose that the meaning of knowledge and knowing unfolds in a non-linear way and is restructured at each level (Hofer, 2016; Murphy & Alexander, 2016). For example, strong disagreement on an item about the certainty of knowledge may be more likely to be associated with multiplism (which is at the midpoint developmentally) than evaluativism (a final stage; Hofer & Bendixen, 2014). A related question is where evaluativism might be represented on the Likert scale; is it represented at the midpoint of the scale or beyond (Muis et al., 2006)? Further, despite being a non-dichotomous construct, the dichotomisation of beliefs into “sophisticated” and “naïve” poles has also led to concerns about the meaning of scores on the Likert scale, such as midpoints on items that ask, for instance, whether “truth in a field is unchanging or not” (Hofer, 2004a; Hofer & Sinatra, 2010; Muis et al., 2006). Hofer and Sinatra (2010), however, argue that the midpoint on such scales should not be taken as the midpoint developmentally, with questions remaining regarding what the midpoint actually represents. There are also related questions regarding whether disagreement with an item is akin to holding the contrary belief, or not,

given the continuum these beliefs are proposed to exist on (Greene & Yu, 2014). For example, Greene and Yu (2014) question the assumption that a non-expert respondent disagreeing with the claim that “to know [subject] well, you need to memorise what you are taught” implies they hold beliefs about justification similar to those of experts (who would also be expected to disagree with such a statement).

Concerns have also been raised about the items on these scales being too general or vague, the specificity at which respondents are answering the items, whether they understand what is being asked of them, and their point of reference (Barzilai & Weinstock, 2015). Specifically, inconsistency within scales is argued to threaten the psychometric properties of those scales (Mason, 2016), with item phrasing making it difficult to determine whether the participants are referring to their own beliefs, the beliefs of others, their own enacted epistemic processes, or their professed, general beliefs about knowledge. That is, often within the same measure some items reference the individual (in the first-person or second-person format), while others refer to the third person. For example, in Conley and colleagues’ (2004) epistemological beliefs in science questionnaire, questions in the source dimension reference “the teacher” and “you.” Examples include, “Whatever the teacher says in science class is true” and “If you read something in a science book, you can be sure it’s true.” Similarly, in the SEQ questions vary from, “When I study I look for specific facts” to “You should evaluate the accuracy of information in a textbook if you are familiar with the topic” and “Scientists can ultimately get to the truth.”

Furthermore, in both the JFK-Q and EOCQ, the items assessing the justification by authority dimension appear to tap into the individual’s actual epistemic processes. As an example, in the EOCQ one question asks, “If a [mathematician/historian] says something is a fact, I believe it.” In contrast, questions about the personal justification dimension appear more related to general beliefs about knowledge. For instance, another question in the EOCQ asks whether “[Mathematical/Historical] knowledge is all factual and there are no opinions.” Moreover, in questionnaires exploring representations and understandings of scientific knowledge, questions

have been raised regarding whether respondents are referring to their own knowledge or that of scientists (Mason, 2016). In other cases, the use of differently worded statements (“I believe” for some items and general statements for others) may falsely create dimensions that appear conceptually meaningful yet have only factored together because of language similarities (DeVellis, 2016). Lastly, an individual’s epistemic cognition may also be reported inaccurately due to abstract item wordings, the complexity of questions asked, and the depth of engagement and metacognitive awareness required to report on such cognition (Barzilai & Weinstock, 2015; Chinn et al., 2011; Ferguson et al., 2012; Greene et al., 2008).

Others have also argued that questionnaires are inauthentic and an inappropriate way to measure contextualised, tacit, and complex cognition (Chinn et al., 2011; Chinn & Rinehart, 2016; Sandoval, 2012; Sinatra & Chinn, 2012). Specifically, self-report questionnaires are critiqued for measuring an individual’s thoughts about their epistemic cognition outside the actual context of ongoing task performance (Bråten, 2016). In particular, self-report measures are said to provide details on students’ *professed* underlying beliefs, that is, what they can articulate about the nature of knowledge and how they think they handle competing knowledge claims (i.e., a type of best-practice report or offline data; Bråten, 2016; Greene, Cartiff, & Duke, 2018). This contrasts with their *enacted* beliefs, which are seen as online data of how they actually manage conflicting information or evaluate knowledge claims (i.e., their tacit beliefs in action or actual practice; Ferguson et al., 2012).

Importantly, one’s expressed reconstruction of their epistemic cognition is said to be different to how they actually enact that cognition (Sandoval et al., 2016). Further, correlations between explicit beliefs and practical epistemology are said to be low (Chinn et al., 2011). In other words, what individuals report understanding about knowledge and knowing in various fields (i.e., understandings of formal epistemologies, such as that knowledge in science is complex and uncertain and justified through the use of evidence) is argued to be poorly related to how they actually enact their epistemology and reasoning about knowing (Barzilai & Weinstock, 2015;

Ferguson et al., 2012; Sandoval et al., 2016; Sinatra & Chinn, 2012). Therefore, the very act of asking students to reflect on and make explicit their tacit epistemic cognition conflates these professed and enacted cognitions. This means that such questionnaires are not tapping into the epistemic processes that actually impact on thinking, reasoning, and task performance in the contexts in which individuals need to enact such cognition (Kelly, 2016; Sandoval, 2005; Sinatra, 2016). Moreover, those that view epistemic cognition as a process instead of static beliefs also state that Likert scales are unable to capture the richness and dynamic nature of this process (Sinatra, 2016). Consequently, there is a need for assessment of epistemic cognition, with a focus on processes, in the context of actual task performance, alongside a better understanding of the relationship between what people say they do or think they will do with regards to their epistemic cognition with what they actually do (their epistemic practices).

Finally, it is worth highlighting that most studies using self-report measures have utilised variable-centred approaches to provide evidence of correlations between the various individual dimensions of epistemic cognition and outcomes. However, it has been argued that by focusing on how variables relate to other variables on average there is the risk that the results describe “nobody in particular” (Molden & Dweck, 2006, p. 192); this results in misleading conclusions from these studies being applied to practical contexts, such as classroom teaching (Chen, 2012). Greene et al. (2008) argued instead that some of the limitations of using self-report Likert scales can be overcome by considering patterns of responses to items on such scales through the use of statistical techniques like latent profile analysis. Several researchers have consequently utilised person-centred approaches in which cluster analysis, latent class analysis, or latent profile analysis is used to identify sub-groups of individuals within the population that share similar patterns or profiles of epistemic beliefs/cognition. Such profiles are then explored to examine group differences on various performance measures, such as multiple-text comprehension (Ferguson & Bråten, 2013), science achievement, goal orientations, and science self-efficacy (Chen, 2012), chemistry achievement (Dai & Cromley, 2014), physics course grades (Trevors, Kendeou, Bråten, & Braasch, 2017), and self-

concept, motivation, and science achievement (Kampa, Neumann, Heitmann, & Kremer, 2016). This approach has also been used to draw conclusions regarding which profiles can be considered adaptive, or not (Ferguson & Bråten, 2013). However, while making valuable contributions to the field, as with variable-based approaches, the conclusions of such studies are overshadowed by the limitations associated with the use of existing self-report measures; namely, that such studies are only as good as the self-report measures on which they are developing such profiles.

Other forms of measurement. In response to these critiques about self-report measures, particularly with regards to their inability to tap into an individual's enactment of their epistemic cognition, some researchers have turned to the use of alternative forms of measurement in authentic practice contexts (Sandoval et al., 2016). This has included conducting think-aloud studies while participants engage in tasks such as searching for and evaluating information on the Internet (Barzilai & Zohar, 2012; Ferguson et al., 2012; Greene, Yu, & Copeland, 2014) and to explore epistemic performance (Greene et al., 2021). Similarly, Mason and colleagues (2010b, 2011) combined the use of think-aloud protocols with cluster analysis to explore patterns of epistemic dimensions while high-school and university students conducted a web-searching task. While overcoming previous critiques of offline measures and variable-centred analyses, the results are still limited by the deductive coding of the think-aloud protocols based on current conceptions of epistemic cognition. More specifically, while able to confirm the presence of such dimensions, they do not allow for a consideration of what is missing. That is, if inductive coding had been used, it might have revealed expansions or changes to current conceptions of epistemic cognition beyond the four dimensions (i.e., those of Hofer and Pintrich, 1997) often used.

Task-based observation and discourse analysis have also been used to assess enacted epistemic practices (Mason, 2016; Sandoval et al., 2016). These online approaches to collecting process-oriented data are said to tap into enacted epistemic cognition in the contexts in which it is used and while it is being used. While seen as valuable alternatives, a key downside of such approaches is the huge resource demands of collecting and analysing the vast volume of data

obtained (Bråten, 2016; Greene, Copeland, Deekens, & Yu, 2018). Further, as noted by Sandoval et al. (2016), the inferences required to make the link between such online data and research findings is often challenging to justify, although triangulating results with data from interviews and other methods is a productive approach. Lastly, the context-bound nature of these assessments makes comparison across these studies challenging (Sandoval, 2005).

Returning to the use of interviews and mixed method studies is also being advocated for to better understand how epistemic cognition develops and is enacted. For instance, qualitative interviews can allow researchers to explore the conceptual foundations of the field and examine what might be missing, instead of constraining research to the confirmation of existing theory as typically seen in quantitative studies (Greene & Yu, 2014). In response to critiques about the poor psychometric qualities of existing measures and questions about the models on which they are based, Greene and Yu (2014) returned to the use of qualitative interviews to explore individuals' epistemic cognition in different domains and consider how conceptualisations and measures of epistemic cognition might be improved. By using an inductive approach to analyse interviews conducted with novices and experts in the areas of biology and history, they determined that some results confirmed current conceptions such as the certainty of knowledge. However, other results did not align with widely used conceptions, such as distinctions between different kinds of knowledge, differences in the kinds of knowledge valued, and understandings of justification, suggesting a need for further review of the dimensions.

Cognitive interviews are also being used to understand how individuals make sense of items on self-report instruments (e.g., Greene, Torney-Purta, Azevedo, & Robertson, 2010). These offer a useful way to improve current measures by facilitating an understanding of the participant's depth of engagement with the items. They also allow an exploration of whether the participants are referring to their own knowledge or that of others, and of their professed beliefs versus enacted processes. Arguably, the use of alternative approaches and triangulation of data across approaches is a productive avenue for exploring and improving models and measures in the field.

Summary

In a rapidly changing, digital, post-truth world, individuals not only need to keep abreast of knowledge changes and paradigm shifts, but they also need the skills and dispositions to evaluate conflicting claims and discern knowledge from opinion, dogma, misinformation, and fake news (Cartiff et al., 2021; Greene et al., 2021; Sandoval et al., 2016; Sinatra & Lombardi, 2020). Implicit in this is that individuals will need the capacity and willingness to critically reflect on, and evaluate, the evidence supporting such claims as well as the sources presenting them. Research in the area of epistemic cognition can provide insights into the development of these vital skills and dispositions to ensure individuals not only survive but succeed in an epistemically hostile world (Greene et al., 2016b; Sandoval et al., 2016). This research area, that focusses on individuals' ways of knowing, is one that has long been of interest to researchers, especially those seeking to understand how one's ways of knowing have implications for learning, reasoning, and critical thinking.

The field, however, still faces numerous methodological challenges and conceptual debates. Many have echoed the calls over the years for the need for a unified construct as well as consensus on terminology, a conceptual framework, and measurement to advance the field (Briell et al., 2011; Greene et al., 2008; Hofer, 2004b; Hofer & Bendixen, 2012; Sandoval et al., 2016; Schraw & Olafson, 2008; Sinatra, 2016). In particular, current models of epistemic cognition are limited due to their focus on inauthentic epistemic beliefs instead of enacted processes as well as the overreliance on homogeneous samples of university students in their development (Buehl, 2008; Greene et al., 2008). Issues of construct irrelevant-variance and construct underrepresentation (Messick, 1995) further threaten the construct validity of epistemic cognition.

Measurement issues have also been of key concern in the field, with measures often reported to have poor validity, reliability, internal consistency, instable factor structures, and poor predictive validity (Briell et al., 2011; Clarebout et al., 2001; DeBacker et al., 2008; Greene et al., 2010; Schraw, 2013; Wood & Kardash, 2002). The lack of agreement on what is being measured is another key issue (Barzilai & Zohar, 2015). Clarity of meaning may also have been sacrificed as the

field moved from interview studies to questionnaires (Hofer, 2006). These findings suggest that either the measures are poorly written and do not adequately operationalise the construct (Greene & Yu, 2014) or that epistemic cognition has not yet been comprehensively and adequately defined, delimited, and conceptualised (Alexander, 2016; Chinn et al., 2011).

What is clear, though, is that until there is a solid theoretical base and robust construct validity of associated measures, any conclusions about associations between scores on such instruments and with outcome variables are seriously questionable (Buehl, 2008; DeBacker et al., 2008; Greene & Yu, 2014; Mason, 2016; Sandoval et al., 2016; Schraw & Olafson, 2008; Wood & Kardash, 2002). The requirement for robust measures that can accurately and reliably track the effect of interventions on one's epistemic cognition (Mason, 2016) further cements the importance of adequately conceptualising the construct of epistemic cognition. There is therefore a need to refine and expand the models themselves (Chinn et al., 2011; Hofer & Bendixen, 2012) while carefully articulating not only what epistemic cognition is and its breadth and depth, but importantly, what it *is not* (Alexander, 2016; Greene et al., 2008; Sinatra, 2016). What is essential, then, is a comprehensive mapping of the domain of epistemic cognition, which includes all of the ways of knowing used by adults.

This could be achieved through a return to studies focussed on establishing conceptual clarity and construct validity and bootstrapping between the refinement of the construct and its measurement. Such efforts can be enhanced through improved methodological choices, such as using qualitative and process-oriented methodologies (Bråten, 2016; Greene et al., 2008), and integrating research methods by utilising mixed methods research (Buehl, 2008; Chinn et al., 2011; Greene et al., 2008; Hofer & Bendixen, 2012; Mason, 2016; Sandoval et al., 2016; Schraw, 2013), cognitive interviewing (Greene & Yu, 2014; Hofer & Bendixen, 2012), and confirmatory factor analysis (Greene, Torney-Purta, & Azevedo, 2010; Muis et al., 2006). Both theory and practice may also be advanced through the use of person-centred approaches that consider the various profiles of 'knowers' in the larger population (Barger, Wormington, Huettel, & Linnenbrink-Garcia, 2016; Chen,

2012; Dai & Cromley, 2014; Ferguson & Bråten, 2013; Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010; Kampa et al., 2016; Trevors, Kendeou, et al., 2017).

Returning to earlier qualitative approaches would also allow for a focus on the meaning of knowing ascribed by individuals, and not decided a priori by researchers (Elby, 2009) or philosophers, thus allowing a model to emerge from the participants' experiences and any resulting measure to be grounded in the participants' experiences and terminology. As highlighted by Williams (2001, cited in Greene et al., 2008, p. 156), "although philosophical thinking regarding justification can be focussed on determining the *proper and rational* means of justification, psychologists must be concerned with *all* of the ways individuals justify knowledge" (emphasis in Greene et al., 2008). Expanding the dimension of justification by determining the types of justification actually used by adults is therefore particularly warranted, given the centrality of justification to philosophical epistemology. Qualitative research could thus be used to reveal new ways in which individuals justify knowledge (Greene et al., 2008). Further studies with non-student, adult participants, including those who have not completed tertiary education, therefore need to be undertaken to elucidate the strategies and ways of knowing used by individuals, in various contexts, while minimising the confound of education. Due to the reach and significance of epistemic cognition it is vital that changes are made to the current approaches utilised in this field in favour of ones that will be more likely to lead to conceptual clarity and improved instrumentation; ultimately, it is time to advance our knowledge and knowing of epistemic cognition.

Research Questions

As discussed in the literature review, a key gap in the extant literature is a consideration of how the everyday person knows what they know. Ideally, such insights can inform and extend current models and measures. With the overall aim of this research being to contribute to a more comprehensive model of ways of knowing, the research question guiding this work is:

How do people know what they know?

In other words, how do Australian adults decide what they rely on when determining what they know or whether a claim is to be accepted as knowledge?

In the initial, qualitative phase, the focus is on exploring and understanding the participants' experiences of knowing what they know in various areas, in order to expand on current conceptions of knowing. Therefore, the central research question for the qualitative phase is:

- What are the *ways of knowing* for a group of adult participants in Australia? In other words, how do adult participants *know what they know*?

Given the focus on understanding the prospective participants' ways of knowing, it is also a good opportunity to explore the meaning they make of those experiences of knowing. This may reveal additional areas of relevance to one's epistemic cognition, beyond the dimensions and correlates currently described in the literature. Therefore, a secondary research question for this phase is:

- What does *knowing* mean to these participants?

The focus of the quantitative phase will be to follow up the results of the qualitative phase and determine whether the results generalise. Specific research questions will be outlined following completion of the qualitative stage.

Chapter 3: Methodology

Design

The ultimate aim of this research is to contribute to a better understanding of epistemic cognition; that is, to understand how the everyday person (i.e., the layperson who is not a philosopher) knows what they know and to consider how this informs, expands, refines, and adds detail to current conceptions and measurement of epistemic cognition. One way to overcome the limitations of current approaches in the field is to use an exploratory qualitative approach (Bråten, 2016; Greene et al., 2008) which is not constrained to confirming a priori theory. However, qualitative approaches can be limited by the extent to which results from such approaches generalise to the larger population; this is vital if such research is to inform models, measures, and interventions in the field. A viable alternative, then, is to utilise a mixed methods approach, in which both qualitative and quantitative phases of research are used. Of note too is that several researchers in the field have specifically advocated for such an approach in order to overcome the limitations of current approaches (Buehl, 2008; Chinn et al., 2011; Greene et al., 2008; Hofer & Bendixen, 2012; Mason, 2016; Sandoval et al., 2016; Schraw, 2013). Therefore, this research plans to utilise mixed methods in the form of an exploratory sequential design. Under this design, the research commences with a qualitative phase to explore the phenomenon of interest. The qualitative results are then built on in a subsequent quantitative phase, the objective of which is to lead to detailed, generalisable results (Creswell, 2011, 2015; Creswell, J. W., & Creswell, J. D., 2018).

Mixed methods

A mixed methods research approach will therefore be taken in this work, with mixed methods research defined as:

The type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of

breadth and depth of understanding and corroboration (Johnson, Onwuegbuzie, & Turner, 2007, p. 123).

As an approach, the use of mixed methods is advantageous in that it incorporates the strengths of both qualitative and quantitative approaches while offsetting the weaknesses inherent in using either methodology on its own (Creswell, 2011; Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Leech, 2005). For instance, while qualitative research brings in the voice of individuals and allows for rich, thick descriptions and an understanding of the meanings that individuals give to a phenomenon under study, generalising these findings to a larger group can be limited by the specific context of the research and small number of participants studied (Creswell, 2011). By combining qualitative and quantitative methods in a sequential study these limitations can be overcome and the exploratory, qualitative findings based on a few individuals generalised to a larger sample (Creswell, 2011; Onwuegbuzie & Leech, 2005). The depth and breadth obtained through this combination in this research will thus contribute to the development of a more complete and comprehensive account of epistemic cognition (Bryman, 2006).

Mixed methods research is particularly appropriate for this study's goal of comprehensively understanding and conceptualising 'ways of knowing'. That is, this approach can be used to explore ways of knowing qualitatively, develop a preliminary model of ways of knowing, and then develop an instrument in the quantitative phase to test this model (Creswell, 2011; Creswell & Plano Clark, 2018). Similarly, instrument development is one of the rationales for using mixed methods research advanced by Bryman (2006), an approach that can result in the development of scale items that are better worded or more comprehensive. A related rationale for the use of mixed methods is that of 'instrument fidelity', which refers to the mixing of qualitative and quantitative techniques to create and refine new instruments and maximise their utility and appropriateness (Collins, Onwuegbuzie, & Sutton, 2006). Likewise, the use of one method to develop and inform the purpose and design of the other method is used to increase the validity of constructs, with the thoroughness and convergence of validity evidence obtained arguably leading to improved instrument revision (Johnson &

Onwuegbuzie, 2004; Mayoh, Bond, & Todres, 2012). Mixed methods research is also being used in this study to increase the breadth of the study beyond what would be achieved by utilising either method in isolation (Johnson & Onwuegbuzie, 2004). Finally, given the focus of this study is on 'ways of knowing', it is apt that a research paradigm advancing multiple ways of knowing and getting at knowledge is being used to guide the design and analysis of this research.

Specifically in this study, the objective of the qualitative phase is exploration in order to gather information about the nature and meaning of the lived experience of "knowing" and to conceptualise this phenomenon (Mayoh & Onwuegbuzie, 2015). The results of this qualitative phase will then be fed into a quantitative study involving the development and validation of a tool to test the resulting conceptual model (Mayoh & Onwuegbuzie, 2015). This study may be described as comprised of two phases; however, it should not be taken to imply that the qualitative and quantitative data collection and analysis techniques will be conducted independently in their respective phases. That is, this study will also take the form of a '*fully mixed sequential equal status design*' (Leech & Onwuegbuzie, 2009, p. 268). This design is defined by the mixing of qualitative and quantitative techniques within one or more stages of the research process, with both techniques having equal status (Onwuegbuzie, Slate, Leech, & Collins, 2009). Mixing will occur in the data analysis stage with the data collected in the first qualitative phase used in the planning of the subsequent quantitative phase.

Qualitative approach

A qualitative approach was chosen for the first stage of this research in order to explore lived experiences of knowing in adults' daily lives, such as in their work, studies, and at home. This was partly in an attempt to overcome some of the gaps and limitations in the field identified in the literature review. In particular, an inductive, qualitative approach could arguably contribute to an understanding of how adults experience knowing and what knowing means to them from their perspective, instead of considering a priori conceptions from philosophers, psychologists, and other researchers, as is the core approach in the field (Elby, 2009). Moreover, using the participants' words

to develop measures may overcome some of the critiques of previous scales regarding the use of vague, abstract language and concepts (Barzilai & Weinstock, 2015; Chinn et al., 2011; Ferguson et al., 2012; Greene et al., 2008).

Current conceptions of epistemic cognition have also tended to guide the development of measures and interview questions with participants then asked to confirm or disconfirm these, without considering the relevance or meaning of these to individuals and their knowing. Moreover, despite acknowledgement in the field that sufficient detail and depth is lacking in current models and measures (Schraw, 2013), the current implementation of predominantly quantitative or explanatory approaches has thus far not been able to address this. Arguably, there is a need to adequately define and comprehensively map the construct of epistemic cognition (Messick, 1995) before setting out to develop valid and reliable measures upon which to assess this construct and associated outcomes. Qualitative, interview-based approaches are therefore vital in exploring 'knowing' deeply and adding the detail missing in current conceptions and measures (Greene et al., 2008; Greene & Yu, 2014). Indeed, they are necessary to overcome the limitations associated with developing questionnaires based on a priori theories of epistemic cognition and then setting out to empirically verify these (Greene & Yu, 2014; Tafreshi & Racine, 2015).

A thematic analysis approach to the qualitative phase was chosen as this approach guides the researcher in identifying and describing the central ideas, or themes, in the material under study, often through the inductive analysis of interview data (Pistrang & Barker, 2012). This contrasts with other approaches which may focus on the unfolding of events (narrative approaches), language-based approaches which are concerned with uncovering social rules governing language production and usage, and ethnographic approaches utilising extensive field data collection and participant observation. Moreover, thematic analysis is an accessible, flexible, and systematic method that can be used to explore patterns of meaning relevant to the research question across an entire data set (Braun & Clarke, 2012). It is thus appropriate for the aim of this project, which is to identify the central ideas relevant to how adults know what they know. More specifically, the

thematic analysis method outlined by Braun and Clarke (2006) was chosen to guide the analysis of the interview data.

An inductive, semantic, and critical realist approach to thematic analysis was utilised. That is, the analysis focussed on understanding and exploring patterns amongst the participants' experiences of knowing, rather than applying a priori theories to the data. Analysis was undertaken at the semantic level, which involved focusing on the surface meanings of the data, instead of analysing it on an interpretive level. Lastly, the critical realist approach acknowledges "the ways individuals make meaning of their experience, and, in turn, the ways the broader social context impinges on those meanings, while retaining focus on the material and other limits of 'reality'" (Braun & Clarke, 2006, p. 81).

Quantitative approach

In the first, qualitative phase of this research, the participants' meaning making of their experiences was prioritised. To complement this phase, the quantitative study utilised a person-centred approach, as such approaches can overcome some of the limitations of the variable-centred research which dominates quantitative approaches in the field. In particular, in variable-centred approaches, averages of individuals' scale scores are correlated with outcomes (Barger et al., 2016; Chen, 2012). These approaches, however, arguably "obscure how real people actually function. That is, by attempting to describe only the average, one runs the risk of describing nobody in particular" (Molden & Dweck, 2006, p. 192).

Additionally, such studies may also only focus on a few variables at a time. The construct in reality, though, may instead be complex and context dependent, with the variables operating simultaneously within people (Barger et al., 2016; Chen, 2012; Kusurkar et al., 2021). There are also limitations associated with using Likert scales to measure epistemic cognition, as previously discussed. This has included critiques about the dichotomisation of beliefs and the meaning of midpoints on Likert scales. More specifically, a single item on a scale may only be able to capture the perspectives represented at either end of the continuum.

Using person-centred analysis to understand patterns of responses to many questions can inform understanding of two or more qualitatively different perspectives or subgroups (Greene et al., 2008; Mason, 2016). It can therefore facilitate more nuanced interpretation of the data, thus generating findings that have useful theoretical and instructional implications (Chen, 2012; Kusurkar et al., 2021). By understanding how the identified subgroups differ regarding the variables under study, teaching approaches or interventions can be targeted at, and customised for, these different groups (Clatworthy, Buick, Hankins, Weinman, & Horne, 2005; Kusurkar et al., 2021; Roeser, Eccles, & Sameroff, 1998). Proponents of person-centred approaches have also advocated for its use as a way to advance both theory and practice in the area of epistemic cognition (Barger et al., 2016; Chen, 2012; Dai & Cromley, 2014; Ferguson & Bråten, 2013; Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010; Kampa et al., 2016; Trevors et al., 2017).

Cluster analysis, the person-centred approach chosen for this research, is a case-based, descriptive, exploratory technique. It is generally used to group cases (i.e., individuals) into different groups, such that members within a cluster are more similar to one another than they are to members in the other clusters (Everitt, Landau, Leese, & Stahl, 2011; Kent, 2015). Like the thematic analysis approach taken, it is a method of data reduction which is generally unconstrained by theory (although some approaches to cluster analysis do utilise theory to inform the creation of clusters). However, a structure will always be imposed on the data, even when there are no natural groupings in the data (Kent, 2015). Therefore, there should be a strong conceptual basis for why any such groups exist in the first place; evidence for the existence of such groupings in this research could come from the qualitative study and any future replications of the cluster analysis in a new sample.

Lastly, as previously noted, qualitative approaches allow for rich, deep exploration of a phenomenon, while quantitative ones allow such findings to be followed up and considered in relation to the general population. As such, cluster analysis is argued to be a particularly useful way to bridge the gap between nomothetic and idiographic approaches to psychological research while contributing to both the development of theory and targeted clinical applications of such research

(Clatworthy et al., 2005). There are also parallels between thematic analysis and cluster analysis worth noting. In particular, thematic analysis begins by exploring themes from within a case before searching for patterns of themes within groups of individuals. Similarly, cluster analysis is used to look at variables and how they configure to form patterns *within* a case, before a search for similar configurations of these variables within small groups of individuals.

Philosophical foundations

I will now detail the epistemological foundations that underpin this work. These personal views are the result of my intellectual considerations on this topic. It is imperative they are considered and declared due to their influence on my approach to this work. I cannot confidently say whether there is either a singular reality or multiple realities. However, through my previous work and interest in the study of individual differences (De Raad & Schouwenburg, 1996; McGrew, 2009), I have reason to anticipate that there is likely some common form of reality that everyone experiences. Moreover, I have concluded that each person has their own unique way of interpreting that reality and understanding the world around them, a way that is ultimately influenced by, and influences, their experience of that world.

Knowledge, I have come to understand, can be both objective and subjective. It is objective in that it can be governed by natural laws; discovered, evaluated, and supported by scientific practices including the systematic gathering and consideration of evidence under the authority of credible experts. At the same time, I must not deny subjectivity, so that even the words representing the notions above ('science', 'credible', 'evidence', 'authority', and 'experts') are personally and socially constructed and understood through the lens of my own personal experience. As a researcher I need to identify and own the biases that entails. I therefore also recognise the importance of the subjective human creation of meaning and that knowledge involves an interaction between a subject and an object that, to me, in my current understanding at least, cannot ever be completely separated. There is arguably a knowing that is more than mere fact, and that some

philosophers argue lies somehow in our human being. As such, reviewing it is beyond the scope of this research. For all intents and purposes of this research it is simply accepted.

As an aspiring evidence-based practitioner, I aim for my work to be situated in the interplay between research and practice, particularly in the use of research to solve real-world problems as well as allowing for real-world practice to inform research. I am not interested in methodological paradigm 'wars' per se and in debating which research method, qualitative or quantitative, is 'best' overall or in restricting my researching to the use of only one paradigm to the exclusion of the other. Instead, I see the value in considering the individual merits of each and how different elements can be used and combined to solve real-world problems most appropriately. I therefore position myself as a pragmatist: one who is focussed on research questions and the consequences of research over the methods used to answer those questions (Creswell, 2011). Methodologically, pragmatism dictates that the research method be guided by the research question and purpose with a consideration of 'what works' or what is appropriate to answer that question (Johnson & Onwuegbuzie, 2004; Mertens, 2015; Patton, 2002). Such a philosophy therefore sits well with the mixed methods approach to research that has been chosen to guide this research and answer my research questions.

Chapter 4: Qualitative Method

Participants

As indicated in the literature review, there is a need for studies to explore all of the ways of knowing used by adults, and not just those of a limited subset. Moreover, as the aim of this qualitative study was to conceptualise ways of knowing from the perspective of the individual knower, it was considered important to ensure that a range of participant's voices were heard, beyond those of the university students who have tended to predominate the studies in the extant literature. This is important to ensure models are not biased by these limited samples and instead are representative of the ways of knowing of the general population. Therefore, the aim was to recruit adult Australians in the community who had experience with 'knowing' and were willing and able to talk about their experiences of this. No other inclusion criteria were specified.

A further consideration focussed on the question of how many participants to interview. While there are no hard and fast rules for determining sample size in qualitative research, Patton (2002) argues for the specification of minimum samples and criteria for judging the adequacy of that sample. Guidelines are provided by methodologists for various qualitative approaches; for instance, one to two participants are recommended for narrative approaches, three to ten for phenomenology, and twenty to thirty for grounded theory (Creswell, J. W., & Creswell, J. D., 2018). Smith, Flowers, and Larkin (2009) recommend interviewing between three to six participants for novice interviewers or student projects.

In contrast, guidelines for sample size in mixed methods research focus more on the design and purpose of the mixed methods research. This includes a consideration of whether the samples for each phase will contain the same or different individuals, and whether the sample sizes will be the same or different (Creswell, J. W., & Creswell, J. D., 2018; Mertens, 2015). As the purpose of this research was to obtain rich, detailed descriptions of the meaning of knowing in the qualitative phase, before seeing how this generalises in a quantitative phase, the decision was made to utilise separate samples and different sample sizes. Moreover, to minimise threats to the validity of

exploratory sequential mixed methods designs, it is recommended that a large sample of individuals is used for the quantitative phase who are different from those of the qualitative phase (Creswell & Plano Clark, 2018). Therefore, for the qualitative phase a small sample was utilised, based on qualitative recommendations. Then, in the quantitative phase, a separate, larger sample that would meet the assumptions of the approach taken was recruited. Further, there were pragmatic considerations that needed to be balanced, mostly the need to transcribe and analyse the huge volume of data collected from the lengthy, in-depth interviews before commencing the quantitative phase of research. A decision was thus made to interview 'enough' participants such that data saturation would be obtained; this was implemented by planning to recruit and interview participants until the researcher got the sense that no new material was being added with the addition of each interview.

Convenience sampling was subsequently used in this phase of the research (Mertens, 2015). Individuals who had previously taken part in "Ways of Thinking" research (conducted by the student's supervisors) and volunteered their email address to be contacted regarding future research were emailed and invited to participate in the current research. Participants were recruited in waves to provide the researcher with time to reflect on the interviews and consider ways to improve how the interviews were conducted or the questions were delivered. Of note is that the recruitment of participants and collection of data was an open, flexible, and iterative process. 63 Table 5 includes brief details on the six participants.

Table 5

Participant Demographics and Pseudonyms

Participant pseudonym	Age (approx.)	Gender	Occupation
Angela	60s	Female	Small business owner (music industry)
Wendy	50s	Female	Small business owner/Studying Bachelor of Education
Tom	60s	Male	Semi-retired social worker
Andrew	60s	Male	Semi-retired; previously secondary teacher (science and maths)
James	50s	Male	Storeman/Studying agriculture at polytechnic college
Beverly	60s	Female	Retired; previously worked in office administration

Data collection

Data were collected through individual, in-depth, semi-structured interviews (Patton, 2002). The open-ended questions included general questions to explore the meaning and nature of knowledge and knowing to the participants in various contexts, such as in their profession and during their studies, and over time. An interview protocol (Appendix A) provided a framework for the interview with suggestions of possible prompts and probes, serving to systematise the interview, as much as possible (Creswell, 2013; Patton, 2002). At the same time, the exploratory nature of the interview was not forgotten, with freedom and flexibility permitted in ensuring the interview unfolded towards an understanding of what is important to the interviewee and their perspective on knowing, and not by what was predetermined by the interviewer and her perspective (Hugh-Jones, 2010; Marshall & Rossman, 2006; Patton, 2002). The development and refinement of the interview guide will now be detailed.

Initial development of the interview guide. An initial interview guide was developed to elicit descriptions of lived experiences of knowing. From discussions and pilot interviews with friends and colleagues, it became evident that most found it hard to “*describe, in as much detail as possible, an experience of knowing something.*” However, once a “type” of experience (Wertz, 2005) was designated by asking about *the kinds of things they had to know in their work or everyday life*, it was

possible to follow up their answers with a request for them to describe a salient experience of knowing related to these “things” they said they knew about. Consequently, the participants were able to elaborate on their experiences. These two situations (work and everyday life) were chosen as being relevant to everyday adults and beyond the realm of education-related topics which have tended to dominate previous research. Moreover, it was expected that they would allow the researcher to explore any differences, if at all, between knowing in these different domains. While specifying these domains could arguably be seen as removing an element of choice or agency for the participant, they were still free to describe an experience within these domains that was salient to them. Such a compromise was deemed appropriate for this research.

The interviews, therefore, were initially centred on gathering descriptions of adult’s experiences of knowing both in their work and their everyday life. For those not currently in work, it was determined that descriptions could focus on previous work or study, if need be. Possible prompts and probes were added to the interview protocol as a guide for the interviewer to use as necessary. The aim of using these was to clarify a point made or encourage the interviewees and draw out their descriptions, while taking care to ensure such queries were not leading or biased by my understanding of the literature or my own conceptions of the dimensions of ways of knowing. For instance, while the literature has suggested that “knowing” may involve the sources and justification of a claim (Hofer & Pintrich, 1997), there was a need to be careful not to force any external framework on to the interview and instead elicit the meaning and structure of knowing for the participants (Ashworth, Freewood, & Macdonald, 2003; Bevan, 2014). Similarly, the literature also suggests that “certainty” of knowledge is a domain of knowing (Hofer & Pintrich, 1997). Again, however, to avoid implying this was the case and salient to adults, it was planned that this was not asked about or participants probed regarding how sure they were that they knew something, or not, unless these were spontaneously brought up.

However, upon further piloting of this initial interview protocol, there were certain questions and feelings of frustration regarding my questions and my approach to coming to know

about knowing. Specifically, there was a sense that the concept of knowing was not being adequately tapped, if at all. There were questions regarding whether the interview prompts were sufficient to initiate prolonged, extensive, and rich descriptions of knowing, and, more importantly, whether the interviewer's skills were sufficient to elicit, sustain, and probe such lengthy descriptions. Consideration was also given to whether experiences with knowing could be elicited through such questions and whether "knowing" is a phenomenon of which adults are aware of their experiences with and can readily describe. It was therefore conceded that it was necessary to further refine the interview protocol to provide more context for the participants to aid in their description of experiences and allow a broader exploration of *how they know what they know* and *what knowing means to them*.

Refinement of interview questions. At this point consideration turned to how questions could be adapted or added to the interview protocol to facilitate a discussion of the context and experiences which give meaning to the experience of knowing for the participant. In other words, there was a need to understand the experience of knowing for adults across various settings and times. However, it was also necessary to not assume that knowing would fundamentally differ across these settings or even that these settings were important or exhaustive. Next, then, followed an exploration of the various settings in which knowing may be relevant for adults.

The proposed areas to guide the interview came from considerations that flowed from discussions with my supervisors and peers as well as a consideration of the relevant literature in the field of epistemic cognition (as outlined in the literature review chapter). These include disciplines of science (Conley et al. 2004; Ferguson et al., 2013), history (Greene et al., 2008), and medicine (Kienhues & Bromme, 2012); domains of personal taste, aesthetics, values, and judgements of truth about the social and physical world (Kuhn et al., 2000); and topics such as climate change (Brandmo & Bråten, 2018; Bråten et al., 2009). Also taken into consideration were common areas of relevance, particularly socio-scientific issues, that have a current presence in the media and online that individuals are generally exposed to fairly frequently, such as vaccination, climate change, and

evolution (Sinatra et al., 2014). These additional domains, and suggested questions for each can be found in Appendix A. As noted, no assumptions were made that these domains were exhaustive or that they would be relevant to every participant and their way of knowing; however, they were to be used as a starting point to facilitate discussion. Prompts and probes were also provided on the interview schedule, as an aid for the interviewer. Although many questions were written, it was not intended that all would be asked. Instead, the aim was to cover a variety of domains and topics while still following the participant's lead and the discussion of their knowing in relevant areas.

Finally, while the interview protocol and overarching questions could be seen to systematise the interview, as much as possible (Creswell, 2013; Patton, 2002) and focus it on experiences of knowing, the exploratory nature and purpose of this interview was kept in mind. Freedom and flexibility was therefore permitted in ensuring each interview unfolded towards an understanding of the participant's experience of knowing and its meaning to them, and not by what was predetermined by the interviewer and his or her perspective (Hugh-Jones, 2010; Marshall & Rossman, 2006; Patton, 2002). Therefore, it could be seen to be semi-structured in that the interview questions were provided to start off and guide the interview, while the wording and ordering could also change to follow the participant's experiences and use of terminology. There was also a commitment to openness, active listening, and an approach of reflexivity during and across interviews in an attempt to identify and clarify various aspects of the experience as they arose. For instance, if participants spontaneously brought up that the advent of the Internet had changed how they knew certain things, then this could be followed up and these changes explored. Or, if they mentioned climate change, then a question about how they know what they know about climate change would then be asked. Lastly, questions were also reviewed by peers for clarity and piloted in order to aid smooth delivery.

Ethical considerations

Ethical approval for this study was granted by Monash University's Human Research Ethics Committee (CF14/1019 – 2014000427). Although the interview was not designed to be intrusive,

various measures were taken to minimise the risk of harm to the participants being interviewed. Firstly, participation was voluntary with participants under no obligation to take part in an interview. Participants were also free to withdraw from the study at any time and to also choose not to answer any questions they were not comfortable with.

While the questions were planned to be unobtrusive, there was a remote possibility that reflecting upon their experiences and ways of knowing could result in the participant feeling a level of unease or discomfort. The explanatory statement (Appendix B) provided to the participants therefore included details of a support service that could be accessed by them, should the need arise. The explanatory statement also highlighted the voluntary nature of participation and included details regarding what involvement in the research entailed, consent and withdrawal, confidentiality, and the possibility to receive a summary of the research at a later stage. Finally, informed consent was obtained prior to the interviews being conducted and included consent to record the interviews.

Procedure

Data collection. Individuals who had previously taken part in “Ways of Thinking” research and volunteered their email address to be contacted regarding future research were emailed and invited to participate in the current research. Inclusion criteria were that participants were adults and both willing and able to discuss their experiences of knowing. Following an initial indication of interest, individuals were sent an explanatory statement (Appendix A) and, after any additional questions were answered, they were asked to nominate a convenient day and time for a phone interview. No incentives were offered for participating, although it was recognised that participants may have gained something positive from the novel opportunity to discuss their experiences with knowing with another person.

Participants were invited to either a face-to-face or phone interview, at their convenience. Due to geographical location or work commitments, all elected to undertake phone interviews. While Skype interviews were also offered, this was not taken up either by any of the participants. In-

depth, semi-structured phone interviews were conducted by the researcher in a quiet, private office at Monash University at a time and day that was convenient to the participants. With participant consent, all of the interviews were recorded using a small digital recorder. Interviews lasted approximately one to two hours (average duration = 1 hour, 24 minutes).

The interviews were preceded by providing necessary background information about myself and my role and also thanking the participant for their interest and for agreeing to participate. Key information from the explanatory statement and consent form (Appendix C) was restated and the participants encouraged to ask any questions. This included assurances that the interview is not a test of *what* or *how much* they know but about *their experiences* with knowing and how they came to know it. They were encouraged to speak as freely and in as much detail as possible but to also feel comfortable to not answer a question or to skip it and return to it later, if desired. Participants were also told they could change their minds later about something they had said. Lastly, participants were assured that their identities would be kept anonymous and that any details that may reveal their identity would be changed or revealed.

To initiate the descriptions of their experiences of knowing, participants were first asked to tell me about themselves, such as what they are currently doing for work. After asking the participant to describe the *"kinds of things they have to know"* for their work, they were then asked to describe an experience they can recall with knowing something for their work. At suitable times, prompts and minimal encouragers were used to encourage the participant to keep speaking. Where appropriate, their use of certain words and the meaning of these were probed. The participant's lead was followed, in that the selection of further questions was made in response to what they had said. For instance, if the participant spontaneously discussed climate change or politics, at an appropriate point a relevant question from the interview guide was asked, such as *"how do you know that climate change is real, or not?"* or *"how do you know that a politician is to be trusted, or not?"* At these points the participant was reminded that they need not talk about whether they think

climate change is real or not (if they did not want to) or which political party they support, but to focus on *how they know it (or not)*.

Towards the end of the interview, the participants were asked whether they had anything further to add, if there were additional areas they should have been asked about and, finally, how they had found the interview and experience of talking about knowing. Following the conclusion of the interview, any further questions about the research were answered before the participant was thanked for their time. Participants were also advised that, if interested, a summary of the research would be sent to them at a later stage. Following each interview, the audio files were uploaded to the researcher's computer at Monash University and then transcribed by the researcher. During transcription, data was deidentified by replacing names with pseudonyms and removing any details that might identify the participant or another person, including personal, business or place names. Data were managed using MAXQDA Version 18 (VERBI Software, 2017), a software for qualitative and mixed methods data analysis.

Researcher subjectivity and issues of data trustworthiness. Although I strive for impartiality in my research, I realise that I cannot fully remove myself from my work, with any decision or analysis I make likely to be shaped by my own experiences, worldview, values, and suppositions. This fact is arguably paramount to consider in qualitative research in which the researcher is the primary 'instrument' of data collection and analysis (Marshall & Rossman, 2006; Patton, 2002). Threats to the quality or rigour of this research were therefore considered and safeguards put in place to enhance the credibility and dependability of this qualitative phase (Mertens, 2015). Essential to this has been an ongoing reflective process which started before data collection during the development of the interview questions and continued throughout the interview process, after each interview, and throughout the data analysis phase. A key part of this process has been the keeping of a reflective journal (Ortlipp, 2008). Prior to data collection, I regularly recorded my own thoughts and understandings about my ways of knowing, my experiences, values, and the theories and models I read about in the literature, in order to consciously acknowledge these and consider their influence

on the interviews. I also took care to be aware of such knowledge when developing the interview protocol and conducting the interviews. I regularly also considered how my questioning or use of probes, summaries, and follow up questions could impose my own ideas and assumptions. Following each interview, I also reflected upon the interview process, in particular my role and my use and delivery of questions, summaries, and probes. I considered whether my questions and comments could be construed as leading or being influenced by my presuppositions. I also wrote down my thoughts, further questions, and ways I could improve future interviews. Throughout the process of analysis, the steps and decisions taken as well as questions, comments, and issues to follow up were also noted in the journal and discussed with peers and supervisors.

I later engaged in a more formal process of preliminary data analysis (Grbich, 2013). This involved reading through each transcription and reflecting upon not only what was said or asked by myself and the participant, but what was *not said*. It should be noted that this stage did not consist of data analysis techniques such as looking for themes or codes. Instead, it included a consideration of how the interview process could be improved, such as making the questions clearer, asking for more examples, and noticing areas that I could better follow up. It also included identifying if there were relevant areas, situations, or times that I was not asking about, so I could ask later participants about knowing in this area and determine whether it meant something to them and even whether it was relevant to them, or not (Grbich, 2013).

One thing I noticed from one of my earlier interviews was a tendency to unquestionably accept how the participant said they knew something in one area without further probing *how they knew this* or their reasons, evidence, or criteria for this. Upon reflection, I noticed that this had happened when I also had the same perspective on knowing in that area. Consequently, I reminded myself for future interviews not to assume that the meaning, reasons, and development of knowing were the same, even if on the surface I could relate to what was being said and identify with that element of their experience as being one that I had experienced.

These reflections and questions were also discussed with my peer debriefer (Mertens, 2015), a fellow PhD candidate conducting her own qualitative research at the same time. We met regularly to engage in extended discussion of our questions, challenges, and concerns regarding the data collection and analysis phases of our respective research. We questioned each other to clarify our research aims and goals as well as to confront our values and biases and the influences of these on our work, before formulating steps to minimise the impact of these during later interviews or analyses (Mertens, 2015). We also each conducted a preliminary analysis of two of the other's deidentified transcripts, which were then discussed in one of our debriefing sessions. This process illuminated some areas or biases that had been hidden, including responses by one participant later on in their interview that had contradicted their earlier responses, and gone unnoticed and unchallenged. Again, this feedback and my reflections informed future interviews and my intent to explore the content and structure of the participant's experience and not seek to confirm my own understandings and experiences. Lastly, supervision and peer review were also used to ensure the fairness of the research process and confirmability, or objectivity, of the claims made. During analysis, data were continually compared with the codes and themes being developed, in order to minimise drift in the meaning of codes and themes.

Position statement

Another important aspect of qualitative research is to engage in a critical, reflexive consideration of one's personal thoughts, experiences, biases, disposition, values and assumptions, and how these influence one's research (Bourke, 2014; Ortlipp, 2008). Writing a position statement, alongside other processes detailed in this chapter, is one way to reflect on, and remain aware of, the position from which one approaches all aspects of their research (Bourke, 2014). In this regard, I continually reflected upon aspects of my personality, interests, training, socialisation, education, work, upbringing, and identity and how these inform and shape my perspectives on knowing that I bring to this research. Of particular relevance to this research, I acknowledge that as an adult, Anglo-Australian female with a background, work experience, and extensive training in psychology and the

scientific method, my personal ways of knowing preference the scientific method. I highly value evidence-based practice and scientific practices for knowledge generation and evaluation, including gathering, corroborating, and synthesising multiple sources of evidence for claims, consideration of statistical probability, and the practice of peer review. Moreover, regarding evidence, I recognise the disciplinary perspective I have gained from science, and psychology more specifically. In particular, I recognise that I value evidence gained from peer-reviewed studies and experiments, over anecdotal evidence and personal experience.

Data Analysis

The interview data were analysed using Thematic Analysis (Braun & Clarke, 2006). The iterative and inductive analytic cycle proceeded as outlined in Table 6.

Table 6

Steps of Thematic Analysis

Step	Description
1	Immersion in the data set. This involved listening to the audio recording as well as repeated reading of the transcript. Initial notes were written on the transcripts.
2	Initial coding. Systematically coding interesting features of the data into concise phrases or meaningful statements. This process was repeated over several readings of the data, with the researcher becoming more responsive with each reading. The 'labels' given to segments of text often changed during repeated readings of the transcript.
3	Searching for themes. Grouping the data into relevant themes and subthemes.
4	Reviewing the themes. This was another iterative process of structuring, restructuring, and reordering the themes. The text was returned to during this time as part of the process to check the analysis. Thematic maps were generated.
5	Defining and naming themes. Reviewing data extracts for each theme and determining which aspects of the data each theme captures. Naming themes in a concise way that gives the reader a sense of the essence of the theme.
6	Producing the report. Writing up the themes and subthemes to tell the story about the data and topic. Selecting appropriate extracts to illustrate the themes and subthemes.

Note. Adapted from "Using thematic analysis in psychology," by V. Braun and V. Clarke,

2006, *Qualitative research in psychology*, 3, p. 87. Copyright 2006 by Edward Arnold (Publishers) Ltd

The first phase involved familiarisation with the data set. This immersive process involved repeatedly listening to the audio recording and reading the transcript. Afterwards, initial notes and thoughts on items of interest were written down on the right-hand side of the transcribed document. These included initial thoughts, ideas, questions, comments on language use, summaries, and features of note relevant to the question of how the participant knows what they know. This was repeated multiple times and aided in the interviewer's familiarity with the interview as a whole before the next stage commenced.

At this point, the document was imported into MAXQDA Version 18 (VERBI Software, 2017). The interview was then coded inductively, with the aim being to identify interesting features of the data relevant to the research question and labelling these with concise summaries, phrases, or meaningful statements (Braun & Clarke, 2006). An inductive approach was also taken, in order to ground the results in the participants' words as much as possible, instead of constraining the results to existing theory or the researcher's expectations. Coding was focussed at the semantic level of the text, instead of an interpretive coding of the interviews. Again, coding was an iterative process, being updated and modified as the process progressed. Memos, which included the researcher's ideas, questions, comments, and reflections, were also recorded to aid in the analysis and writing up process and as part of the audit process.

Next began the search for themes. These are seen as capturing "something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set" (Braun & Clarke, 2006, p. 82). This involved a process of reviewing all the codes used, identifying areas of similarity, and then sorting codes into meaningful categories and subcategories, such that codes grouped together shared a unifying feature. This process was managed using MAXQDA, although at times this involved printing off the list of codes and using techniques such as colour coding the various codes into different groups and subgroups. The aim was for each theme and subtheme to reflect a coherent and meaningful pattern in the data.

Thematic maps and tables were also created to aid in the process and see how themes and subthemes fit together.

The next step was to go through a process of reviewing the potential themes and subthemes. This involved going back and forth between the themes, codes, memos, and text to check whether the data supported the proposed themes and subthemes. Theme coherence was also reviewed to ensure that data within a theme cohered together meaningfully, while the different themes were distinct from one another with minimal overlap (Braun & Clarke, 2012). Where necessary, themes and subthemes were added, renamed, regrouped, discarded, and modified. All the interviews were then read through again to ensure that the proposed themes and subthemes meaningfully captured the whole data set in relation to the research question. The next stage involved defining and naming the themes and subthemes with labels that were “informative, concise and catchy” (Braun & Clarke, 2012, pp. 68-69). This also involved a process of refinement as themes were further examined to determine how best to meaningfully summarise and define their constituents. The final phase involved writing, and re-writing, the results into a meaningful narrative that told the story about how adults know what they know and illustrating this with appropriate extracts from the interviews.

Overview of qualitative results

Following the analysis of the six interviews, five themes and associated subthemes were identified. Table 7 provides an overview of the themes and a brief description of each. These themes included how participants justified their knowledge on various topics; the sources of knowledge they used and why these were valued, or not; influences on their knowing; knowing about knowing; and personal meaning of knowing.

Table 7

Five Themes with Descriptions

Theme	Meaning
Justification for knowing	The reasons or justifications given for knowing that something is known.
Sources of knowledge	The people or places where knowledge comes from.
Influences on knowing	The factors that facilitate or hinder the production, sourcing, or implementation of knowledge.
Knowing about knowing	Formal understandings of characteristics and definitions of knowing and knowledge.
Personal meaning of knowing	The personal meanings and impacts of having knowledge.

The following chapters will now present and illustrate each theme and associated subthemes in turn. Following the results for each theme will be a discussion of that theme with reference to relevant literature. Once all the qualitative themes and subthemes have been presented and discussed, there will then be a general discussion of the qualitative study. In that chapter, there will be a brief review of the results before relevant implications, strengths, limitations, and future directions are discussed.

Chapter 5: Justification for Knowing

Results

The first theme relates to the participants' justifications for their knowledge on various topics. That is, it includes the reasons participants gave to explain *how they know* what they know. In the interviews, participants justified their knowledge in various areas, including *how* they know that climate change, evolution, or God(s) is real, or not; that they like someone or something, such as a book or movie; or how to do their job, raise their children or solve a problem. Moreover, beyond justifying their own knowledge, it also includes the reasons they gave to support their acceptance or dismissal of the claims of others. The various reasons they gave to support their knowledge claims included *justification through others, seeing as knowing, feeling and instinct, and other justifications.*

Justification through others. All of the participants justified their knowledge on various topics by reference to the knowledge of others. That is, instead of relying on their own firsthand experience to justify what they knew, they referred to the knowledge and evidence put forward by various experts and frameworks. In essence, the participants know what they know because others have already justified or proven such knowledge through the use of studies, evidence, statistics, and the scientific method. The participants trust these people as objective experts "who've done the study... who've gone to university for 20 years, who've done the work" (Wendy) and thus accept their knowledge claims as true. As Wendy further stated after seeing all the evidence put forward for climate change, "it all makes sense, it's just logical, logic and evidence. That's how I know to accept, 97%, what 97% of climate scientists are saying."

Often, multiple experts, or the evidence provided by various experts, were used to justify the participants' knowledge. This was particularly the case for Wendy, who had recently studied a coursework degree in science at university and backed up her knowledge of vaccination, climate change, and other topics with "evidence" from various experts and disciplines. She particularly referenced the multitude of studies and conclusions of a raft of experts in relevant fields to justify her knowledge of vaccination:

the experts in the field... the hundred and nine different studies saying that vaccinations don't cause autism, which includes the meta data study of 1.25 million children... the thousands of people who've done the study, who've done the immunology, who've gone to university for 20 years, who've done the work. (Wendy)

She similarly justified her knowledge that climate change is real by reference to the “overwhelming” evidence in different areas that she obtained from her recent studies:

The evidence is overwhelming that it's anthropogenic. It was, it was just phenomenal. I was, I was tsunami-ed with information on why it's anthropogenic, climate change. I found, like we found every little bit about it, we went from the physics of it, to the chemistry of it, to, the, the, why the journalism and how it's reported, it's a fascinating unit because it covered right through the sciences, social science, journalism, media, it was a fascinating, eye-opening. (Wendy)

Finally, she turned to the great array of verifiable and indisputable evidence put forward in reports and studies to justify her claims about “damaged kids.” Notably, she strengthened her claims by highlighting it is not just conjecture, but actually proven by others:

How do I know that, because, we know that, we know that little kids being brought up without, without love and education turn into loonies, we know that, not all of them, but we know that that's what happens, the evidence is there, I'm big on evidence... There is lots of evidence... Evidence of this damaged kids, there's plenty of psychological reports and studies aren't there that, that that show that, that show that didn't somebody in the US do a stack, in fact it's not just the US there's one coming out, there's several coming out of Europe too... this is stuff that it's not just people think it, they put it down on paper and show you that 95% of serial killers come from homes where they were abused or they were damaged or

they ended up in foster home to foster home, I mean it's fairly, fairly indisputable statistics on it. Evidence, again. Peer-reviewed evidence. Scientifically verifiable. (Wendy)

In addition, participants often turned to experts to provide evidence for claims that they were unable to prove on their own. For instance, James and Angela had initially noticed some changes themselves with regards to climate change. This then prompted them to turn to the data and statistics being put out by experts, such as NASA, universities, and the United Nations. The evidence purported by such experts consequently gave them the confidence to accept the claim that climate change was real and assert that it was not made up.

I grew up during the space race so as an, you know, for all my, life has always been that thing about people going and making use of the technology, so you've got people who were getting out there and they're sending up satellites, and you're going, because you were a science geek, you were just going, and they were actually sending pictures back and going 'what's that big hole for?', why is that there?, you know, and people were going well that's because we are pumping this into it and, and the more information that was being made available at the time, because of museum dumps sent from NASA and stuff like that, you could just watch it and were sort of going, you can't make up this stuff, there's no benefit to making it up. (James)

I'd said, "well look, you know, we've got this, you know, kind of idea about how, how much the sea is encroaching on the, our area at [place name] which, and it's encroaching in an incredible way, and very quickly, and they went away and got all the stats for me that they had so that we could say "look, we're not making this up, we've got the, we've got the evidence." (Angela)

This was also the case for Andrew, who turned to others to justify knowledge he felt was "beyond me intellectually." Specifically, he referred to his acceptance that the knowledge put forward by

others is right as “faith,” which he defined as “something that you’ve got no evidence for.” He added that even though he does not necessarily understand certain scientific subjects, such as the Big Bang, or the science and maths behind them, he still accepts that “there's evidence for it, in their words there's evidence for it or there's logic behind it, in a mathematical sense.” Andrew further elaborated why he particularly trusted the claims of these thinkers and accepted them for himself:

Well they've come up with some really good theories in the past that I do understand, like Richard Dawkins, the selfish gene, was a, was a, you know he wrote a book quite a long time ago and he's written a lot of other books on evolution and that too that I do understand, I guess it's the step from what they say in the things that I do understand to what, to actually believing what they say in when they say things that I don't understand. Like, Stephen Hawking in the same sense. (Andrew)

Given his trust that these thinkers have done the work and gathered appropriate evidence for their claims, he is confident taking on board their knowledge “as being the truth in a sense”:

faith generally is, is knowing something that you’ve got no evidence for, I would consider that to be a definition and, and so it’s kind of, when they say a leap of faith, it's kind of like well you'll just take that on even though you don't actually know for sure that it's right, you don't, you don't actually know for sure that it's right and I all I do is I take on what people like Stephen Hawking and Richard Dawkins and those people have said about scientific things, as being the truth in a sense because there's evidence for it, in their words there's evidence for it or there's logic behind it, in a mathematical sense, but I don't understand some of their logic and their evidence because it's beyond me intellectually, so, so I have to say, if it's beyond me intellectually and I don't under, and I don't get the maths or I don't get the scientific logic that's led them to say this particular thing, if it's beyond me, then it must be a kind of faith I have in them as, as thinkers. (Andrew)

In contrast, while generally the participants justified their knowledge through experts in various fields, in one instance a combination of evidence from both experts and those close to the participant were utilised. That is, for Wendy her knowledge on vaccination was not only justified by scientific authorities, but also backed up through family experience:

so I've got a bit of history, knowledge in the family, and mum remembers polio, being, affecting the children that were around her back in the 30s and 40s, so there's some, you know there's some people around me saying "we remember these horrific diseases" and vaccination's the only thing that's, you know, cleared it, so it's not just 30 years of science and scientists, thousands of scientists, it's also backed up with real life experiences from people close to me. (Wendy)

Moreover, Wendy was the only participant who justified knowing, in particular knowing how to do something, because of a celebrity. Particularly, it seems it is the evidence put forward by this person and the fact it seemed to work for her which helped her to accept the claims of this person as knowledge.

I was fortunate enough to have super nanny on the telly and her methods worked, I always like evidence, I like repeatable, verifiable evidence and what she did seemed to work so I did a lot of what she told me to do and it worked with my daughter, so I was lucky enough to have some, you know, experts on telly and to this day I still use some of the tips that she used on two year olds and three year olds and four year olds, it's great. (Wendy)

Further, many participants justified what they know because of "the science" (Beverly). This justification was used for various topics, from the more science-based ones like vaccination, climate change, and evolution, to justifying the existence (or not) of God. Moreover, science was particularly used as a justification by those who defined themselves as scientific or had a background and interest in science. In particular, two participants discussed using science as a framework with which to evaluate knowledge claims, and either accept or dismiss them as knowledge. For example,

Andrew described considering whether there is a “scientific basis” to claims and will dismiss as “mumbo-jumbo” those that are not “scientifically right.” He noted a discussion with his wife regarding dubious claims about a special water glass; because of his background in science, he was confident to dismiss it as “not right... you know I just knew, I just dismissed that straight away as being mumbo-jumbo.” Likewise, Tom defined himself as having a “scientific and analytical brain.” When justifying his knowledge on climate change, he further described himself as “strongly in favour of science” and as someone who “value[s] science enormously.” He therefore concluded that, “as a scientific person I, I’m fairly confident that human activity is going to make some change to the climate, that’s probably a fairly good sound bit of knowledge.” Wendy similarly justified her knowledge on some topics with ‘science’, specifically asserting that the impacts of “locking children up” is “scientifically verified.” Knowledge associated with science was even used to justify other knowledge, with Beverly backing up her claim that there is no God through “the knowledge of evolution” (Beverly). In contrast, Tom noted how he could “have a pretty good argument scientifically” to support his knowledge on the existence of God. Moreover, Tom was the only participant to justify knowledge through reference to religion, particularly his Christian faith. Particularly, Tom discussed how “underpinning” his scientific views on climate change is his “belief system.”

Seeing as knowing. In contrast to knowing through others, four of the participants justified their knowledge on certain topics through their direct observation. Specifically, their knowledge on a topic was justified by either seeing it happen firsthand, seeing the evidence for it themselves, or having seen the outcomes of the topic being discussed. That is, when answering “*how do you know [topic e.g., that climate change is real]?*” some participants took what they had directly observed themselves as reason to conclude that their knowledge on the topic at hand was correct or true. This was particularly the case for vaccination, with two of the participants justifying their knowledge of vaccination through references to seeing the impact themselves of diseases in the past and “seeing people not have polio anymore, not have TB anymore” (James). Moreover, it was this firsthand

experience that gave them confidence in their knowledge of the importance of vaccination. For example, Beverly had personal experience with family members contracting polio and whopping cough; seeing the impact of these disease for herself and the outcomes when diseases like polio were stopped led her to confidently assert that “vaccination is, the quality of life of families and children depends on it greatly, so yes, I'm a great believer in vaccination.” James further highlighted this confidence and appeared to preference this type of justification over second-hand verification of such knowledge:

So yes I'm on the side of vaccination, I've seen it actually physically work, I know that it works, so I'm happy... I've physically seen it work, so it's not a, it's not a subject that I've read about or you know seen studies about, or things like that, you know, you're sort of, you're watching people who've, you know. (James)

Participants similarly justified other knowledge claims by what they had seen. James for instance justified the claim that climate change is real because he had seen the impacts of “what it was doing to the ozone, you could actually see it happening in real time.” Two of the participants also partly justified evolution by what they had seen, although they also referred to other forms of justification as well. Specifically, Wendy’s knowledge of evolution was “backed up by millions of pieces of evidence I’ve seen, over, in the world,” while Beverly answered:

how do I know how it's real, I think just the science and it's just even the animals and the Earth and it's all changing, and of course it's come from evolution, I really don't know whether they've quite pinpointed it yet, they haven't quite worked it out, but when you look at it and just see, even if you notice, even the animals are learning more, they're learning tricks, everything's evolving. (Beverly)

Others not only justified knowing by seeing the impacts of the topic at hand, but also questioned how others could see and not know. Specifically, when it came to justifying their

knowledge on whether the government's asylum seeker policy was good or bad, two of the participants both "knew" that it was wrong because of the outcomes they had seen. For them, the evidence was so obvious to see that they could not understand how others could see but not know what was happening. As Angela stated, "you have to be some sort of, you know, cruel awful person not to see what you're doing to her or doing to these people." Indeed, Wendy even commented that the impacts of the government's policy are so clear to see, that even "blind Freddie can see that what we're doing to children will damage them."

However, while seeing was generally associated with knowing, it was also noted that at times this is not always a reliable justification for knowing. Specifically, one of the participants noted how there are times when knowledge may be hidden or misrepresented by others, and drawing conclusions based on what we see can put us at risk. This is highlighted when Beverly commented on her knowing regarding the government's asylum seeker policy. She emphasised the need to know who we are bringing in, otherwise we risk putting ourselves at danger. Her use of the Trojan horse metaphor highlighted how we can be blinded or tricked to see one thing, but ultimately not know what is really happening:

I do think we need to perhaps make sure that we know who we are bringing in, because you could end, it's a bit like the Trojan horse, you really don't know, who is coming in, and they have to be, we have to protect ourselves and if we don't, we're silly I think. (Beverly)

Similarly, Andrew pointed out the risk of misperceiving what we see, which can lead to the wrong conclusions being drawn. That is, under some conditions 'seeing' is not always accurate with some things easily misconstrued for others, resulting in false positive claims being made.

There's various kinds of things coming out of the bush, like dust and smoke, other things that can be misconstrued as a fire... Yeah, like looking, looking out into the bush, like I made a few false calls, like you'd see something, another thing that's often misconstrued as smoke is steam coming out of the bush after a thunderstorm... and there's this kind of steam that

comes out of the bush when the sun comes out again, we call that 'Fogs Dogs' and it's very easy to misconstrue as smoke, so quite a, I think I might have made a few false observations and radioed them in. (Andrew)

Feeling and instinct. In contrast to knowing by seeing the evidence firsthand or from others, participants also justified their knowledge by reference to their own feelings or instincts.

Interestingly, this type of justification was used more to refer to aesthetic domains, such as how the participants know they like something or not such as a book, movie, or music. For instance, when asked how they know they like a particular interest of theirs (such as a book or movie), many reported knowing based on a feeling or sense they get. Specifically, many spoke of a sense or feeling that tells them to go on with the book, or not, even after just a few pages. Both Andrew and James, for example, described a process of reading a few pages of a book; then, if they're still engaged, they know that they will like it. Likewise, books have to interest Beverly and "hold my attention"; she knows when she enjoys something because she will "sit there and not want to get up." Similarly, Wendy noted,

That is such a different way of looking at life, it is, I understand it's like art and how do you like art, how do you like music, it's very personal, it's very individual, how do you know, you know because it makes you feel good or you actually go back to read to the book or you can't put it down, if you pick a book up, sometimes I don't know if I'm going to like it, but reading the back of it might give me a hand, but after the first few pages, and if I just want to put the book down, you know that's it's just not doing it for you. (Wendy)

Angela also knows that she likes something because it "stimulates her" and she likes the feeling of her brain working. Equally, she knows when she does not like something as she immediately has a physical response to it that makes her want to get rid of it:

how do I know if I like them or not... If they don't irritate me... I'm reading three novels at the moment and anything political I'll read, you know, unless it's crap and then I won't read it but, and how do I know I like it?, because it, it stimulates me and I like that feeling of, of my brain working, I like that trying to work out if it's a red herring you know and it's the same with music. (Angela)

Wendy also highlighted how personal feeling can override evidence from others when the focus is on aesthetics:

Oh yeah, yeah, I mean you can take 50 photos of me in a dress and all 50 people say "don't you look lovely" but if I am subjectively looking at myself going, I don't like that, then the evidence is irrelevant, it's how I feel. (Wendy)

Beyond relying on their feelings to justify their interests and likes, two of the participants used their feelings and instincts to justify knowing about other people and their own decision making. Tom, for instance, justified how he knows about other people through instinct. He spoke about "a personal radar," an "instinctive" process or "sense" he gets from other people which guide him in his work and dealings with them:

I'd have to say honestly, it's instinctive, I don't, I don't know that I think that through, I tend to read people in the moment and there's often a cue that comes from that person or they'll give me a lead on something and I can get a sense that they are open to, perhaps going from the serious to a moment of humour, it can be quite useful, but I, I can't analyse that one for you too well... And I guess that comes from constant contact with people you know you get a sort of sixth sense about where people are at and you know when people are not responsive, you just instinctively know that they're, the body language, the tone of voice, the words they choose they're all kind of barriers, you get that sense the wall's gone up. (Tom)

Similarly, Angela knows when she is about to make the right decision for work because she “can feel it” and gets the sense that she now “know[s] what [she’s] doing.” It seems she sees this process of knowing how to make decisions for work as “intuition” that is backed up and “born of years of research and there’s all that stuff in my head.”

I just wake up and it’s there. It’s usually after a fairly long period of research but I feel myself moving towards it and I, my, I feel my confidence building and then as I say it seems like, it’s like everything just kind of falls into place, and I feel very calm, and once I’m there the guys know that there’s just no point in going on.... And, and so I have to now go and research all this, make sure I’m not talking through a hole in my head, and that, that’s how I kind of got to the point where I said to the guys “okay this is it because we’re going to die a death if we don’t move with the times” so, it’s, it’s intuition, born of years of research and there’s all that stuff in my head. (Angela)

Other justifications. The final justifications used included experience, logic, coherence with personal criteria, and not knowing how they know but instead ‘just knowing’. For a start, some of the participants justified their knowing because of their experience, such as whether somebody is trustworthy or not.

Trustworthiness is a bit different, how are you going to trust somebody, ah - experience. Just dealing with them, if you really want them to be part of your life, then you just keep... asking them to be part of your life and if they want to be part of yours and... At the age of 50 you're kind of a bit full of, you're full, your friends are full, you, you're done, your kid's at school, it's all about the people you need, I know people come and go but, um, let me think, when my husband and I broke up I went looking, after a while, for... male companionship, how do you know who is right for you, how do you know they're trustworthy... You don't. You don't, until they stuff it up. (Wendy)

Wendy also justified her knowledge of the importance of kindness, from her experience:

but you just be nice to people, and, and it gets, you know, they, they like to have you around. Kindness I think is the key. And how did I know that? I dunno, just, 50 years on the planet, being right is not nearly as important as being kind. (Wendy)

Similarly, Angela and Wendy referred to their experience and knowing through trial and error when knowing how to fix things at home or solve problems. It seems that through trying to do something then reflecting on what happened that they could conclude whether they know something, or not.

Now, to make something, give it a shot and if I stuff it up, I know I haven't done it right. I'm pretty good with my hands but I had to bring in the plumber to put the toilet in, I couldn't do that, that was beyond, I did give it a shot (laughs) but it didn't work so, I suppose there's a, comes a point in time when you think they're plumbers for a reason... how do you know, you give it a shot I suppose, I can paint, I can paint a wall, I've been painting my bedroom, but just it's not as good as someone who's been doing it for 30 years. (Wendy)

I think experience. And also it's not that I'm moving into areas that have never been in before, I'm working with a community centre that's next to a jail and I'm helping with their policies and event coordination for them it's only little but I've done all these things before so I draw on my experience and I take that and I manoeuvre it so that it works for new task that I have to, I have to do. (Angela)

Logic was also used to justify Wendy and Tom's knowing. For Wendy, this related to knowing about climate change and vaccination: "That's just not me, why I know that that's right, it just seems to be right, it just seems to be logical to me" (regarding her knowing about vaccination and that it does not cause autism). In contrast, Tom justified knowing how to fix electrical problems at home based on his understanding of the logic behind the inner workings of electrical systems.

so I followed the wires from the switch to where they ultimately ended up and discovered one had broken so, just the, the logic of understanding the basic principles of how something works and then deducing from that what the most likely cause and then going and investigating that, so just a process of elimination for me, cos I don't, you know, I'm not an expert in any of those fields, I just use those well-worn techniques. (Tom)

Two of the participants relied on their personal standards and values as a way to justify their knowing. That is, they justified claims based on coherence with their own values. For instance, Angela knows that locking up children in detention is wrong because she's "a human" and knows "that in my heart, that it is wrong, it is morally and ethically wrong." James similarly knows who to trust and vote for based on a consideration of who the politician is and what they stand for; he evaluates this against his ideals to justify his decision.

OK look well if I can't trust you on face value, I'm going to dig deeper to get out there and sort of go, OK well I'm going to read your policies, you know, and find out, what you actually physically support, ok, and if what they physically support, well it's going through and going, well, hang on, sort of, if you're allowing this to happen, or if that's what you believe, then sort of, that goes against all my ideals of what someone who should be leading, you know, they should be getting out there and saying, no, this is not the direction that's in the best interests of everyone, or the particular status, and it's only purely done again, that thing on the individual basis, whereas you know, how much is in it for me. (James)

Angela similarly knows whether a politician is trustworthy or not or if she wants to work with someone or not, by consideration of her standards.

it's about standards, it's all about standards, you know, and everything I do it's always, you know, to try and work hard to get the best possible outcome, at the highest possible standard and that might sound a bit cruel but some people just don't make the grade and

you've just gotta let them go because they become like a stone around your neck and it stops you from doing your job to the best of your ability. (Angela)

At times, however, participants could not articulate how they knew something or noted that they had never had to question it. Here, the participants would instead state that they “just know” it (Beverly). This ranged for topics on knowing whether they like something or not, to knowing about evolution and knowing how they knew to do something. Beverly, for instance, was confident that she just knows what she knows about evolution: “you just know that evolution is definitely, without question, the part of the Earth and all it's different layers.” At other times the participants could not pin down how they knew something, and instead presented various opinions, viewpoints, and theories to back up what they know. This related to various domains of knowing, from knowing about their interests, to immigration and overpopulation, evolution, and the existence of God. Both Tom and Beverly, for instance, were not sure but theorised about something inside us and how that relates to knowing:

So, I don't know, there must be something in our brains that requires or needs that bigger picture, or the hope that there's, it's like a genie in a bottle, that there's some magic, and whether it's our brains that need that reassurance, I'm very much, can't stand them, sorry. (Beverly, regarding her claim “that there is no God”)

I'm of, of the opinion, maybe rightly or wrongly, I don't know that there's a kind of built rhythm inside us, a bit like a sort of wave form and somehow or another there's particular styles of music that engage with that and make us feel, better, happier. (Tom)

Angela similarly “just knows” what music she likes, and offers some possible reasons that may underpin that knowledge:

I just know very quickly if I'm going to like something with, as far as music goes. With some of the pop stuff it's easy cos you just know... but with pop music in general you know pretty

much, well I know pretty much very, very quickly if I'm going to like it, and the same thing with the book, you know and that's probably to do with style, and rhythm. (Angela)

Beverly was not particularly certain regarding how she knew to raise her kids, answering "I don't know how I managed." She was, however, confident in knowing that she just did it. It is almost that now, with the passage of time, she can conclude that she must have known how to do this, although at the time it might have seemed that "it must be a natural instinct" or involved trial and error.

And yet I, all I knew was when I had my children, I realised, or the first one, it's a huge responsibility, to take that person through life, so I don't know how I managed but you do, you learn as you go, too, it's just hard to, and all the challenges you get in life with all the complications... Yeah, it wasn't from any guidance from anyone, it was definitely a hit and miss learning curve... (Beverly)

Andrew discussed his knowledge on the government's asylum seeker policy and his viewpoints on migration, conflict, and overpopulation. On conclusion of his discussion of these, he reflected on how he knew all of this, and was not able to articulate a specific justification. Instead, it appears this knowledge reflects an accumulation over time, and is justified through just knowing that he knows or remembers it.

Well, I don't know how I know all that, I've just sort of got it in my head, that's what you want to know, isn't it? It's kind of like you build up a philosophy which is a, a mismatch of, a miss mash of what you've learned, what you've been told, the kind of things your parents did and knew... so how do you know, you sort of get, you get influenced by parents, family and then your education and then you sort of work through things with that kind of, influences from friends and so on that you sort of respect, I guess. (Andrew)

Summary of justifications for knowing used by participants. In Table 8, there is a summary of the participants' uses of the various types of justifications by the different topics. As can be seen,

Wendy used all types of justification across a variety of topics. For some topics, such as vaccination and climate change, she used multiple forms of the same type of justification (e.g., scientists and evidence from studies from *justification through others*), as well as justifications from multiple categories (e.g., both vaccination and climate change were justified by scientists and logic). Angela, Beverly, and James similarly used a variety of justifications, using justifications from across all the different categories to justify their knowledge on different topics, but not to the extent that Wendy did. Angela specifically tended to only use one form of justification when justifying each knowledge claim. However, James and Beverly, unlike Angela, occasionally used multiple types of justification across categories to justify their knowledge on specific topics (climate change for James; evolution and the absence of God for Beverly). Tom and Andrew both used (or at least discussed using) the fewest justifications of all the participants, and neither mentioned using *seeing as knowing*.

Table 8

Summary of Participants' Justifications use by Topic

Justification	Participant					
	Angela	Wendy	Tom	Andrew	James	Beverly
Justification through others		Vaccination <i>Experts</i> <i>Science</i> <i>Scientists</i> <i>Studies/data</i> <i>Meta data</i> <i>Evidence</i> <i>Family experience</i>				
	Climate change <i>Data and statistics from universities</i> <i>Official reports</i>	Climate change <i>Evidence from studies</i> <i>Climate scientists</i>	Climate change <i>Science (tells us some things)</i> <i>Belief system (Christianity)</i>		Climate change <i>Data from official organisations</i>	
		Parenting <i>Celebrity</i>				
		Evolution <i>Taught it at school</i>				Evolution <i>Science</i>
		Other: Asylum seeker policy,	Other: existence of God			Other: No God <i>Evolution/science</i>

Justification	Participant					
	Angela	Wendy	Tom	Andrew	James	Beverly
		damaged kids, locking kids up <i>Scientifically verified, peer- reviewed evidence in reports and studies</i>	<i>Science</i>	Other: Big Bang <i>'Faith' in scientists and mathematicians, in their evidence and logic</i>		Increasing population <i>Data</i>
Seeing as knowing	Asylum seeker policy	Evolution <i>Seeing evidence herself</i>			Vaccination Climate change	Vaccination Evolution Asylum seeker policy
Feeling and instinct	Interest in book Work decision- making (intuition)	Interest in book		Interest in book	Interest in book	Interest in book
			(How to) Working with others			
Others <i>Experience</i>	Knowing how to work with others Problem solving in community work	Music				

Justification	Participant					
	Angela	Wendy	Tom	Andrew	James	Beverly
		Fix something Trust somebody Importance of kindness				
<i>Logic</i>		Climate change Vaccination				
<i>Personal standards or Values</i>	Trusting politician Locking children up Working with someone		Fixing something		Trusting/ Voting for politician	
<i>Just know/ Personal theories</i>	Music interest		Music interest	Asylum seeker policy, migration, conflict, overpopulation		Evolution No God Raising children

Note. Not all questions were asked to, or answered by, all participants. Plain text indicates topics, while italics indicate specifics of justification used.

Discussion

The first theme related to participants' justifications for knowing. That is, it encompassed the reasons or justifications participants gave for knowing that something is known. This was made up of subthemes of *justification through others*, *seeing as knowing*, *feeling and instinct*, and *other justifications*. The use of multiple types of justification by the participants is consistent with more recent multidimensional and integrated models of epistemic cognition (e.g., the trichotomous justification belief framework of Ferguson and colleagues, 2012, 2013; and the EOCD model of Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010), which posit that individuals use multiple forms of justification to justify knowledge claims, and that a single dimension of justification, as in earlier models, is not sufficient to capture the phenomenon of epistemic cognition (Greene et al., 2008). As in these models, the participants in this study justified what they know through the use of various types of justifications, including both internal, personal ones (*seeing as knowing*, *feeling and instinct*, and *other justifications*) and external, formal ones (*knowing through others*) and combinations of these; these are analogous to the dimensions in the trichotomous justification belief framework of personal justification, justification by authority, and justification by multiple sources, respectively. The following section will elaborate on these and highlight similarities and differences between the current results and previous models.

Justification through others. Consistent with the trichotomous framework and EOCD model, all of the participants justified what they know regarding various topics through reference to other people and the work of other people, specifically scientists, scientific research, and experts such as mathematicians and climate scientists. This subtheme is consistent with the *justification by authority* dimension, in which individuals would say they know something if it came from an expert, teacher, or other reputable source or from scientific evidence conveyed by teachers, textbooks, and scientists (Ferguson et al., 2012, 2013; Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010). Generally, participants in this study discussed a larger range of authorities and at a finer grain size than those mentioned in existing models. These included more specific means of justification

beyond “science” and “scientific research,” such as data, meta-data, peer-reviewed evidence, and statistics from universities, official reports, experts, and official organisations. These findings answer the calls of Chinn and colleagues (2011) that a broader range of justifications, and at a finer-grain size, needs to be considered in epistemic cognition research, in line with the philosophical literature. However, while current models and associated questionnaires also include other reputable authorities which convey scientific research, including teachers, classes, and textbooks, as forms of justification by authority, these were rarely mentioned by the participants. Notably, only Wendy partially justified her knowledge on evolution through having been taught it at school. Moreover, while participants discussed turning to textbooks and their studies, these were deemed as sources of knowledge in that participants were focussing on where that knowledge came from, instead of giving reasons for how they knew that they knew that knowledge.

Further, while participants generally justified their *knowledge through others* which could be seen as experts or authorities in their fields, two participants turned to others not commonly discussed in the literature. For instance, Wendy also justified her knowledge through other people, including a celebrity and family members, who might not conventionally be labelled as authorities. This provides another reason for not labelling this as justification through “authority,” alongside Chinn and colleagues' (2011) argument that this term has negative connotations, and that the term “testimony” is preferable. On the other hand, Tom, who identified as a Christian, was the only one to justify some of his knowledge (including that about science and climate change) through reference to his religion.

As noted, participants often used the framework of science as the basis with which to accept or reject knowledge claims. However, it should be cautioned that the word “science” was accepted by the interviewer on the basis of assumed knowledge. Further exploration of what science means to the participants as well as their grounds and thresholds for accepting scientific knowledge, or not, would therefore further enhance models and add to their predictive validity. Likewise, the use of religion as a framework, while only mentioned by one participant, warrants further investigation.

Specifically, the participant (Tom) who mentioned religion also stated he valued “science enormously” and he could see the role they both played in his life and on his worldview; exploration of the knowing of individuals from different religions, and of those who preference religious ways of knowing over scientific ones would also be a useful avenue of exploration.

The finding that participants justified much of their knowledge through others is unsurprising, given the recognition of the social context of knowledge and knowing and the role of testimony in epistemic cognition (Chinn & Rinehart, 2016; Greene, 2016). Further, as it is not feasible for an individual to substantiate every knowledge claim they come across, it is argued that relying on others to substantiate knowledge is necessary for effective epistemic cognition (Greene, 2016). This is known as the division of cognitive labour and is best exemplified by Andrew, who put his trust in thinkers and mathematicians regarding knowledge he saw as beyond him. Given the acceptance of the role of testimony in justifying one's knowledge, the question then shifts to how individuals determine whether a particular source of testimony is reliable, or not (Greene, 2016).

Possible answers to this question were provided in the reasons given by participants for why they justified their knowledge through these authorities (as well as in the subtheme of *source evaluation* in theme two). This included the participants seeing these people as experts because they have spent many years studying and working in their fields. This was also because of what they saw as the volume and variety of evidence put forward by these experts and in these disciplines. One participant (Andrew) even noted how his acceptance of the evidence put forward by experts could be labelled “faith,” as he accepted their claims as truth even though he had no evidence of his own to back it up and he did not understand the evidence put forward by these scientists and mathematicians. He further elaborated, though, that he trusts these thinkers and their evidence for these claims because of the credibility he ascribed to them through his ability to understand previous knowledge claims put forward and justified with evidence by them. As noted by Chinn and colleagues (2011), the grounds for trusting authorities/testimony are missing from current models.

The results from this study therefore provide preliminary examples of these which can be used to expand current models.

Seeing as knowing. Some of the participants also justified what they know through what they saw. That is, instead of relying on external authorities, they justified knowledge through what they had seen firsthand themselves. While this form of justification was evident in earlier developmental models, it is not so apparent in more recent models and associated measures. Specifically, observation is reported as a means for justifying beliefs at lower levels in developmental models (e.g., King & Kitchener, 1994). In current dimensional and expanded models, *seeing as knowing* has not been explicitly articulated as a form of justification. Arguably, though, it is consistent with the dimension of *personal justification* in earlier models (e.g., Ferguson et al., 2012, 2013; Greene et al., 2008; Hofer & Pintrich, 1997).

Individuals having strong beliefs in this form of justification warrant knowledge claims based on internal means such as personal experience, opinion, reasoning, or logic. Justifying what one knows through what one sees firsthand could arguably be analogous to justification based on personal experience. Further clarification and illustration of the term 'personal experience' as used by authors in these models would however aid in drawing such conclusions. Seeing as knowing as a form of justification is also consistent with those forms of justification identified in the philosophical literature. That is, the use of sense data is among the numerous justifications that philosophers have identified as being used by individuals (Greene et al., 2008). It is also consistent with the acknowledgement that in philosophical epistemology, perception and observation are sources of knowledge (Chinn et al., 2011, 2014); the overlap between sources and justifications will be discussed shortly.

Feeling and instinct. Participants also justified what they know through reference to how it made them feel or an instinct or sense they had. As with *seeing as knowing*, justification on the basis of what feels right is seen at lower levels in King and Kitchener's (1994) reflective judgement model. It is also consistent with the personal justification dimension in the literature which includes gut

feeling as an internal source with which knowledge claims can be validated (Ferguson, 2014). An alternative explanation is that the identification of *feeling and instinct* as a justification is reflective of the topics used in the current study's interviews. That is, this justification was mainly used for aesthetic topics (i.e., all but one of the participants used this to justify knowing that they liked a book) or procedural knowledge (i.e., knowing how to make a decision for work or how to work with other people). As has been pointed out, philosophers generally view topics relating to aesthetics or tastes outside the realm of epistemological enquiry as it is difficult to justify claims relating to these as true or right (Pollock & Cruz, as cited in Greene et al., 2008).

Notably, while seeing as knowing and feeling and instinct may be considered as forms of personal justification, these specific forms of this dimension have not been included in relevant measurement tools. Further, it is unclear whether items have not been written to measure these, or they have been written but discarded through the instrument development and validation process. Given Chinn and colleagues' (2011) arguments about the need for fine-grained detail to enhance predictive validity in epistemic cognition research, consideration of the inclusion of these types of justification in current models is warranted. The results may suggest a need to broaden current measures to include these and to consider the extent to which these forms of justification are used, or not, and in which contexts.

Other justifications. Participants also justified their knowledge through *experience, logic, personal standards or values, and not knowing, but just knowing or theorising*. These internal forms of justification are most consistent with what has been seen in the literature on personal justification (e.g., Ferguson et al., 2012, 2013; Greene et al., 2008; Hofer & Pintrich, 1997), that is, justifying claims on the basis of personal experience, reasoning, opinion, or logic (Greene et al., 2010). While *experience* was seen as a form of justification in this study, a closer examination reveals the need to elaborate on what is meant by this term. For some of the participants, it may relate to memory; that is, knowing they know something because they remember having done it. For others, it might be closer to "seeing as knowing," in that they know something is true because they have

tried it for themselves, evaluated it, and seen that it works for them. Again, this may be reflective of the type of knowledge the participants were justifying, in that the use of these justifications tended to be for know-how (procedural knowledge) instead of declarative or conceptual knowledge.

Two of the participants also justified some of their knowledge claims through their personal standards and values. Again, this form of justification is not evident in the developmental or dimensional models, and nor has it been reported as a justification in the philosophical literature (Chinn et al., 2011). Only in Perry's (1970) model is it noted in the final stage (commitment within relativism) that an individual's views of knowledge and knowing are shaped by their values and identities. This justification therefore requires further investigation. This justification may be considered as a form of personal justification, or more specifically, on the basis of what feels right. However, it again may have been reflective of the topics and questions these were used for. That is, when these justifications were used, participants were discussing how they know whether a politician is trustworthy (or not) and whether to vote for them (or not), as well as how they knew whether the government's asylum seeker policy was right or wrong. The focus on knowing about a person's character or issues of morality and ethics may therefore have moved away from the traditional focus of epistemology and epistemic cognition which considers the justification of declarative and conceptual knowledge (Greene et al., 2008).

Both Wendy and Tom's use of logic as a justification fit with the notion of personal justification. Moreover, evaluation of whether the content is "logical" is included in the personal justification dimension of the ISEJ (Bråten et al., 2018). However, further consideration of what logic may mean to each of these participants reveals possible meaningful differences. Tom's use of logic as a justification for knowing how to fix something at home could for instance be seen as a process of personal justification relying on a combination of reasoning, past knowledge, trial and error, and then seeing if it worked for him. In contrast, depending on Wendy's use of the word *logical*, her justification of knowing about climate change and vaccination could fit with *feeling as knowing*, as she talks about it making sense to her or logic in the sense of reasoning and following formal rules of

inquiry. Asking participants to elaborate on their use of these words would aid in their accurate classification. Further, it should be highlighted that differences in meaning may also be due to the type of knowledge being discussed; that is, Tom used logic to justify questions relating to know-how, while for Wendy it was used for conceptual knowledge.

Participants also discussed not knowing how they knew certain topics, but instead stated that they “just know” it or they theorised about how they might have known it. It may be the case that the participants could not remember how that knowledge was first justified in the first place, just that they remember getting it and accepting it from somewhere. *Just knowing* may also relate to a process of instinct, suggesting it could alternatively be categorised in the subtheme of *feeling and instinct*. The process of theorising about how they know something could also represent either a reasoning process, or alternatively, raises the prospect that participants are moving beyond justifying knowledge to discussing their opinions on a topic. As has been noted by Greene et al. (2008), opinions are outside the scope of epistemology.

Use of multiple forms of justification. Some participants also gave multiple justifications for the one topic, including different types of justification both within and across subthemes. This provides preliminary answers to Greene and Yu’s (2014) call for research to determine the extent to which individuals use single or multiple forms of justification to evaluate knowledge claims. Further, these findings are consistent with the dimension of *justification by multiple sources* found in the trichotomous justification framework (Ferguson et al., 2012 2013). However, the focus in that framework is on the general use of multiple sources. For instance, items in the questionnaire based on this framework, the Justification for Knowing Questionnaire (JFK-Q), ask “*To be able to trust knowledge claims in natural science texts, I have to check various knowledge sources*” and “*Just one source is never enough to decide what is right in natural science.*” The results from this qualitative study therefore extend on this framework by revealing *which* sources the participants are using in combination. For instance, regarding vaccination, Wendy references experts, science, scientists, studies/data, meta data, evidence, and logic, but notes that this is also backed up by family

knowledge and the real-life experiences of people close to her. She also justifies climate change through internal and external forms of justification, including logic and evidence. Beverly similarly justified her knowledge on evolution through the use of multiple sources, including through what she had seen herself as well as the science and just knowing. Chinn and colleagues (2011) also recognised the need for models to consider the role of multiple sources being used simultaneously, and interacting with one another, instead of being viewed as opposite ends of a continuum.

Moreover, Greene and Yu (2014) suggested that the number of justifications used may depend on one's expertise, with students proposed to rely on only one or a few kinds of justification, while it was suggested that experts would use a larger range of justifications. While acknowledging that the participants were neither experts nor students, similar patterns in their use of justifications were evident. Angela, for instance, tended to rely on single forms of justification while Wendy used a broad range and variety of justifications; this may be due to Wendy's current studies in science at university. The others tended to fall somewhere in between, often using one type of justification at a time, while occasionally using multiple forms of justification for some topics (e.g., climate change, evolution, and the existence of a God). However, it should also be noted that in this study, participants were not asked or encouraged to give multiple justifications, so their use may have been underreported. Therefore, definitive conclusions regarding when single or multiple justifications are provided, or by whom, cannot currently be drawn.

Chapter 6: Sources of Knowledge

Results

The theme, sources of knowledge, refers to where participants acquire(d) knowledge from. A large variety of sources was described by the participants, and included people, written sources, and their own experiences. Participants also discussed why they valued or trusted these sources, while highlighting the need to be sceptical of others. The sources utilised also varied depending on the topic or type of knowledge needed. Moreover, as with justification, participants often referred to multiple sources regarding where specific knowledge came from.

People. One of the most commonly used sources of knowledge for the participants was other people. In fact, all but one (Tom) of the participants referred to the various people that they got their knowledge from or that they would go to if they needed to know something. These included skilled people, experts, mentors, colleagues, university lecturers, friends, and family members. Notably, this subtheme differs from the similar subtheme in justification of *justification by others*. That is, in *people as sources* participants are referring to whom they acquire(d) knowledge from, instead of explicitly justifying their knowledge on a topic *because of* the evidence and knowledge put forward by other people. In essence, the focus here is in describing from *where* their knowledge comes or came, compared to *how* they know to accept it, or not.

Generally, when the participants did not know a topic, when they wanted to know how to do something, or for gaining work knowledge, they reported going to people who were seen as skilled or experienced in the topic at hand. This ranged from friends and people “who have degrees in marketing” (Angela), to nurses (Beverly), and those who “have studied vaccination, who have done research on vaccination... scientifically or medically trained” (Andrew). More often than not, the people valued as useful sources of knowledge in various areas were those deemed as having more knowledge through their study, qualifications, or experience in the topic at hand. For instance, James discussed relying on people in the field seen as “smarter” and who “knew what they were talking about.”

Participants invariably deemed these sources as “experts” (Andrew, Wendy) and were confident that they were, or would be, reliable sources of knowledge for the topic at hand. Andrew, for instance stated that “people who were further up the chain in terms of research and academia” were “a huge resource” for science knowledge in his teaching career. Similarly, practical knowledge for his current work came from a mentor, who he described as:

someone who’s done the job for a lot longer than me... a person who knows the ropes and knows what to do and knows how to identify, for instance the difference between smoke and dust. (Andrew)

However, experts were not the only valued sources, with some also turning to those seen as equals, including “colleagues” and “parallel teachers” (Andrew) and “partners within the communities” (Angela). As Andrew demonstrated, knowledge can even come from people seen as “junior”:

but that doesn't mean that you wouldn't sort of pick up from other people who were maybe junior to you or maybe, you know, not even involved with the actual classes that you're taking, they might have done it the previous year or a couple of years before that, and they'd moved on to somewhere else. (Andrew)

In addition to the use of experts, the female participants discussed the use of people close to them as sources of knowledge. Specifically, for two of the women their partners were sources of knowledge, with Angela gaining the technical knowledge she needed for her work from her husband. In contrast, Beverly’s partner was a source of life knowledge at a time when she was feeling insecure and naïve as her time in a convent had not taught her anything.

Yeah, yeah it's quite, and then reflect on how you survived and it was in that circumstance I met this person who just, I thought, it wasn't all, he wasn't a brain surgeon or anything like that, it was a person who was very alert to life and just knew, was very aware of his surroundings and what, you know, what to expect in life and I then took that in as my,

absorbing every bit of information I can, cos it's important, so that's quite an interesting, challenging, you know, just to, so you can, when you need information you've got a fair idea, so very aware of what life's all about.

Family members were also sources of knowledge for science-based topics, with Beverly acquiring knowledge about science from her family and Wendy gaining some knowledge about evolution from her parents. Interestingly, parents were not seen as useful sources for two of the women, particularly for knowing how to raise their own children. Beverly noted how she was on her own in this area, as her parents and in-laws “were useless.” Similarly for Wendy, her parents were a source of knowledge for what *not* to do when raising a child.

...how do you know how to raise a child? A lot of it is reactive parenting, you know that what your mum and dad did, what you didn't like, so you're not going to do that... so a bit of parent help, what works for you, but also what didn't work for you when you were a kid, and your parents were beating you over the head with discipline. (Wendy)

Participants also spoke about how they gained or accessed the knowledge from such sources. Specifically, they particularly relied on calling on their contacts or spending time and having conversations with them. Angela and Andrew both described “picking the brains” of skilled people to gain practical and theoretical knowledge for work. Andrew further added that constructive feedback from other teachers and students was also a helpful source of knowing how to teach. Beverly further illustrated the collaborative nature of sourcing knowledge from others:

Oh yeah, but it's fascinating, our family loves science and discussing it and sharing any knowledge we get about, the planet, you know all of that, we're a great one for new discoveries from our armchairs. (Beverly)

However, though collaborative, collegial discussions were seen as one way to source and perhaps construct knowledge, at other times it seemed that knowledge was transmitted and

received through a 'top-down' process. That is, half of the participants saw some of the practical and theoretical knowledge they had gained as passed down from those deemed as knowing more than them. This often occurred through a process of formal training (Tom and Andrew), feedback or teaching.

...there'd be people presenting and they'd be doing sample experiments and sample how to solve particular concepts, understand particular concepts, they'd have big plenary sessions with people who were further up the chain in terms of research and academia, and they'd be, you know, they'd be speaking about the new ideas of teaching science and chemistry and whatever, so that was a huge resource. (Andrew)

Wendy particularly demonstrated her passivity in the process when she stated she has "always been fed information" from her parents, one of whom was a chemistry teacher and the other a university lecturer. This is further seen when she followed the advice of someone she saw as a parenting expert on television and "did a lot of what she told me to do."

Written materials. All of the participants referred to gaining knowledge about various topics by reading many written sources, including printed materials and online ones. The participants detailed both generic and more specific written materials that were useful as sources; this included books, magazines, textbooks, and newspapers as well as articles and reports from universities and large organisations. Notably, two of the participants (Beverly and Tom) mentioned only online forms of written materials and not other forms of written materials.

Half of the participants discussed reading, going to the library and "doing your research" (Angela) as ways to acquire knowledge on various topics, including work, politics, vaccination, or climate change. James particularly attributed a great deal of his knowledge to reading widely and being "well read," with Andrew similarly putting down his "knowledge" on politics to reading "a lot on it." Interestingly, while Andrew finds the library to be "a good source of information," for Angela it depends on the type of library. That is, for work she notes that she does not "tend to use libraries because they're a whole other, I would have to immerse myself in how the library works." In

contrast, for her previous job in politics she noted that having access to the parliamentary library was “the most wonderful thing.” Here though her approach was to make friends with people there and utilise them to source the knowledge she needed.

More specific written sources of knowledge were also mentioned, particularly for general and specific knowledge about science-based topics including climate change, how to conduct science experiments, building atom bombs, statistics, and evolution. These included written sources such as textbooks (Angela and Andrew), science books (James), practical manuals, maths books and non-fiction books (Andrew) as well as “naturalist books, biology books, palaeontology books” (Wendy). James even noted how “any book written since 1945” could provide knowledge on how to build an atom bomb, or “at least have in knowledge to put you towards knowing it.” Half of the participants also used printed and online magazines and newspapers. This included science-related articles published in the science and mass media for Wendy and Andrew. Moreover, Angela stated that she particularly values magazines in her work, and described how:

There are magazines that are, are both online and you can buy them in the shops... And we keep these magazines from the old days because they have such a wealth of information.

(Angela)

These same participants also mentioned official, published reports, “original papers” (Andrew) and articles from large organisations and universities as sources of their knowledge, again for science-based topics.

I was getting IPCC reports from the UN read out to me by [name removed], when very few people were taking it seriously. I learned about the Greenland ice shelf very early on in the piece. (Angela)

Beyond the use of online magazines and newspapers, all but one (James) of the participants talked about going “onto the Internet” (Tom) when they needed to know something. This was particularly the case when they did not know something, as highlighted by Beverly and Tom:

...and then if I don't know something I'll look it up on the Internet, and find out what it's all about, so I've just been on some penicillin, so I'll look that up and see whether that's right for what I've got, so yeah. (Beverly)

...if I don't have them in my head, I'll go find them, you just go and look it up, we live in the information age, it's great, you can find anything you want... Well, we have, we have a set of standard resources and contacts, but, in the event that it's something out of the box that I don't normally deal with I just go onto the Internet, and my skills at defining a search field are pretty good so I can find whatever I need. (Tom)

While participants discussed going to particular sites, such as the Bureau of Meteorology (Andrew), for their immediate needs, more often than not they relied on conducting online searches or pulling “up stuff on the website” (Wendy). This included making use of the search functions of their browsers (Beverly), in addition to search engines like Google Scholar (Wendy). As Beverly demonstrated, “I'd go to Safari and type in whatever I'm interested in.” Notably, this was a more recent source as Andrew pointed out: “well earlier on there wasn't any sort of online things or YouTubes.” Moreover, it has usurped other sources for Beverly, who now sees no need in “getting the dictionary or the encyclopaedia or anything else.”

Other sources. Four of the participants also identified general sources of knowledge, including training, their accumulated knowledge and experience. Andrew, for instance, talked about how the initial theoretical knowledge for his teaching career came from university, while the practical knowledge for his recent work came from a “formal training day.” Tom similarly noted how “if I go back to my earliest experiences of work where I was in a laboratory, if you look at the knowledge there, the knowledge is, is gained by training.”

When it came to knowing how to do things, such as helping people, solving problems, and working with others, participants did not tend to refer to specific sources of their knowledge such as people or books. Instead, many discussed drawing on their own “hard-won experience” (Tom) as sources of knowledge in these areas. It may be that they do not remember where such knowledge initially came from, just that they know it. Angela, for instance, described pulling on her many years of experience in different roles to know how to work with others. Andrew similarly discussed drawing on his lengthy teaching experience to know how to do his recent job:

So, I found that quite interesting to do and also I really enjoyed teaching the prospective primary teachers because a lot of them didn't have much of a background in maths and science, it was, so in terms of what I knew it was my own experience from teaching secondary science and maths for 30, 35 years. (Andrew)

For half of the participants, the personal experience drawn on was described as a process of “trial and error” (Tom). Again, this particularly related to knowing how to do things, such as practical work knowledge and solving problems.

but most of it's just hands on and making the odd mistake and then remembering that mistake in the future. (Andrew)

I came to know how to do it through the many mistakes that I made over the years. (Angela)

Half of the participants also discussed the importance of drawing on knowledge they had accumulated from various personal and professional experiences. Beverly, for instance, described relying on her “general knowledge” to solve problems and help others. She also highlighted how she is the “go-to” person among her family and friends for various topics, and draws on the knowledge she has gathered over time:

...you do gather your, your memory, or your, things you know, don't you, it builds up and by the time you get to this age, you've got it down pat, and then you can hopefully help the younger ones and support them. (Beverly)

Participants also added the importance of having knowledge and experience in their head to draw on as needed. Having such a base of knowledge seems necessary for getting their work done and building on existing knowledge. In these cases, too, it appears they see themselves as a source of knowledge.

I need to have quite a wealth of knowledge in my head I guess of resources for people, how to find solutions to problem... so we'll talk about that and work through that and then I'll apply my knowledge of services or supports that work with that particular problem. (Tom)

if I didn't have the breadth of experience and the knowledge that I've got inside my head, it wouldn't matter, because there'd be nothing to connect to. (Angela)

In contrast, Wendy acknowledged that she has never really relied on herself as a source of knowledge:

So, I've never really trusted my own, and maybe that's the difference between [brother] and me, my brother, is that I've never really trusted my own, my own brain. (Wendy)

Further to this, Tom detailed how his personal and professional experience has been a key source of "valuable knowledge" for him. Specifically, his "broad experience" working with many different people and in diverse fields is drawn on when solving problems or working with others. He highlighted the knowledge used in his current work role as coming from

an accumulation of experience, it's an accumulation of lots of things I guess where a lot of what I do is kind of fly by the seat of my pants, because I have to be adaptable, I have to be able to respond to changing situations, so there's no script, so that one, that kind of work

relies on, I guess yeah adaptability, flexibility but still having a background of information to draw on, but you won't be doing it sequentially, you'll be actually pulling that information out, almost ad hoc depending on the way that the conversation's drifting, cos we're talking about people in crisis who are telling a story, usually which is fragmented, not sequential, highly emotive, stressful and, so yes, you need to be able to kind of switch on and switch off all sorts of aspects of your knowledge base and experience base to come to the table for that, does that help? (Tom)

It seems that for Tom, there is a difference between knowledge "gained by training" for his past job in a laboratory, and that accumulated through experience that he applies in his current work.

... and then there's just, as I said the common sense and then there's my acquired knowledge, you know, the areas that I can, sometimes it's people have got issues with something that's not your standard everyday thing and I just happen to be able to speak into that because I've had experiences in the past. (Tom)

He also discussed relying on common sense in this role which he defines as "a range of knowledge that we have that enables us to function as human beings and in the absence of that we make mistakes."

Source evaluation. The participants also discussed why they valued the sources they relied on. In particular, they tended to trust people or written sources seen as credible, having expertise, being reliable, or unbiased. Firstly, many of the people trusted as sources were those seen as credible. This credibility often stemmed from the person's role, experience, seniority or deemed expertise in their field and that they "knew what they were talking about" (James). Wendy further illustrated this point when she stated,

For something like physics if I'm stuck I'll go to my lecturer, now I'm pretty confident my lecturer knows what he or she's doing, otherwise they wouldn't be a university lecturer.
(Wendy)

Moreover, the participants appeared to place trust in these sources to tell them what they need to know, because of the experience and abilities of such sources. For instance, Andrew noted that the people he would go to for knowledge about teaching would have had “some sort of record of being experienced and competent.” Being respected and recommended by others is also further verification of the source’s credibility and competence, as Andrew indicated:

Yeah, you'd have an idea about their, their modus operandi, for instance if one of them was the science coordinator and that they had a kind of, they'd been there a while and they were respected by others, 'oh go and ask so and so, he'll know', kind of thing, well you would go to them. (Andrew)

For three of the participants, perceiving the source as knowledgeable or smart was important in differentiating those seen as useful from those that were not. For instance, James “always... made use of, made use of having people around who were smarter than me,” while Wendy accepted everything her brother told because he’s “very bright... totally brainiac... he’s my big brother, he knows everything.” In contrast, Beverly’s parents were not seen as a source of knowledge regarding raising children as “they were useless... quite naïve.”

For four of the participants, their experiences with specific sources were also an important aspect in ascribing credibility to those sources. Essentially, a source was valued if it was seen as reliable and consistent in giving the participant the answers they were looking for. Beverly, for example, stated “nurse on call” is a useful source as “they’ve never failed us,” while Angela particularly values the reliability of her work magazines to tell her what she needs to know. Moreover, her experience with the authors of these sources gives another level of trust and credibility to this source.

I know if I buy one of these I’m going to get the information that I need because they've always supplied me with the information I need and I don't think they're going to change now... And I also have experience and know journalists and know photographers that print in

journals and in magazines and I know their credibility and it comes back to experience, you know. (Angela)

The Internet was similarly seen as reliable, with participants noting their experience with it being able to provide the answers or resources they are looking for. Wendy, for example, stated that Google scholar is good at “bringing up the actual reports that are done on these.” As Beverly noted,

...you just type in something and there is the answer, so it's all covered... I'd just type in, I'll get in Safari, and I'll just type in, like this table name, push the entry button and there it comes up and you might have 20 or 30 options on the side effects, what it's for, what else it'll do, you know, all sort of things, so it's endless what you can just find out instantly, so yeah, it's great, I think. (Beverly)

Two of the participants also discussed preferring those sources they saw as nonbiased. This particularly related to the media, with participants commenting on the need to consider the agendas of media owners and blog writers. As Wendy noted, she trusts the ABC because it is “not owned by people with their own agenda,” it gets a “broader picture of what's going on” and reports have revealed that it shows “no bias.” James similarly stated that he prefers authors without a hidden financial agenda, along with a track record for their work:

...again that circle of reading 12 different things, do you read just one because someone puts it on a blog and says 'well this is what I believe' or you get out there and read a scientific paper written by somebody who's written 10 other scientific papers saying exactly the same thing, who's not making any money out of it, versus a person who's writing a blog saying, no it's wrong, is, you know, getting funded and you're sort of going, no, my scepticism kicks in and says, well, if you're taking money for something, you know, who's profiting? (James)

Moreover, sources not seen as gaining a financial benefit from disseminating knowledge are deemed as trustworthy portrayals of objective knowledge. This is illustrated by Wendy who stated she trusts

the knowledge about vaccination from doctors and scientists in the area particularly because they have “nothing to gain from vaccinating your child.”

The participants also valued sources for other reasons. One source was valued simply because of its existence:

Oh, look the only magazines that survived are good... the ones that are on the stands in the in the music shop or in the news agency if they've survived, I know they're good. (Angela)

Andrew also valued written sources when the knowledge they provided was accessible; this was particularly the case for books that took scientific topics or research publications and “condensed” them “into books” “in a readable way.”

Well, mathematicians, I know Adam Spencer, he's a, he got to uni as one of the star maths students, and when he became, when he came into the field of mathematicians, he realised he wasn't a star at all, he said well these people are far brighter than me, so he became a maths and science communicator and so he's written books about things like, you could look at Adam Spencer's books or Karl Kruszelnicki, the science guru, they write sort of science and maths in a readable way, which gives you lots of sort of facts I suppose about what might happen and the chances of it happening and all of those sorts of things. (Andrew)

Two of the participants even distinguished between sources to demonstrate their preferred qualities in a source. For instance, James and Wendy differentiated between the opinions of those seen as biased by a financial agenda, from the reliable, verifiable, and objective scientific writings of others. Moreover, they valued knowledge obtained from peer-reviewed articles over opinion pieces in blogs and the media.

You have to trust it [peer review] over some opinion piece or something out of Natural News. It's [Natural News], a bunch of loonies out there, they're a bit anti-VAX, anti-GMO, anti-science, anti-listen to logic and reason. (Wendy)

James similarly preferences sources who have studied a topic for years as opposed to conspiracy theorists "who have a belief that the government's out to get them":

...it's trying to talk to people who have a belief that the government's out to get them as opposed to people who've studied aeronautics, and you're sort of going, well you know what, I might just go with the people who've studied aeronautics. (James)

Wendy even goes as far as insisting that knowledge she will accept from a university needs to be done by "a good university, it's not some, you know, drama college in back block New York, it's actually Stanford or, you know a decent college."

Participants also noted the huge volume of information and "millions of different answers" (Wendy) that could be found on the Internet. As Beverly stated, "it's endless what you can just find out instantly," while Angela noted, "with the online magazines there's a plethora of those." While the multitude of information that could be gained from an Internet search could be seen as a strength, it was also a weakness of this source. That is, the magnitude of sites meant "you just can't go into all of them" (Beverly). Therefore, participants needed to differentiate between those sites worth considering as a source and those that need to be instantly dismissed. As Tom elaborated, "I'm fairly good at figuring out, when you do a search that there's a, you know, there's a huge amount of rubbish and there's some good knowledge." Wendy further specified the need to use sites that can be substantiated, as university taught her to "be very, very careful of my sources, you can't just go on the Internet and go 'oh, why is the sky blue?' you'll get millions of different answers, you actually have to go to sites that you know can be verified."

Four of the participants described how they "filter through all the different options" (Beverly) and evaluate different sites on the Internet. Various criteria were used, depending on the

type of knowledge that was needed. For some, Internet results were filtered by various criteria, such as “geographic information” (Tom) or interest (Beverly). Beverly also reported trusting sites of “well-known brand names” and evaluating where the source is from:

Well, I'd probably go to the source and think, well, that's a bit American, or whatever country, and I'd, more rely on the Australians, like is it Wikipedia and all that different things.
(Beverly)

For Tom, various criteria were also considered with a foremost consideration being the relevance and suitability of the results for the needs of his client:

I'm fairly targeted in terms of what I need to know so I guess there'd be geographical issues in most cases, if you're looking for whatever solution is in a reasonable distance of where you are, so geographic information is important and then a brief of the services, if I don't know them I'd be looking at the kind of services they provide, and making some decisions as to whether that was valid for the client that I'm working with. (Tom)

Two of the participants also spoke about judging the quality of online sources such as magazines and articles by evaluating the language used in them. It seems they quickly get a sense for the author and how the material is written. This then determines whether they will continue with that article or site or dismiss it.

I'd make an assessment based on the presentation of an article and it made sense and, you know, I get a feel for those things where I think this person's just a rat bag so I'm not going to even bother reading it, so I dismiss a lot of things on the basis of I guess, I hate to use the term, but prejudice. (Tom)

with the online magazines there's a plethora of those and but I, it, it only takes me a minute, or a couple of minutes to know if I'm at the right site because I know just by the language

that they're using, it's like if you go to buy some face cream and you go and you read the information that's there and you go "oh that's just crap" you know, and you move onto the next one, it's very much the same for me with the magazines you know some of them... it doesn't take very long to go through 150 different types and just tick them off, you know, you just go nah, yes, no, no, no, no, no, no, yes and once again it comes back to the language, it comes back to the standards of journalism and you can pick it pretty quickly, you can get through a lot, and that's good, that's really good. (Angela)

In addition to source credibility and trustworthiness, participants also spoke about the need to be careful of some sources. Tom highlighted this necessity stating, "I don't instinctively think that every kind of institution or research document or official government paper is necessarily a hundred percent right, I reserve the right to be suspicious." Wendy also demonstrated the need to be wary of sources close to you:

Although it does, it is nice to have 50 people say "don't you look lovely" but you're not going to trust them because they're your friends, course they're going to. (Wendy)

Both Andrew and James also noted the need to be sceptical of the knowledge presented by politicians. Specifically, they highlighted not taking what is said by politicians at face value:

OK look well if I can't trust you on face value, I'm going to dig deeper to get out there and sort of go, OK well I'm going to read your policies, you know, and find out, what you actually physically support. (James)

... but really, you take a lot of it [politics and politicians] with a grain of salt with, see what they say and see what they end up doing. (Andrew)

Half of the participants particularly highlighted the “many agendas” (Tom) of various sources, which biases the knowledge presented by these. This included sources seen as distorting the truth or attempting to refute more reliable sources for their own financial gain.

again that circle of reading 12 different things, do you read just one because someone puts it on a blog and says 'well this is what I believe' or you get out there and read a scientific paper written by somebody who's written 10 other scientific papers saying exactly the same thing, who's not making any money out of it, versus a person who's writing a blog saying, no it's wrong, is, you know, getting funded and you're sort of going, no, my scepticism kicks in and says, well, if you're taking money for something, you know, who's profiting. (James)

It's, a bunch of loonies out there, they're a bit anti-VAX, anti-GMO, anti-science, anti-listen to logic and reason. But they're also trying to flog their own stuff, I mean they're going to say, don't, don't listen to doctors who've spent, you know, 30 years in their trade because I've got this supplement I want to sell you. (Wendy)

Participants also noted the political agendas of various sources, which results in various aspects or interpretations of the truth being presented. James for instance described how written material often includes many different opinions, each dependent on who the writer supports politically. Tom also conceded, “there's many agendas” and that knowledge about a topic is often “hugely political” with “truth on both sides of the argument.”

However, criticisms about source quality were most notably targeted at the media. Participants specifically highlighted the superficial nature of material in the media today, calling into question its value as a credible source. As James noted about the media today, “things are never delved in deep enough because they don't make good copy.” Similarly, Tom lamented that

Sadly, a lot of our, I was going to call them newspapers, they're not, media outlets are... trending more towards just being social media commentary than anything of intelligence,

finding intelligent journalism in the common media today is pretty hard, I think a lot of it's just waffle to be honest, emotive and it's kind of there to get attention and it's not much better than Facebook. (Tom)

This critique is echoed by those who saw the media and its owners as presenting knowledge in a way to suit their own financial and political motives. James was particularly sceptical of the media and the impact their financial and political agendas have on the portrayal of information within them.

That's not to say that I'm sure that, you know, they'd be getting out there and going, you know what, they invaded us once, maybe they'll come back again, that's not to say it's not an underlying thing, it's but that the reality is going, they haven't done anything to us for 25 years because they are not really interested in overtaking us anymore, you know they've got enough of their own problems, but that doesn't suit the purposes of people who profit by having, you know you don't sell newspapers on happy news.

In an exception, Wendy noted trusting the ABC because it is "not owned by people with their own agenda," it gets a "broader picture of what's going on," and reports have revealed that it shows "no bias." However, she is also critical of other media and its owners:

I've been fairly comfortable with what the ABC, it does seem to get a broader... picture of what's going on, it's certainly not owned by Fairfax or Stokes or Packer or what's the other one the idiot that other Murdoch guy, but I mean, the ABC's not owned by people with their own agenda... Yeah, I do understand that people who own media don't own it because they are altruistic. Certainly not Murdoch, there is nothing, nothing philanthropic about him, is that the right word, philanthropy, yeah philanthropic yes. I don't think he owns any television stations, but he certainly owns a lot of our newspaper media and that's really quite frightening. (Wendy)

Because of these agendas, participants noted needing to question and not just accept what is presented in the media. Moreover, they were mindful of the need to “get rid of all the extraneous stuff” (James) to get to the truth:

...whereas the media works on the basis of going, we make money out of this you know, so we're just going to do this, my scepticism comes into play. (James)

There were also negative connotations associated with the knowledge and the approaches of some organisations, such that they were seen as tainting all knowledge associated with that field. James particularly illustrated the impact that Monsanto has had on knowledge of the science of genetically modified organisms. Moreover, because of Monsanto’s financial and political agendas, James suspects others are now sceptical of the science, instead of separating the science from the organisations who use, or abuse, such science.

you know, Monsanto do themselves no favours and they don't really care, because they are making bucketloads out of it, so why should they, and they've got enough money to get out there and sort of if anybody objects to it they can just lobby for something like the TPV to say that, OK, if you don't like it, I can find some financial restitution along the line, because I lobbied really well to get it, and sort of yes, they're the ones who give, you know, things like, GMO a bad name, because nobody can advance the science without it being discredited all the time, quite justifiably, by what Monsanto do. (James)

Likewise, Tom noted how the rejection of knowledge in particular areas due to the fallibility of that knowledge can result in a scepticism being transferred to all knowledge put forward by the sources of that knowledge.

I guess there's a smaller group of people who reject it on the basis of counterintelligence that there might be problems with it because of, this side-effect or that side-effect and so

they then marry that to a general distrust of society, particularly corporations and governments. (Tom)

Summary of sources of knowledge used by participants. Table 9 provides a summary of the specific sources of knowledge used by the participants. As can be seen, a variety of each type of source was used by the participants. Of note too are the variations in the number of sources used by each participant.

Table 9

Summary of Participants' Sources of Knowledge

Source	Participant					
	Angela	Wendy	Tom	Andrew	James	Beverly
People	Skilled people Friends/people in marketing Contacts Partners within the communities, the council Husband	Experts Parents Expert on TV Lecturer Brother Thousands of people who've done 20 years' study at university Thousands of scientists Teacher	-	Experts Scientifically/medically trained people People further up the chain in terms of research and academia Mentor Colleagues Parallel teachers Junior teachers Scientists Mathematicians	Experts Smarter people in the field	Nurses Partner Family
Written materials	Textbooks Music trade papers Magazines (online and printed) Official IPCC reports Info from universities Reading Library	Naturalist books Biology books Palaeontology books Science-related articles published in the science and mass media	-	Textbooks Practical manuals Maths books Non-fiction books Science-related articles published in the science and mass media	Science books Reading	-

Source	Participant					
	Angela	Wendy	Tom	Andrew	James	Beverly
		Verified study done by a university Published report and peer-reviewed The ABC		Science books (research publications condensed into books) Original papers Print media Newspaper Reading Library		
	Online	Online	Online	Online	-	Online
Other sources	Experience Training Trial and error Knowledge inside head	Self NOT a source	Experience Training Trial and error Self/wealth of knowledge in head Broad work experience Common sense	Experience Formal training Trial and error University	-	General knowledge

Note. Dashes “-” indicate that no source was mentioned by the participant.

Discussion

Sources of knowledge. In the interviews, participants spoke about numerous *sources of knowledge*, which referred to where they acquire(d) their knowledge from. Various sources were described, including *people*, *written sources*, and *others* including training, accumulated knowledge, and their own experience. The participants also discussed why they valued these sources but were wary of others. As with *justification for knowing*, participants spoke about a larger range of sources and in greater detail than in current models, thus responding to Chinn and colleagues' (2011) calls to investigate a broader range of sources and examine the grounds for trusting such sources.

This theme is consistent with Chinn and colleagues' (2011) third component of epistemic cognition, which includes sources of knowledge alongside justification of knowledge and other epistemic achievements. In their framework, sources of knowledge "refers to where knowledge originates, such as a person's reasoning or perceptual processes" (p. 142). Further, while five sources of knowledge are generally discussed in the philosophical literature, including perception, introspection, memory, reasoning, and testimony (acquiring beliefs from the claims of others), other sources include faith, intuition, experience, revelation, success, tradition, sacred scriptures, special mystical or religious experiences, fiction, art, literature, and findings of research (Kitchener, 2011). Chinn et al. (2011) also noted how, in most epistemic cognition research, authority and experience tend to be the most commonly investigated sources (although these are sometimes included as justifications). The results from the interviews appear to be consistent with the sources of authority/testimony and experience, while providing further elaboration of these terms.

Specifically, testimony, which refers "to all social forms of sharing information and knowledge with others" (Chinn et al., 2011, p. 152) would encompass the use of external sources, including experts and other people as sources. This would also include the knowledge products created and disseminated by these sources, including the various written sources discussed by the participants and the training mentioned by both Andrew and Tom. The results from these interviews therefore provide detail on the specific external sources being used, and for which topics. This list

extends beyond experts and skilled people to include family, friends, community partners, and junior colleagues. Moreover, a variety of written sources was also mentioned by the participants, from articles, reports and textbooks to magazines, newspapers, and the Internet (note that the Internet is discussed separately below).

The other sources mentioned by the participants, including training and accumulated knowledge, are consistent with the source of experience (Chinn et al., 2011). Chinn and colleagues (2011) particularly noted that experience, which is one of the most common sources investigated in epistemic cognition research, can be taken by participants to include many sources, including perception, introspection, intuition, reasoning, memory, and research findings. Given that participants spoke about acquiring knowledge over time and then remembering that knowledge to apply that in the future, the labels of experience and accumulated knowledge as used in my results may therefore more accurately have been labelled as the source of memory. Similarly, participants also spoke about drawing on knowledge “in their head,” which might more accurately be labelled as memory or introspection in the philosophical literature (Chinn et al., 2011). Specifically, Chinn and colleagues (2011) noted that introspection refers to people’s examination of the contents of their own minds and thus produces knowledge of one’s own internal experiences. While most participants spoke about what could be classified as external sources and their own self as sources, they tended to turn more to the external sources (e.g., other people, experts, written sources) and see these as valued and reliable. Moreover, while they did see themselves and their own experience as sources of knowledge at times, this often related to know-how, such as knowing how to do things and solve problems.

This study also provides explicit details about the specific sources of knowledge actually used by adults. This is in contrast to developmental models and Hofer and Pintrich's (1997) framework which focus on beliefs about knowledge coming from either internal or external sources, and the supposed sophistication, or not, of these beliefs. It also indicates the relevance of sources of knowledge to epistemic cognition, despite this not being a distinct dimension in current integrated

models. That is, recent models and measures, apart from those explicitly based on Hofer and Pintrich's (1997) conceptualisation, have not tended to include *source of knowledge* as a dimension or instead subsume it under *justification for knowing* (e.g., justification by multiple sources in the trichotomous framework). In order to understand why it was evident in the interview results, despite not being a feature of current models, a closer examination is warranted of not only my analysis of the participant's utterances and meanings, but also the extant literature and the various terminology in use. That is, given the possible overlap of dimensions and drifting terminology in the current models, further fine-grained analysis of the terms *justification* and *sources* is needed, to clarify this terminology as philosophers and psychologists are using them and how I have used them. It must be particularly highlighted that in my results, based on my analysis of the participants' words and meanings, I created two separate categories of *justification for knowing* and *sources of knowledge*. Further, I differentiated between people (including experts and authority) used as justifications for knowing (i.e., as reasons given for accepting a claim) and those seen as sources (i.e., where knowledge is transmitted or came from). In contrast, philosophers count authority/testimony as a source of knowledge, while in more recent dimensional models, authority tends to be viewed as a form of justification. As highlighted by Chinn et al. (2011):

It appears to us that the constructs investigated by EC researchers as “sources” and those investigated as “justifications” are often the same (e.g., “authority” and “experience” may be treated as a source in one study and as a basis for justification in another). Most of those in this list would be viewed by philosophers as sources. Hence, we have mixed categories of sources and categories of justification together in generating this list. (p. 152)

Furthermore, it has been suggested that in Hofer and Pintrich's seminal framework, not only is the justification dimension vaguely defined, but there is also considerable overlap between the source and justification dimensions (Greene et al., 2008). Specifically, Hofer and Pintrich (1997) grouped justification and sources of knowledge together under the umbrella of 'nature of knowing'. Sources were seen as being on a continuum; on one end knowledge was viewed as originating

outside the self and residing in external authority, from whom it may be transmitted. On the other end, the source of knowledge was seen as the individual who constructed knowledge in interaction with others. Justifications, in their framework, ranged from the justification of knowledge claims through observation and authority, or on the basis of what feels right, to the use of rules of inquiry and the evaluation and integration of different sources.

Later models extended on Hofer and Pintrich's (1997) model and did not clarify the distinctions between sources and justifications, or even merged these two. For instance, Ferguson et al. (2012) note that, in the EOCD, Greene and colleagues particularly drew on philosophical epistemology “which identifies a number of different sources, both internal and external to the individual, that can be legitimately used to justify knowledge claims” (p. 104). Here, while indicating that sources can be both internal and external, the main focus of sources is on how they are used to justify knowledge. That is, the distinction is not beliefs about *where* knowledge comes from, but justification of knowledge *because* of where it came from (e.g., “If a math teacher says something is a fact, I believe it”; Greene, Torney-Purta, & Azevedo, 2010). Ferguson et al. (2012) subsumed Hofer and Pintrich’s *source of knowledge* dimension under *justification for knowing* in the trichotomous justification framework; thus, *justification by multiple sources* became one of their three forms of justification. This was defined as the extent to which individuals find it necessary to ensure the veracity of claims by consulting more than one information source (Ferguson, 2014). More recently the five categories from Chinn and colleagues’ (2011) framework were integrated into a unified framework, the AIR model (Chinn et al., 2014; Chinn & Rinehart, 2016). Notably, sources, justification, and virtues and vices were all reconceptualised as subtypes of reliable processes (the third component) involved in generating and evaluating knowledge claims.

Further examples of the overlapping terminology between the source and justification dimensions can be seen when questionnaire items are analysed, as shown in Table 10. For instance, the JFK-Q, EOCQ, DEBQ and Conley et al.’s EQ all have similar questions along the lines of believing as a fact or true what is said by a teacher or written in a textbook.

Table 10

Sample Justification and Source Items from Epistemic Cognition Instruments

Instrument	Dimension	
	Justification	Sources
JFK-Q	<p><i>Justification by authority</i></p> <p>If a natural science teacher says something is correct, then I believe it.</p> <p>Things that are written in natural science textbooks are correct.</p> <p>If a scientist says that something is a fact, then I believe it.</p>	
EOCQ	<p><i>Justification by authority</i></p> <p>If a [mathematician/historian] says something is a fact, I believe it.</p> <p>If a [math/history] teacher says something is a fact, I believe it.</p> <p>Things written in [math/history] textbooks are true.</p>	
DEBQ	<p><i>Justification for knowing: personal</i></p> <p>First-hand experience is the best way of knowing something in this field.</p> <p>I am more likely to accept the ideas of someone with firsthand experience than the ideas of researchers in this field.</p>	<p><i>Source of knowledge: authority</i></p> <p>If you read something in a textbook for this subject, you can be sure it's true.</p> <p>Sometimes you just have to accept answers from the experts even if you don't understand them.</p>
ISEJ	<p><i>Justification by authority</i></p> <p>When I read something about an educational topic on the Internet, I evaluate whether this information is written by an expert.</p>	

Instrument	Dimension	
	Justification	Sources
	To determine whether information I find about an educational topic on the Internet is trustworthy, I evaluate whether the author has sufficient knowledge of the topic.	
Conley et al.'s	<p><i>Justification of knowledge</i></p> <p>Good ideas in science can come from anybody, not just from scientists.</p> <p>Ideas in science can come from your own questions and experiments.</p>	<p><i>Source of knowledge</i></p> <p>Whatever the teacher says in science class is true.</p> <p>If you read something in a science book, you can be sure it's true.</p>
TSEBQ-N	<p><i>Justification</i></p> <p>To check whether what I read about climate problems is reliable, I try to evaluate it in relation to other things I have learned about the topic.</p> <p>When I read about issues related to climate, I try to form my own understanding of the content.</p>	<p><i>Source</i></p> <p>With respect to climate problems, I feel I am on safe ground if I only find an expert statement.</p> <p>When I read about climate problems, I only stick to what the text expresses.</p>

Note. JFK-Q = Justification for Knowing Questionnaire (Ferguson et al., 2013); EOCQ = Epistemic and ontological cognition questionnaire (Greene, Torney-Purta, & Azevedo, 2010); DEBQ = Discipline-Focussed Epistemic Belief Questionnaire (Hofer, 2000); ISEJ = Internet-Specific Epistemic Justification Inventory (Bråten et al., 2018); Conley et al.'s = Conley et al.'s epistemological beliefs in science questionnaire (Conley et al., 2004); TSEBQ-N = Topic-Specific Epistemic Beliefs Questionnaire-Norwegian participants (Bråten et al., 2009). Italics indicate the dimension name for that instrument.

However, in the former two scales these are part of a *justification by authority* dimension, while in the latter two they are part of the *source of knowledge* dimension. Moreover, while Conley et al. (2004) state that their *justification of knowledge* dimension is concerned with how individuals use evidence and evaluate claims, the questions in their justification factor instead tend to focus on where knowledge can come from. Furthermore, in the TSEBQ, items for the *source of knowledge about climate change* dimension were written to assess where knowledge about climate change resides (e.g., personal judgements and interpretations or expert authors), while those for *justification for knowing about climate change* focussed on how the trustworthiness of knowledge claims about climate change can be evaluated. However, factor analyses revealed items written to assess source of knowledge loaded on the justification dimension and vice versa.

This brief analysis highlights the fuzzy nature of terminology use in the field, thus raising the question as to whether there is a real distinction or not between justifications and sources. It further lends support to ongoing criticisms in the field regarding how these constructs are defined, delimited, and measured. In summary, a strong case for the need for conceptual clarity can be made here. Moreover, it points to the need to closely consider and clarify participants' meaning making of their experiences as well as the real-world implications of differences in meaning; this may reveal an artificial segmentation between the justifications and sources themes. Closer inspection of the participant's comments in this study reveals that some of the statements that were categorised as *sources of knowledge* may more accurately be described as justifications (i.e., *justification through others*), while other statements highlight the discrepancy between professed beliefs and epistemic practices or processes. Further reorganisation and refinement of the qualitative analysis may therefore be warranted. Specifically, several possibilities arise from my categorisations. Firstly, some of the segments coded under *sources of knowledge* may be representative of sources in the original meaning of the word (that is, *where* knowledge comes from). Participant responses here could include those in which they explicitly discussed where particular knowledge came from, including Andrew stating mentors and academics were sources of work knowledge and Angela and Beverly

talking about their partners as sources of work and life knowledge, respectively. These appear to be reflective of their past experience and may involve their memory in that they are recalling where they obtained or learned that knowledge from. Implicit in this, though, is the assumption that, by taking on board this knowledge, they see it as justified knowledge. Exploring with participants whether that is the case is therefore necessary to check this assumption. Alternatively, if this is not the case, more appropriate terminology here could be "sources of information" (Sinatra & Lombardi, 2020). Further, while reliant on memory, such responses represent what participants do or have done instead of their abstract beliefs about who or what is a good source of knowledge.

Other segments in the interviews may more accurately have been coded as *beliefs about sources* (as in Hofer and Pintrich's [1997] dimensional framework). This would include utterances in which participants discussed *where they would go* if they wanted to know something, such as the following:

For something like physics if I'm stuck I'll go to my lecturer, now I'm pretty confident my lecturer knows what he or she's doing, otherwise they wouldn't be a university lecturer.

(Wendy)

so how would you say you know whether we should vaccinate for diseases or not? Andrew:

I'd look at the science, I'd look at the, the people have studied vaccination, who have done research on vaccination... scientifically or medically trained. (Andrew)

These segments reflect the idea that knowledge about these topics is transmitted by these external sources (and why they see these as trusted sources). An alternative explanation is that these responses are reflective of their past experience with these sources and related to their epistemic practices, not just beliefs. A further possibility is that these utterances are indicative of metacognition, that is, participants reflecting and thinking about *what or who is a good source* and not necessarily the sources they *would* use. In such cases, there may also be an element of social desirability at play, in which case the participants are answering based on what they think is the best

answer and not necessarily indicative of their own beliefs or processes. That such brief segments could be indicative of implicit beliefs, epistemic cognition processes, or metacognition (among others) highlights the challenges of interpretation inherent in qualitative research, particularly given the possible differential outcomes associated with each. Essentially, though, given low correlations between professed beliefs and reasoning processes (Chinn et al., 2011; Schraw, 2013), accuracy in naming constructs is vital to ensure we are measuring what we want to measure.

Another alternative is that some of the segments coded as sources could have been coded instead as justifications (particularly *justification through others*). This would fit with Chinn et al.'s (2011) definition about testimony referring to all social forms of sharing information and knowledge with others. For example, when Angela was asked to justify her knowledge about climate change, she confidently talked about all the places that this knowledge came from (including university courses, textbooks, discussions with husband, and reports). Some of this was coded in *justification by others*, because of her confidence that she knew this, while others appeared more relevant to *sources of knowledge*. However, this could have been coded either way, and therefore would require further consideration and clarification.

Source evaluation. At this point, it is also worth considering the subtheme of *source evaluation* and how this might also help with understanding and differentiating between the themes of *justification for knowing* and *sources of knowledge*. Participants provided many reasons for why they used or trusted particular sources of knowledge including credibility, expertise, seniority, smartness, experience, reliability, consistency, existence, accessibility, verification, and being seen as unbiased. Participants also discussed assessing the agendas behind particular sources, such as the media and politicians, and were particularly wary of those seen as biased. While source evaluation is not an explicit dimension in developmental or dimensional models, Chinn and colleagues (2011) highlighted the importance of examining the *grounds* by which individuals trust various sources as they are arguably important in accurately predicting or explaining individuals' learning processes, reasoning, and outcomes, beyond just considering which broad sources are used. Moreover, the

Epistemic Ideals component of the AIR model (Chinn et al., 2014; Chinn & Rinehart, 2016) similarly considers source evaluation in the form of standards expected to be met regarding the testimony from others. Also consistent with the subtheme of source evaluation is "epistemic trust," which considers how individuals evaluate information from a source and decide whether to trust that the source is providing reliable knowledge (Sinatra & Lombardi, 2020). Evaluations of epistemic trust include the source's expertise, integrity, and benevolence of the source, which are similar to some of the evaluations identified in the interviews (Hendriks, Kienhues, & Bromme, 2016).

The growing literature on sourcing and source evaluation is also relevant here. This is a burgeoning field which considers how individuals identify and represent source features including who the author is, their credentials and possible bias, their position and level of knowledge on the topic, their purpose and motives for writing the material, and when the material was written and updated (Brante & Strømsø, 2018). As can be seen, many of these were identified as source evaluations in the interviews. It may be the case though that, while related to epistemic cognition, sourcing/source evaluations is a distinct construct. Notably, some research within that field considers how an individual's beliefs about knowledge and knowing influence their evaluations of a source's credibility (Barzilai, Tzadok, & Eshet-Alkalai, 2015; Bråten, Britt, et al., 2011; Strømsø, Bråten, & Britt, 2011). Specifically, source credibility is said to be influenced by a variety of epistemic factors including expertise (indicating knowledge or competence) and trustworthiness of the source (Bråten, Strømsø, & Salmeron, 2011). Further research then is needed to explore whether source evaluation is part of epistemic cognition or a related, yet distinct, construct.

Another possibility worth exploring is that participants' source evaluations, in combination with their use of those sources, imply justifications for their knowledge. That is, it is possible that by discussing *where* knowledge on a particular topic came from as well as *why that source was valued*, the participants were attempting to justify their knowledge. Sources and their evaluations may thus be more appropriately categorised under *justification for knowing*. Considering the wording of items in scales relating to *justification for knowing*, this suggestion is plausible. For example, items in the

ISEQ and ISEJ discuss checking whether knowledge that one comes across is reliable or trustworthy by evaluating whether it is logical or consistent with current knowledge, consistent across multiple sources, or written by an expert or author with competence or sufficient knowledge of the topic. It may also be the case that in some recent models and associated measures (e.g., JFK-Q, EOCQ; see Table 10), sources of knowledge and their tacit evaluations have been combined as a type of justification. That is, the implication is if a trusted source (e.g., a teacher or scientist) says something, an individual would accept it and say that they know it (e.g., *"If a scientist says that something is a fact, then I believe it"*). The question then that is relevant to the analysis of my interviews is whether a participant stating, *"my knowledge that climate change is real **came from** science and scientists"* (which would fall under *sources of knowledge* in my analysis) is equivalent to saying, *"I know that climate change is real **because of** the science/what climate scientists have said about it"* (*justification for knowing*). Further, an individual saying, *"X is a good source because it is credible"* may by extension be taken to mean, *"Therefore, if X tells me something, I accept it as valid knowledge"* or *"My knowledge on Y came from X. I see X as a trusted source. Therefore, my knowledge on Y is justified."* Such a recategorisation would be consistent with the *justification by authority* dimension, with individuals with a strong belief in this justification saying they "know" something if an expert, teacher, or other reputable source said it (Greene, Torney-Purta, & Azevedo, 2010). It would also fit with the claim that research on source evaluation focusses on answering the question of how individuals determine whether a source of testimony is reliable, or not (Greene, 2016). In future, further probing of statements made alongside follow-up interviewing could be used to explore and check such interpretations.

Internet as a source. Not surprisingly, all of the participants discussed using the Internet as a source of knowledge. Not only did participants discuss sourcing knowledge from the Internet when they did not know something, but they also discussed the various Internet sources they used, from specific sources to general searching. They also discussed how they evaluated the Internet as a source, including its reliability and their experience with it providing the answers they are looking

for. Moreover, while some mentioned the volume of information on the Internet as a possible risk, they also recognised the need to differentiate between better and poorer Internet sources and discussed their evaluation criteria.

The use of the Internet as a source is therefore a valuable addition to traditional and philosophical conceptions of sources of knowledge. Recently, there has been an increase in research focussed on the use of the Internet as a source, alongside the justification and checking of knowledge on the Internet. Two measures have also been developed including the ISEQ (Bråten et al., 2005) and the Internet-Specific Epistemic Justification Inventory (ISEJ; Bråten et al., 2018). The ISEQ was developed based on Hofer and Pintrich's (1997) conceptualisation to assess beliefs concerning Internet-based knowledge and knowing. Their *source of knowledge* dimension focussed on beliefs about the extent to which knowledge is thought to originate and reside in the Internet, from which it can be transmitted, rather than being constructed by the self. The results from the interviews therefore extend on this through details about not just which specific sites are used for various topics, but why they are used, or not.

More recently, the ISEJ, based on the trichotomous justification framework, was developed to assess epistemic beliefs concerning the justification of knowledge claims encountered on the Internet. The source evaluations discussed in the interviews have some consistencies with items from the ISEJ, including items that focus on checking or evaluating the reliability or consistency of information on the Internet (in the *personal justification* dimension). Some of the evaluations used by participants were also similar to those in their *justification by authority* dimension, including the evaluation of the author and their expertise or competence as well as the need to go to sites that can be verified. To some extent, participants' comments about how they manage the volume of information on the Internet relates to the final dimension in the ISEJ of *justification by multiple sources*, which concerns evaluating information found on the Internet by checking several information sources and comparing across websites. However, the results of this study also extend on this with detail about additional criteria considered by the participants, including more personal

and pragmatic criteria such as source location, interest, source reputation, language used in the source, and ability to provide the required knowledge.

Considering the literature, several think aloud and interview studies have also explored how individuals evaluate the credibility or accuracy of websites as a source, as well as the veracity of information on those sites (Hofer, 2004; Mason et al., 2010ab, 2011). Particularly, think aloud studies by Mason and colleagues (2010b, 2011) have shown that students evaluate aspects of websites such as source popularity, authoritativeness, and scientific nature. A similar study utilising retrospective interviews identified that middle school students evaluated online source credibility on the basis of clarity, completeness, agreement/disagreement with prior knowledge, already being used for school assignments, expertise, and inclusion of scientific evidence (Mason, 2010a). Similarly, Hofer (2004) noted results from think aloud studies that high school and college students evaluated online information for its utility, length, specificity, and whether it meets the student's purpose, accessibility, level, and the intelligibility of the writing.

The evaluations discussed by the participants are most consistent with the evaluations mentioned in these studies of source popularity and authoritativeness, agreement/disagreement with prior knowledge, expertise, meeting its purpose, accessibility, and level and intelligibility of the writing. Notably, the think aloud studies coded the source evaluations based on predefined categories, thus raising the possibility that additional evaluations might have been evident had coding been deductive, as in Mason's (2010a) study and in the current study. Additional source evaluations identified in this study include the existence of the source and the source being seen as smart or unbiased. Participants in this study did not discuss the inclusion of scientific evidence, although this might have been because such detail was coded in the justification theme. Some of the other source evaluations not seen in the interviews may also be due to the previous studies having been conducted with students, and thus including academic criteria for source evaluation. The results of this study therefore also highlighted the benefit of using deductive coding, as it allowed for a consideration of evaluations used by participants and not just those expected by researchers.

Chapter 7: Influences on Knowing

Results

The participants alluded to various factors that influence how they seek out, evaluate, and use knowledge. These included external influences, such as frames of reference, access to knowledge, other people, and time. Internal influences were also identified, including individual characteristics, personal biases, and emotions. These influences were seen as both facilitators and barriers in the acquisition and evaluation of knowledge. Andrew particularly illustrates how several of these influences come together to form one's personal philosophy through which to make sense of knowledge claims:

It's kind of like you build up a philosophy which is a, a mismatch of, a miss mash of what you've learned, what you've been told, the kind of things your parents did and knew... so how do you know, you sort of get, you get influenced by parents, family and then your education and then you sort of work through things with that kind of, influences from friends and so on that you sort of respect, I guess. (Andrew)

Frames of reference. Various frameworks, including science, education, and religion, were seen as influencing several of the participants' approaches to knowing. One participant, Tom, spoke explicitly about the need for a "framework of reference" to help convert information to knowledge:

Yeah so I guess that the word I'd come up with maybe is a framework of reference that you need, because there's certainly some things out there, some blocks of information that are absolutely no value to you at all cos you've got no framework to... convert that into knowledge. (Tom)

The idea of needing to convert information to knowledge came from a previous manager of Tom's who pointed out that "information isn't knowledge, it's just information." Tom elaborated this as a process of taking the information that is available, evaluating it using common sense, past

knowledge, and past experience, and then drawing a conclusion. He pointed out that the conclusions drawn are not always necessarily right and that everyone does the best with the information they have. He further highlighted that some people do better with some types of information than others, and this is due to the different frameworks that people have:

I guess, you do the best you can, you take the information available and you weigh it on a scale of common sense and sanity and past experience and you draw a conclusion, it doesn't mean you're always right... you've done the best you can with the information you've got and obviously some people can do a better job with information than others and that could be field-specific so, you know, you, you might read papers that are, you know, based on psychology and you'll understand it and be able to make sense of it and convert that into an outcome, whereas maybe someone who hasn't got any understanding of that could read it and make not a scrap of sense to them and get nothing out of it, so the information is useless, so I guess training is part of it too, you know, your skill set. (Tom)

These frames of reference can be field-specific, whether that is science or psychology. The influence of these frameworks, particularly science, is seen in how the participants defined themselves and justified what they know. Tom, for instance, “value[s] science enormously” and is “strongly in favour of science” and described how “as a scientific person I, I’m fairly confident that human activity is going to make some change to the climate, that’s probably a fairly good sound bit of knowledge.” Similarly, Andrew, with his background and training in science, stated he is “big on probabilities” and discussed drawing on this framework to “work through all the probabilities” in relation to vaccination. He also relies on science as a way to evaluate knowledge claims and accept or reject them. As he stated:

I suppose I’ve got a fairly, fair background in science so I can just look at something and say oh no that's not necessarily right, for instance my partner got this glass recently, not recently it was a couple of years ago and it was a particular shape and the people who were selling

these glasses said if you, if you put water in these glasses it makes the water different, you know, cos of the shape of the glass, so the water's better for you, and I thought no that's not right but, we've still got the glass but, you know I just knew, I just dismissed that straight away as being mumbo-jumbo. (Andrew)

According to Tom, training and education play a role in creating these frameworks. This includes university, which “teaches you how to gather information and turn it into some knowledge” (Tom). Wendy’s experience of university as a mature age student further illustrated Tom’s claims about the importance of having a framework. Specifically, her recent studies at university further cemented the importance of science and backing up knowledge claims with evidence, particularly influencing the type of evidence and sources she relies on, from “random websites” in the past, to “verifiable scientific evidence” today. University also played a role in her developing an awareness of the sources she uses to seek out information.

Oh, now where do you go, that’s a tough one because that’s something uni has taught me to be very, very careful of my sources you can’t just go on the Internet and go “oh, why is the sky blue?”, you’ll get millions of different answers, you actually have to go to sites that you know can be verified, and that’s a really tricky thing and I think that comes from being taught from Uni ... but if I didn’t have that sort of experience, and that sort of education, I’d probably struggle, and I’d be far less aware of this seeking out information just to confirm what you already know. (Wendy)

Religion was also mentioned as an influence on the approach to sourcing and justifying knowledge by three of the participants. However, for each of these three it had a different impact. For Wendy, her upbringing as an atheist meant that she “violently reject[s] the idea of accepting anything without evidence.” When justifying her knowledge of evolution, Wendy also highlighted how she has no religious beliefs clashing against it that would challenge her ability to accept the truth of this claim:

I've always had the view of evolution being, I was taught it at school and it's never been something that I was told was wrong, I have no religious beliefs clashing against it. (Wendy)

In contrast, James attributed his religious upbringing to his tendency to argue about, and question, everything presented to him as knowledge. He described how he “developed a scepticism in myself as such” from his upbringing in an Irish-Roman Catholic background and added that, to this day, this scepticism sees him questioning everything presented as knowledge. James also attributed his religious background to knowing the importance of checking out and questioning the perspectives of others, to verify your own perspective:

...don't know whether or not it's just my contrary nature with things, because of being brought up as an Irish Catholic, whereas we always have to just because we like a talk and an argument, which is a good and a bad thing, yes you have to, even in things that you openly dislike, like I, say for argument's sake, take Andrew Bolt, for argument's sake, I will sit there and I will put up with listening to him through the thing, no matter how much I hate it, and despise it, I listen to it because you can't know what the other side's thinking unless you know what the other side's thinking. (James)

For another participant, Tom, his religion was a framework, used in conjunction with science to make sense of the world and knowledge within it. More specifically, this belief system had an influence on the ultimate value Tom placed on needing to know certain types of knowledge:

...underpinning that [science] I also have a belief system that affects that so, even though I have a great sense of science being important, my belief system would have some bearing on that... Well... I guess it's the only way to put this in a nutshell is that I have a Christian view of the world and therefore that suggests that the Earth was, has begun and has an end date, so I'm not, I don't believe that we're on a spaceship that's gonna be there forever so my ultimate concern for the climate change isn't a huge issue so I'm not gonna spend much

time analysing or worrying about it because I kind of have a belief that overrides that, does that make sense? (Tom)

Tom elaborated how his concern for ultimately knowing about science, climate change, or any related problems is therefore fundamentally influenced by his religious belief system. Further, he does not seem as concerned with determining whether it is occurring or not, because he sees a bigger picture.

So pretty much what I guess I'm saying is that when you have a worldview that's based on a revelation about the reality of what you're living, it must intrinsically affect even how you view science... or climate change or any of those problems that we seem to be facing as a human race. You know if I was, if I thought the world was all there was and this is the only chance we've got and this is the one, this is the beginning and end of it all, you know, I'd be pretty, I'd be a bit stressed about climate change but because I have a bigger view than that in which climate change is possible, significant, but not eternally of any great consequence, I don't spend any time thinking too much about it. (Tom)

James, however, cautioned accepting as given knowledge disseminated through religion. Specifically, he sees religion as a framework providing a guide to true knowledge, but not representative of reality:

go and find out, you know the, the reading of the, our understanding, because up until that time you are told well these are all parables and things like that, which is great, and they are not to be taken as being, you know, as read, they are meant to be, as in, guiding you somewhere as opposed to being reality, and so you go through and you have to start figuring out exactly what it meant in that regard, and so sort of how does that relate to, to now, or whether or not it does relate to now. (James)

Access to knowledge. Being able to access knowledge was also noted as an important influence for the participants. They particularly noted that, at times, knowledge could be hidden by others and removing barriers to accessing knowledge was vital. For Angela, the advent of free tertiary education removed barriers to accessing knowledge, particularly with regards to climate change. Moreover, she saw that this access allowed objective information about the climate and environment to be shared with lots of people, in contrast to the private universities she saw as biased because of financial agendas.

when Gough Whitlam brought in free tertiary education, there was a whole generation of teachers who learned about the environment and cli- what was then called global warming and what they did when they finished their courses, they went to teach in schools and they would take the kids out to the local lagoon and they would get samples of the water and they'd take them back to the school to test them to see they had contaminants in them and I truly believe that this all came from those years of free education which gave people an opportunity to learn things that otherwise they never would have had an opportunity to learn, and where the Ivy League universities and the big universities that charged lots and lots of money were being funded by the companies that were unfortunately responsible for putting the contaminants in the lagoons in the first place, so I think there was a whole generation of people who became teachers and who became scientists who the, you know those companies would rather have not, you know, those people probably would have been better for them if they hadn't had that tertiary education experience and I feel we're going back that way again, that they're trying to keep people out of universities because we're dangerous to the big companies because we learn stuff and we challenge them. (Angela)

Another felt that knowledge was hidden or not provided by their education; in effect, they were kept ignorant by it. That is, while for Tom, Andrew, and Wendy their education or socialisation in a discipline refined their own process of knowing (as noted above), for Beverly her early education

had a negative influence. Specifically, she identified that growing up in a convent had limited what she knew, in that “after seven years in a convent you don't know much”; this lack of knowledge about life and the world around her resulted in her being naïve, lacking confidence and at risk of harm and depression. However, once leaving the convent her world expanded, thus creating a need to rapidly acquire practical knowledge to ensure her survival.

it was like going from an enclosed environment to surviving, so it was, so I did have a few lucky escapes there, just being very naive and trusting... I was so dumb, and then the police would come along and they'd say, just tell them you know us and all the rest but the police protected me and they'd send me on my merry way, so I wasn't really aware of any danger, at all... you know, but it all sort of, I don't think it affected me at the time, but it did affect me later in life when I realised just how much it affected my confidence, and it made me understand why I am who I am, when I understood what happened when I was younger.

(Beverly)

Moreover, participants noted that at times knowledge was not accessible because others would hide it from them or “refuse to give that information to the public” (Angela, regarding climate change). Andrew specifically noted how it is hard to know what is happening with regards to the government’s asylum seeker policy, because “they’re keeping it pretty much closed shop down in Manus and Nauru and you can’t even see what’s happening, you only get bits and pieces coming out.” Knowledge was even kept from the participants by people close to them, such as Beverly’s family:

Yes, I found out a lot of things later on that I didn't know was going on, I thought we were going along very nicely, but they were sneaking out, getting up to a bit of mischief, nothing too bad, but, you know at the time I thought I had it all under control, but probably better I didn't know. But you're not, not looking for the signs I think, whereas now, I'd be quite aware of what everyone's up to, you're just too busy bringing your family up, but yeah,

yeah.... So, it's sort of hilarious that I thought I had really good control, and yet I'd missed a lot of, kids tell me now, or they don't really tell me a lot, but yes it's a bit of a laugh... things that I was not aware of, too naïve, so I hate to think what the real bad kids get up to, goodness me! (Beverly)

Various reasons were hypothesised for why knowledge was kept from others, from “fear of public panic” (Angela) to a desire by others to keep them “well protected” (Beverly) from certain knowledge.

Other people. Many of the participants identified various people in their lives as having an influence on what they know and how they know it. Some were influenced by people close to them when they were growing up; these people influenced their approach to knowing by encouraging them to not just immediately accept what was presented to them as knowledge and to also back up their own claims with evidence.

my dad was a policeman and I'd be watching something on television as a kid and he'd say, I'd go "ooh look at that, you know, this happened" and he'd go "how do you know?" And I'd go "well, well, I think it did" and he'd say, "well you're gonna have to back it up." And, and I think that's where I got this evidence thing from. (Angela)

Tom's manager influenced his approach to knowing by encouraging him to consider how information is converted to knowledge. James similarly noted being encouraged by a priest to question everything, to consider the biases and agendas of different sources, and to utilise various sources. This is an approach that James still references and utilises to this day:

...our chaplain, one of the priests from ours was a chaplain from the university... because he was the chaplain for the university, he got out there and he said, question everything, everything, question religion, question you know what you've been told by your parents about it, it was all to do with the religious side of it and stuff like that... Cos fortunately, in

one way, he wouldn't help us out, he told us to go out and question and said, well look you know, sort of, if I give you the answers, how are you going to get out there and ask the questions, well I'll just ask my mates, and he's going, well that's OK, yeah but I'm in the business, you know, obviously I have a point of view, as in, he's obviously got his point of view because he's already in the trade, so his is going to be coloured by what his opinion is, so he wanted us to get out there and go and ask other people. (James)

For others, their parents had an influence on knowing specific things, such as who to vote for. Perhaps, this is not about knowing who to vote for, but just recalling where their voting preferences came from.

so yeah I think, my, the way I vote is determined by what my parents did, my background, because they had, they had a long time with one Prime Minister and they weren't really happy with that and they wanted to have changed and eventually there was change, and so I'm just kind of rusted on in that, to that party. (Andrew)

and how do you know, I think you are influenced by like, the Catholics were very liberal, my mother was, whose father was working on the docks, he was Labor, she was Labor, and dad was Catholic and Liberal, so in a way you inherit that, who you might lean to... so how do I know? I think probably influenced by family, so definitely dad. (Beverly)

Time. Five of the participants talked about the need for time in order to know certain things, and that not enough time could be a barrier to knowing. Specifically, they felt they needed time to gather and consider enough information before drawing their conclusions about what they knew, or not. This was the case for knowing related to work and about whether they liked someone or not. Essentially, without enough time, they felt they did not know everything they needed or wanted to know. Angela, for instance, noted how in her previous work she never had enough time to do sufficient research to gather the knowledge she needed and work through the issues at hand;

instead, she often felt like she would be “thrown in at the deep end” and that “there was always a little bit that you didn’t get to.” Both Wendy and Andrew noted that you cannot know whether you like someone “straight away” (Wendy), with time needed to get to know them well enough “if you want to read what they’re like” (Andrew).

Moreover, for two of the participants, not enough time had passed for them or others to be able to see what was happening and draw firm conclusions about climate change. As Tom and Beverly noted:

Look I, that’s a tough one, because I hold the view that, possibly I haven’t lived long enough and nor have my peers or my ancestors lived long enough to actually fully explore what the climate’s been doing. (Tom)

Well, I believe it's not, and why I believe that is, we're basing everything on the last 200 years, I mean we don't know what the climate was like here a hundred thousand years ago, you know, it's constantly changing, so for me I think there's too many people on this Earth. (Beverly)

Beverly further added:

I think we very focussed in on very small window of 200 years or two, 300 years of nothing in the timeline and I think when you expand that out to think of what has happened, I can't see how what's happening now, I mean it's seeing all the, we're just getting more and more people, saving more, and to me it's just quite a very small window we're looking at and you look back a hundred years and you think, my god, only a hundred years and we were way back in the dark ages, sort of, you know? (Beverly)

For Beverly, the passage of time also allowed her to reflect on, and realise, what she knows now but did not know, or had hidden from her, in the past. This particularly related to knowing about her

family and her children, and how her children hid knowledge from her to protect her. With time to reflect, Beverly can also look back on her journey from not knowing, and not being confident, to being a survivor today.

Well, looking back. At the time I was an absolute wreck and, you know, I was walking in my sleep and screaming all night, apparently, but, I did cope with it, a lot of rejection, you're at a boarding school, they're not allowed to be your friends for the first year, you know, but it all sort of, I don't think it affected me at the time, but it did affect me later in life when I realised just how much it affected my confidence, and it made me understand why I am who I am, when I understood what happened when I was younger, and yet it's given me, I'm very protective of my family and I think it's because of that, yeah, so, it's so interesting. (Beverly)

Individual characteristics. Individual characteristics were also noted as influences on one's approach to knowing. For all but one (Wendy), an inherent tendency to be interested and curious about the world around them motivated them to seek out knowledge about the areas and topics that interested them. This influenced them to read more, ask others about topics, and be open to new ideas. For example, James described how being "a science geek" made him interested in climate change and motivated to ask questions about the changes he was seeing. Similarly, Angela's curiosity and interest in the environment and "local environment issues" prompted her to seek out more knowledge about climate change and turn to various sources to find further knowledge and evidence of what was happening. Beverly is similarly passionate about politics and global issues like overpopulation, which she finds interesting to think about. She discussed how her family "loves science and discussing it and sharing any knowledge we get about, the planet, you know all of that, we're a great one for new discoveries from our armchairs." Moreover, Beverly is influenced by a desire to know the answers to everything:

I just like knowing the answers to everything, or understanding things, whether it's growing plants or whatever, I just love sort of working it out and doing what you can and then you're over it so, yeah, it's great, I think. (Beverly)

Tom similarly put his diverse knowledge base down to his curiosity and interest in knowing about various topics.

people have asked me the question a few times in my life, [Tom], how come you know so much about so many diverse subjects and I said, hmm I'll say the simplest answer to that is I'm a sticky beak, I actually am interested in what makes anything tick, you know, if it's sitting there in front of me, I'd like to know how it works." (Tom)

Likewise, Tom described how his interest in global politics motivates him to "read a lot on it and have a lot of knowledge on it."

When talking about their knowledge on various topics, participants also often identified themselves as people interested in knowing, particularly in scientific areas. Tom, for instance, saw himself as a "sticky beak" and "scientific person," Wendy described herself as "fairly logical," and Andrew stated he is "big on probabilities." It appears they see it as part of themselves and their identity to know many things and to be questioning the knowledge presented. Further, it seems necessary for them to be involved in the process, not just passively accepting knowledge but actively seeking it out from their sources, questioning and considering it, and being open to considering new ways of seeing things. In contrast, James, who described himself as a "science geek," noted an innate tendency to not just accept what is presented as knowledge, but to question everything.

... there's never any serious questioning, it's because, two reasons, it's one, it's good marketing, whereas the media works on the basis of going, we make money out of this you know, so we're just going to do this, my scepticism comes into play... my natural distrust comes up as in saying, OK look well if I can't trust you on face value... (James)

However, as noted earlier this may also have arisen from his religious upbringing.

Personal biases. For four of the participants, their own biases also impacted on their approach to knowledge. Specifically, two of the participants noted how their evaluation of material from sources is influenced by their own biases towards such sources. Both James and Tom explicitly referenced being “swayed by your own persuasion” (James) and dismissing “a lot of things on the basis of... prejudice” (Tom). There was also a tendency by the participants to selectively seek out information to confirm what they wanted to know or what they thought they knew. Both James and Wendy acknowledged this inclination, with Wendy admitting,

I’ve done it myself, I’m certainly guilty of this, is going off and looking for something that confirms what I think already happens, that confirmation bias... Ah, yes, my niece has got involved in selling diet products and I think they’re a load of rubbish and to show her that they’re a load of rubbish, I’ve just pulled up stuff on the website that says this is all a load of rubbish, but, but I didn’t even check the source, I didn’t check their, their referencing, I didn’t check their, their citations, I just went in and said “look, it’s a load of rubbish.” Of course, she did exactly the same, got out the information that confirmed that, that what she’s selling is good stuff and did exactly the same as me. So, I was totally guilty of confirmation bias in that, in that instance. (Wendy)

Moreover, Beverly, while not explicitly mentioning this tendency, also demonstrated it when searching online:

... generally, it marries in quite well, cos you've got a fair idea what you're going to end up with the answers, so, very interesting that you can then get your thoughts verified, or confirm what you're thinking is, that's it, that's the main, yes. (Beverly)

... if you do go into a couple you end up getting a fairly consistent, you know, things are very similar. (Beverly)

Emotions. Participants also described how their emotions influenced their sourcing and evaluation of knowledge. This included emotions getting in the way of thinking rationally and drawing logical conclusions following the evaluation of knowledge claims.

And you can't let your emotions get in the way. You have to be very careful with that because you can really, really, really like someone and they're a dodo and you just have to realise you've gotta let 'em go. (Angela)

There was also an acknowledgement by Beverly of the need to "curtail your emotions" because of the risk of them blinding your judgments:

To me it's probably a bit more personal, but you might believe in a person, you might know a person, but if you believe in a person you've got a confidence or something, yeah, I don't really know that one, yeah, it's tricky, but we do have our own beliefs, and that's probably the structure of your, who you are, is what you believe in and that makes you quite, especially when you get a bit passionate about it, you know, not wishy washy, but when you start getting a bit passionate about what you believe, sometimes you have to curtail your emotions. (Beverly)

Specific emotions, namely fear and anger, were reported to have an impact. Tom noted how his anger regarding wars and asylum seekers has impacted on his ability to process knowledge about asylum seekers and reach a conclusion regarding his knowledge on this topic:

my political mind is angry that we, globally have allowed situations to develop where we've gotta face this fallout so I'm more inclined to think the argument's not about whether we should have offshore processing or onshore processing or whether we should open the borders and just let people flow in, but actually, I think my mind has been preoccupied with the, it's a kind of righteous anger that we as an international community have allowed things like the Syrian war to go on for whatever reason and I'm sure there's many agendas and we

have a thing called the United Nations which has sat on its hands, allowing all this to happen so that's probably why I haven't drawn a conclusion. (Tom)

For two others, fear associated with the uncertainty of not knowing and not keeping up with others meant there was a need to seek out knowledge to minimise such risks. For instance, Angela's fear of making mistakes motivated her to do more research to gain more knowledge for work to "make sure I'm not talking through a hole in my head." The fear of falling behind in the business world because of changing paradigms also motivated her to know more and make changes to her business based on the knowledge she acquired.

I was looking at other areas where downloading was starting to happen and I, and that made me twig that, how, what sort of effect could this have on our business? And then I got really scared because I thought it can have a really big effect... that's how I kind of got to the point where I said to the guys "okay this is it because we're going to die a death if we don't move with the times" (Angela)

Similarly, for Beverly, the fear associated with not knowing "who we are bringing in" (regarding asylum seekers) puts us at risk of "being naïve in who we let enter" and could include letting in "radicals," "rule breakers," or "troublemakers." She thus highlighted a need to protect ourselves through knowing who we are letting in.

but I do think we need to perhaps make sure that we know who we are bringing in, because you could end, it's a bit like the Trojan horse, you really don't know, who is coming in, and they have to be, we have to protect ourselves and if we don't, we're silly I think. (Beverly)

Discussion

The third theme, influences on knowing, included the factors that facilitate or hinder the production, sourcing, or implementation of knowledge. These included external influences: frames of reference, access to knowledge, other people, and time; and internal influences: individual

characteristics, personal biases, and emotions. These factors are important to consider given the recent interest in the field on the development of interventions aimed at fostering adaptive epistemic cognition in learners.

Frames of reference and other people. Participants discussed how frames of reference, including science and religion, and access to education had an influence on how they acquire knowledge, make sense of it, question it, or convert information to knowledge. These influences are not unsurprising given that education has long been seen as a key facilitator of change in an individual's epistemic beliefs (Hofer, 2016; King & Kitchener, 1994; Kuhn, 1991; Perry, 1970). Particularly, the frames of references may represent what is discussed in the literature as disciplinary perspectives on knowledge and knowing. These signify the accepted processes with which knowledge is accessed and justified in a discipline, such as physics or history. Tom's comments about frameworks of reference, including science and psychology, indicate his knowledge of the normative practices of different larger epistemic systems and how these are used to make sense of knowledge claims.

The results also provide an illustration of the participants applying the disciplinary approaches to knowing they have learned, particularly approaches relevant to science, to other contexts. This transfer of epistemic competence from one context to another is a skill necessary for enacting competent epistemic performance outside one's area of expertise (Greene et al., 2021). However, as noted by Sandoval et al. (2016), further research needs to examine *how* the disciplinary practices learned in educational contexts transfer to knowledge judgement processes in everyday contexts (i.e., outside schooled contexts).

Further, the participants reported that their upbringing as well as education, through training and university, were the means by which they learned these normative practices. *Other people* also had an influence here in informing the participants about different frameworks and approaches to justifying knowledge. These included a family member, manager, and priest. In particular, it indicates the role of other people beyond teachers and experts in individuals

developing one's approach to knowledge, especially regarding metacognitive aspects such as knowing how to know. Such an understanding of who is an influential person to different individuals is therefore important to consider when designing and delivering epistemic cognition interventions aimed at teaching more adaptive approaches to knowing.

These influences are consistent with the idea of social epistemology, which considers how individuals interact with, and are influenced by, others, in pursuit of their epistemic aims (Goldman, as cited in Greene, 2016). These include community and societal level influences of classrooms, schools, communities, the media, and the political climate (Hofer, 2016). The results of these interviews therefore add to the growing evidence of the social context of epistemic cognition and the need to account for it in research and interventions. Further, the shifts in some of the participants' approaches towards evaluating knowledge claims by using evidence, other processes, and considering sources, are illustrative of the process of epistemic change (Bendixen & Rule, 2004). These examples thus provide support to the assumption that epistemic cognition can change as a result of individuals' social interactions with the sociocultural context, across the lifespan, both in and out of school (Bråten, 2016).

Access to knowledge. The subtheme of access to knowledge shows how this influence is like a condition or precursor to knowing. That is, if information is hidden or individuals are kept from accessing it, then they are not able to engage in epistemic cognition processes to evaluate those claims, determine if they are knowledge, and then act on them. With knowledge colloquially seen as power, withholding knowledge or making it inaccessible could also be seen as a way for larger organisations to hold onto that power; that is, by not having knowledge about certain topics such as climate change and the asylum seeker policy, others are prevented from acting upon such knowledge. This subtheme may also be related to sources, particularly those that are unreliable or with their own interests that result in them transmitting their own truth or hiding the truth from others. Nonetheless, this subtheme highlights that beyond facilitating access to educational

interventions to foster adaptive epistemic cognition, efforts must be made to remove any barriers to access knowledge in the first place.

The influence of other people, particularly parents, was also seen on knowing who to vote for. In reflecting where their voting preferences came from, this may more accurately have been coded as *sources of knowledge: people*. This specific question could also be argued to be outside the scope of epistemology.

Time. For the participants, time was another influence and was needed so that they could gather all relevant details and reflect on the topic at hand, before coming to a conclusion. At times, this related to knowing related to work or whether they liked someone or not; notably these topics may not truly be relevant to epistemology. Nonetheless, both Tom and Beverly's statements about time needed to know about climate change possibly indicates a lack of understanding of, or trust in, scientific inquiry to make reliable inferences about the climate from hundreds or thousands of years ago. In this case, time to gather enough data, better, clearer models to predict the past, or even better understanding of such models, would be seen as conditions for knowing with regards to science as a reliable process, as per the AIR model (to be discussed in theme four; Chinn et al., 2014; Chinn & Rinehart, 2016). Alternatively, their reluctance to draw conclusions about climate change may demonstrate a need for definitive, unambiguous answers; this reflects the thinking disposition of need for closure, which is seen as an epistemic vice (to be discussed shortly).

Individual characteristics and personal biases. Participants were also influenced by their own individual characteristics and personal biases, including their interest, curiosity, and scepticism, as well as prejudices and confirmation bias. These fit with the literature on epistemic virtues and vices, commonly discussed by virtue epistemologists, and said to describe relatively stable dispositions of character that either aid or hinder the achievement of epistemic aims (Chinn et al., 2011, 2014; Chinn & Rinehart, 2016). Specifically, epistemic virtues, such as honesty, open-mindedness, and willingness to think deeply, are said to dispose individuals to use reliable strategies (e.g., such as considering alternative points of view before making up one's mind) that are more

likely to produce true beliefs. In contrast, epistemic vices, including dishonesty, dogmatism, close-mindedness and need for closure, tend to lead individuals to utilise approaches resulting in false beliefs (Chinn et al., 2011). Despite their proposed influence, little educational research considers epistemic virtues and vices in studies on epistemic cognition (Chinn & Rinehart, 2016). Current results, though, indicate these have an influence on how participants seek out, evaluate, and either dismiss or accept knowledge. Specifically, curiosity and interest motivated the participants to seek out new knowledge and not just accept it, but actively question it and be open to new ideas. This further supports the claim that certain thinking dispositions, such as being reflective and willing to think deeply, are likely to be associated with higher levels of epistemic cognition (Sinatra, 2016). Finally, it is not surprising that participants discussed how interest in different topics influenced their approaches to knowing, given that topic interest has been shown to be a strong predictor of one's justification beliefs (Bråten et al., 2008).

Personal biases meant that participants either sought out knowledge to confirm what they already knew or wanted to know, or rejected knowledge because of the sources it came from, instead of evaluating the claims on their own merits. Notably, while some demonstrated awareness of these biases, others did not, indicating an avenue for future intervention studies. Furthermore, that biases were mentioned is consistent with research that there are many cognitive biases that could hinder one's evaluation of sources and evidence, including proximal thinking, myside bias, the availability heuristic, and confirmation bias (Sinatra & Lombardi, 2020). Of specific note is confirmation bias, the tendency of individuals to confirm their prior beliefs, which was discussed or demonstrated by several of the participants. Notably, Beverly demonstrated confirmation bias when discussing her Internet search strategies; whether she is aware of this bias and her tendency to engage in it is unclear, given this was not probed in the interview. Further, it remains to be seen whether an individual's awareness of such biases, including awareness raised through an intervention, is enough to reduce these practices. Wendy's comment that she is aware of confirmation bias, but still engages in it, indicates it may not be an influence that is easily addressed.

Emotions. Similarly, participants' emotions also influenced their sourcing and evaluation of knowledge. Generally, emotions were said to get in the way of the logical evaluation of knowledge claims. More specifically, fear and anger were seen as barriers to the drawing of conclusions following the evaluation of knowledge claims for one, but motivated others to seek out more knowledge in order to keep up with other people around them. This is consistent with Greene and colleagues' (2008) suggestion that it is likely that individuals will not always make rational decisions between competing knowledge claims and that such decisions may be influenced by emotions, among other factors. This is also consistent with the post-truth phenomenon, in which individuals base their judgements on their emotions and personal beliefs instead of on objective facts (Prado, 2018). Furthermore, in the AIR model, 'emotion in knowledge-producing processes' is one of the clusters of reliable and unreliable processes of knowledge formation. Particularly, Chinn et al. (2014) noted that recent philosophical and psychological research shows how emotions affect the processing of knowledge. Consistent with the interview findings, anger has been shown to cloud judgement, while curiosity motivates efforts to find answers to questions.

As with epistemic virtues and vices, only limited research has examined the relationship between emotions and epistemic beliefs (e.g., Muis et al., 2015; Muis et al., 2021; Trevors, Muis, Pekrun, Sinatra, & Muijselaar, 2017). However, these studies have focussed on how epistemic beliefs (based on Hofer and Pintrich's framework) predict epistemic emotions, and how these emotions in turn predict learning strategies and learning outcomes. For example, studies (e.g., Chevrier, Muis, Trevors, Pekrun, & Sinatra, 2019; Muis et al., 2015; Trevors, Muis, et al., 2017) have shown that epistemic emotions, including curiosity and surprise, predicted the type of learning strategy that students used when studying conflicting texts about climate change and also mediated relations between epistemic beliefs and learning strategies. In another study, epistemic emotions such as surprise, confusion, and enjoyment were found to mediate the effects of epistemic cognition on critical thinking about genetically modified foods (Muis et al., 2021). For instance, a belief that knowledge should be justified by critically evaluating it negatively predicted confusion. In turn,

confusion positively predicted critical thinking. The results from the interviews in the current study suggest the role of additional emotions which warrant further study, including fear and anger.

Moreover, these findings also suggest the need to examine how emotions predict the sourcing of knowledge and enactment of epistemic cognition (instead of just looking at how epistemic beliefs predict epistemic emotions, which in turn predict learning strategies).

Chapter 8: Knowing about Knowing

Results

This theme consists of the various perspectives and reflections on knowledge and ways of knowing discussed by the participants. This comprises their definitions and understandings of the characteristics of knowing and knowledge, including in different disciplines and topics. It also encompasses the processes they were aware of using to obtain their knowledge, their critique of alternative approaches to knowing used by others, and the processes they saw as more or less valid or appropriate for obtaining true knowledge.

Definitions and characteristics of knowledge and knowing. Some of the participants provided definitions for knowing and related topics, including understanding and beliefs. For Wendy, knowing related to memory:

knowing whether you know it or not is going off and thinking of it again without any help around you, then you know what you've remembered and then you know what you haven't remembered and then you go back and you keep learning it that way, I had to do that several times for lots of different things, that's how I knew, that's how I became to know such detailed information. (Wendy)

In contrast, Beverly differentiated between knowing and understanding with a key difference being the level at which it occurred:

it's sort of layers, knowing is the top layer and understanding is going down a few layers til you get to the sort of, I just think, yes, you can know something but to really understand it is to know a bit more, a wider idea of what that is about, yeah... Yes, yes, it's, cos people might know something, but do they really know the whole picture and I would suppose you'd say there, and all the complexities that might surround that little bit of knowledge, but when you look, it's much wider, yeah.

Beverly also added in her understanding of the word 'believe' and how it relates to knowing. Again, there were layers to her distinctions between these words. Moreover, she saw knowing as being a precursor to believing in something, stating "I'd want to know about it before I believed in it."

To me it's probably a bit more personal, but you might believe in a person, you might know a person, but if you believe in a person you've got a confidence or something, yeah, I don't really know that one, yeah, it's tricky, but we do have our own beliefs, and that's probably the structure of your, who you are, is what you believe in and that makes you quite, especially when you get a bit passionate about it, you know, not wishy washy, but when you start getting a bit passionate about what you believe, sometimes you have to curtail your emotions. (Beverly)

Wendy also defined the word 'belief', which she stated means accepting "something as true without evidence." This is similar to Andrew's definition of faith, which he said is "knowing something that you've got no evidence for."

Two of the participants also discussed their formal understandings of knowledge and knowing and how these were defined according to different disciplines. For instance, for Wendy science was seen as an objective way of accessing the truth:

science is a method of finding out, evidence, finding out what's observable and working out from there, it's not feelings or placebo or it's, it's you know, it's like. It's real, whether you believe it or not, it's still real. (Wendy)

Moreover, both Wendy and Tom, discussed that there are different types of knowledge and ways of knowing, that vary by field or role. That is, in some subjects or roles, particularly those related to science, the process for attaining knowledge was seen as quite fixed or certain, with particular steps or processes to follow.

I can give you a comparison between two roles that might help explain that, so if I look at these two extremes, so let's, if I go back to my earliest experiences of work where I was in a laboratory, if you look at the knowledge there, the knowledge is, is gained by training, so you are, everything is analytical and you're working from a script because you're actually doing science so the test procedures are written down so you're following a set of instructions to achieve an outcome and you're recording the result and then that becomes part of the statistical analysis, and so that, that's very structured and very much relies on information that's been given to you either in writing or verbally through training and you can't deviate from that so you can't actually decide I'll leave out steps two and five today because I'm running out of time, so you know, you absolutely know for certain that there's a routine to follow, so that's one extreme where the knowledge is fixed... (Tom)

I'm fairly logical, I'm doing physics this year so this is going to be interesting because they say it's like chemistry but it's more mathematical so I think that it's just step-by-step, learning the logic of it, learning the, learning the, the steps that make a formula and what, what numbers to plug-in, and then just keep doing them over and over and over again, you'd have to learn why, why it works that way and then you have to learn how to do it, and even if you don't know why, sometimes you can't work out why, so you just learn *how* and if you keep thinking about it then you go "oh, that's how it happens." You just keep thinking, I'm trying to work it out and put it in real life situations in your head and eventually the logic comes, so I'm hoping that physics would just be another branch of, of logical steps to follow and just keep practising doing the, the mathematics. (Wendy)

In contrast, in other disciplines such as social work, the process for obtaining knowledge was seen as more flexible.

...and then maybe where I am today, where the knowledge is an accumulation of experience, it's an accumulation of lots of things I guess where a lot of what I do is kind of fly

by the seat of my pants, because I have to be adaptable, I have to be able to respond to changing situations, so there's no script, so that one, that kind of work relies on, I guess yeah adaptability, flexibility but still having a background of information to draw on, but you won't be doing it sequentially, you'll be actually pulling that information out, almost ad hoc depending on the way that the conversation's drifting, cos we're talking about people in crisis who are telling a story, usually which is fragmented, not sequential, highly emotive, stressful and, so yes, you need to be able to kind of switch on and switch off all sorts of aspects of your knowledge base and experience base to come to the table for that, does that help? (Tom)

Five of the participants also provided various perspectives on what knowledge is to them and its characteristics, including its ultimate attainability and associated tentativeness. Essentially, this included what can be known, if at all, and the certainty with which we can accept knowledge. Firstly, two of the participants spoke about knowledge in absolute terms. That is, Wendy and James saw that knowledge represented a "reality" or "ultimate thing" (James) that could be found. Moreover, they both characterised knowledge in a categorical way, in that it could be valid/not (James), or right/wrong (Wendy). In contrast, two others saw truthfulness as part of knowing, yet were more tentative regarding the certainty with which it could be attained. That is, knowledge to them was not seen as absolute and they did not accept a claim (e.g., about climate change) as one hundred percent right or wrong. Instead, there was an acknowledgement of a spectrum of knowing, in which "there's always shades of grey, there's not one thing or the other" (Andrew), with "a truth on both sides of, of the argument" (Andrew). They further talked in terms of probability (Andrew) and degrees of truth, noting that many claims "may or may not be right" and "may or may not be truthful, it may be partly true" (Tom). Andrew further added that we take on knowledge "even though you don't actually know for sure that it's right." This tentativeness applied to various topics, from claims about vaccination, the Big Bang, and climate change to the asylum seeker policy. Andrew also highlighted the tentative nature and lack of absolutes or categories in science

knowledge. Again, he seems to be pointing towards a continuum instead of knowledge in science being black or white:

Oh, you know it's kind of like a tipping point, some people were saying it's a tipping point but, it's just a number, it's one more than 399 and one less than 401, so it's just part of the continuity, whereas some people say, oh no that's just, we've gone beyond the, you know the point where we can save the world and all that sort of stuff. Just using that 400 is, is, as saying it's a tipping point is not a proper scientific way of approaching it. (Andrew, about climate change)

At the extreme end of the spectrum, Beverly introduced the idea of knowledge that is “unknown” and might never be known. This specifically related to science knowledge including the Big Bang.

...but give me an answer on why, and how, not why but how the Earth began and, you know, they're still searching and still looking, I don't think we'll ever find the answer, the Big Bang theory, I mean it's just too much for our brains to comprehend, I don't think we're quite capable of grasping it all, we try, it's a bit like climbing Mount Everest or the bottom of the ocean or, out into the atmosphere. (Beverly)

Other knowledge, such as that related to the “idea of living in space,” is also “way beyond what we know at the moment” (Beverly). Moreover, she is not certain whether we yet know about evolution stating, “I really don't know whether they've quite pinpointed it yet, they haven't quite worked it out.”

Personal processes of knowing. Perhaps because of the uncertainty associated with knowing, four of the participants described the process of obtaining and justifying knowledge as one of weighing up all the different facts and then “making a decision” (Angela) or “drawing a conclusion” (Wendy). While Andrew turned to statistics and probability, others acknowledged a need to weigh up different perspectives and make a decision:

I think that's particularly now in a, in an age where information is so readily available, you, you have to kind of do some comparisons and some weighing, you sort of weigh the information on a scale using, you know, common sense, past knowledge I guess a sense of where people are coming from, I don't know. (Tom)

you sit down with a piece of paper and you draw a line down the middle of it and you put the good things on the one side the bad things on the other side and you go I'm gonna have to make a decision about this person and it'll, if the things on the good side outweigh those on the bad side then you know you've got your answer. (Angela)

Tom particularly spoke about making "reasonable judgements," using his "best judgement," and making a "rational decision," regarding topics such as vaccination and politics. He acknowledged, however, that even making the best decision or using their best judgement, they could still be wrong:

I guess, you do the best you can, you take the information available, and you weigh it on a scale of common sense and sanity and past experience, and you draw a conclusion, it doesn't mean you're always right... you've done the best you can with the information you've got. (Tom)

James, who used the idea of the Venn diagram to represent knowledge as a truth or "the ultimate thing" which is found at the core of various pieces of opinion or information, described a similar process. His process involved looking past the superficial information and opinion, "bypassing a lot of that pretence bullshit with people" and deciding which 'truth' he likes best or suits him most. He noted how this is influenced by the source:

you know, so you go through and sort of you're going, yes all the rest of it becomes, you know, swayed by your personal persuasion, so you try and dig out, get rid of all the

extraneous stuff, it doesn't stop me from having my own opinion, it just gets out there and going, ok, I now know everybody's facts, and going, whose facts do I like the most? (James)

Critique of alternative approaches to knowing. Participants highlighted that there are various approaches to sourcing, evaluating, interpreting, and accepting truth. Moreover, while not asked to do so, four of the participants explicitly discussed the approaches to sourcing and justifying knowledge of other people. This included people close to them such as friends and family to speaking more generally about the approaches of other people, particularly those they saw as using a different way of knowing. It was acknowledged by these participants that individuals use different lenses or ways of knowing to interpret knowledge and come to their own conclusions as to what to trust. Andrew even pointed out that “men and women have different kinds of ways of knowing stuff” while Angela highlighted the importance of providing evidence in the form of “hard, cold facts” when proving your knowledge to people with certain disciplinary backgrounds, such as engineers or scientists. However, participants also often critiqued approaches that were different to their own and put forward various reasons others might not take the standard or ‘accepted’ approach.

Firstly, participants identified the biases to knowing in the approaches of other people. In particular, both James and Wendy noted the tendency for people around them to seek out information to back up their “preconceived ideas” (James, Wendy), while dismissing alternative perspectives or conclusions.

I went back to my brother and had a chat about it and that was an interesting experience too cos I found out my brother was wrong, and that was, that was an epiphany, my brother's never been wrong, aha, my brother was wrong, and wrong, and wrong big time and all he does is exactly the same as my niece, get on the Internet and confirm his biases. It was fascinating... Well, he just looked up his, his physicist who used to work at NASA who's saying this about the, who apparently is talking about how the ice in Antarctica is getting

thicker and bigger and I went [name] this guy's getting paid by somebody or something, this isn't real and how do you know this physicist is at NASA, just because he said so? That's just nonsense, NASA itself, look at the NASA website, but he didn't want to because it's not confirming his biases. (Wendy)

Yeah, she won't believe me because she's got tied up in this. 'It's all a great thing and I'm gonna make lots of money out of it and aren't I wonderful type', you know those multilevel marketing schemes, it's just at the moment I'll just leave it alone because she is so, there's so much information out there that will confirm what she's hoping is true, and she's already thrown a whole heap of money at it so that's what people do, isn't it, they, they, to, to, to back up their initial decision on spending money on something they'll just constantly reconfirm that initial... (Wendy)

You're not trying to pick their brains as in how clever they are, as such, but you just sort of, you discovered that, by the way that they respond to particular, you know, conversations or subjects, whether or not they're, you know, either taken with it being a straight down the line bias, a bias of ignorance or a bias of really well-held beliefs or whether or not they are open to getting out there and saying, you know, I've had my opinion on this and sort of we'll listen to all these other things and then dismiss all those other 11 that I've listened to because they have no other rational comments, but I'd still go with my original thought or I'm willing to, you know, change it. (James)

Participants also added highlighted the many barriers to knowing which can influence the knowing of other people. These particularly impacted on the conclusions that were drawn by others. For instance, they saw that some were blinded by their experience:

my husband who is an engineer could not see through years of experience working with bricks and mortar. (Angela)

or emotions, instead of evaluating claims using science and logic.

but I know because of my experience with people, with humans, that until they get to that point, there's that part of their brain that, that isn't functioning, cos it can't function at the same time as the other part, you know the two of them are in constant conflict. Once they get to the point that their sensible brain is working, then you can start, right back to square one again. (Angela)

you get push back and when people are pushing back at you they're not using the part of their brain that they would be if they were on board with you because they're arguing with you and that, that part of your brain that's being what's the word [pause] logical, and you know dealing with the facts and putting forward, not the arguments, but putting forward the, the vision, if the person is yelling at you going "rararara" that part of their brain is, is not being used, you've gotta wait till you get them to the point where that anger has gone and then you can talk to them and then you can have a discussion with them. (Angela)

...however, some people might do it based on purely emotion, I don't know. (Tom)

They also noted how individuals could be swayed by their own biases or the superficial presentation of information as knowledge by various sources.

I just, it's, I don't know if it's intelligence, a lack of intelligence or, or just fear of the unknown or listening to our, disgraceful former Prime Minister call these people this war on terror crap, I mean it's just insane but yeah. (Wendy)

I think a lot of times people today get engaged in the process politically at a very low level, in terms of social media ... And yeah I know and that's in part because we've, I guess as a community we're kind of doing soundbites and video bites now we're not actually spending a lot of time, really digging into the issue at a big level, things have changed, I mean (sigh)

we had less information and more knowledge, politically maybe 30 years ago, 20, 30 years ago, then we do now because people now kind of get on the bandwagon and then when you talk to them they actually don't really know much about it at all, they just have a strong opinion based on a very small amount of information. (Tom)

The participants were also quite critical of those they saw as rejecting conventional, collectively accepted knowledge. They also hypothesised various reasons for this, from insanity to resistance to change, distrust of corporations, and acceptance of conspiracy.

No and even to this day he can't, he won't. He still thinks we're all getting ripped off. You know it's a big con by the UN to take us over or some conspiracy theory and maybe my brother's not as... oh not as smart, that's not right he's probably as smart as he thinks he is, no he's not as smart as he thinks he is, he's probably as smart as I always thought he was but then maybe I'm smarter than I thought I was. Does that make sense? (Wendy)

James was particularly critical of those he saw as rejecting knowledge or not considering alternative explanations in order to avoid having to change their perspectives or behaviour.

A lot of the times it's because it abdicates personal responsibility, it's like with the denying climate change, because that means that if you, try and find the science that says that, we are not causing it, then you can say, well we're not causing it, the problem's natural and it's gonna happen anyway and I can't really do anything about it, so therefore I'm not going to. (James)

...and so, you sit back and you, work out from the way that they are dealing with the actual question, whether or not they're thinking about what it actually means and whether or not they're just, have made a stance based on going, well this is my viewpoint and I'm not going to investigate it, because if I investigate it I might actually have to change. (James)

James also pointed out how the “withdrawn and discredited” article on the supposed link between vaccination and autism was still influencing other people’s knowledge on vaccination, to the point that they reject any knowledge on the topic as conspiracy and distrust the sources of this knowledge. He also noted how some conflate science and truth on a topic with their own beliefs and ideas of human rights:

...you ever had, you know, German measles, and they're going, 'no' and there's a reason for that, because you were vaccinated as a young woman, said against it, and she says but yeah I didn't wanna be, but yes you're happy not to have German measles, aren't you, and they're going, she says 'no', and says, yes, you can argue against the fact that, you know, if your argument is against, you know, infringements of your rights or your beliefs and things like that, that's fine, do it as such, but don't get out there and make up the rest of this crap about it being, you know, that it's a government conspiracy or sort of the, biotech world's out there to, you know, poison us all and you know turn us into mindless things, and don't come up with all the rest of the crap. (James)

Tom similarly noted how people’s opinions about some topics and sources can influence how they see all knowledge put forward by these sources, to the point that they reject all knowledge from these sources.

I guess there's a smaller group of people who reject it on the basis of counterintelligence that there might be problems with it because of, this side-effect or that side-effect and so they then marry that to a general distrust of society, particularly corporations and governments... (Tom)

This idea of a group with a general distrust in society with different conclusions about various topics is echoed by James. Notably, he highlighted how, while outside the knowledge generally accepted by society, their knowledge may be valid based on their own way of knowing:

we're a mass communal society, so we have to work on that basis as in, what is in the benefit to the greater good, cos if we had people just dropping off left, right and centre from, you know, various sort of things, there'd be a greater outcry from similar people saying that our government's not looking after us and sort of there's a conspiracy to do that and so the unfortunate, and I know that's denigrating our ideals, but a lot of people who hold one view hold similar views about other things as well, not to say they're not valid, in their own mind, or whether or not, they're valid, it's just that they, you know, someone who is, people that I know, who hold views about anti-vaccination, also hold the views about you know government conspiracy with chem-trails, no moon landings, you know, you go and you say to them, don't you think that there might be some sort of pattern forming here that, yes it's great to have conspiracies, and sort of, 50% of what you say is correct, and the other 50% you just need to put a line through because it's just, you know, yeah, anyway. (James)

Wendy highlighted multiple times how others may accept spurious claims without questioning and equated this approach with being insane or lacking intelligence:

I don't actually get it, I have a friend of my, my partner's friend's wife, she buggered off to [place name] and they're all a bit weird down there, with her kids who she refused to vaccinate because it causes autism, and looking at her going, "you seem like an intelligent person, how on Earth can you accept this?" (Wendy)

I actually don't get how you can just dismiss thousands of people who've done years and years of research into this, but they seem to be able to. (Wendy)

I don't understand how people can see other people as not humans and that's how it sounds like they're, they're, they're being, just to get it in their own heads, to justify in their own head to torture children, just doesn't sound like a sane human personality trait, it sounds ever so slightly insane. (Wendy)

Lastly, while mostly critical of the approaches of others, one participant did highlight that most people “probably go with the flow” and are generally accepting of “the wealth of knowledge that we’ve accumulated” (Tom). Specifically, regarding vaccination, he added that:

the majority have just taken it as given because it’s advice being provided by a medical fraternity for a long, long time and generally it’s been trialled and proven to be accurate.
(Tom)

Valid, appropriate approaches to knowing. While generally quite critical of the approaches and beliefs of others, participants also acknowledged that such approaches may be acceptable or ‘valid’ to those people. However, they also clearly favoured their own knowledge and processes for knowing over those of other people. Through their comments on their own approaches and their judgements on the approaches of others, we can see what the participants value as the most ‘appropriate’ or “valid” (James) ways to source, evaluate, justify, and use knowledge. These included objective, evidence-based approaches, science, the right type of evidence, statistics, logic and reasons, and the need to scrutinise knowledge claims. James, for instance, differentiated between knowledge that is right or wrong through an evidence-based perspective:

not to say they're not valid, in their own mind, or whether or not, they're valid... So yes, I'm on the side of vaccination, I've seen it actually physically work, I know that it works, so I'm happy. Whether I'm right, is a different matter, I could be as equally wrong as the anti-vaxxers, but you know sort of, from an evidence-based point of view, you know. (James)

Similarly, Wendy acknowledged the rights of others to believe what they like, even recognising that someone else might believe that two plus two is five; however, she was adamant that from a scientific perspective, there is only one correct answer:

Well, that's fine and they can accept it and believe whatever they want, I, I uphold their right to believe in whatever they want to believe but I'm not going to accept that, that's fine... It's real, whether you believe it or not, it's still real. $2+2 = 4$, $2+2$ still equals four, if you want to believe it's five, that's fine but it isn't, I mean it's not, we're not going to have a discussion and come to the idea that two plus two is oh maybe it's four and a half, or maybe it's a little bit closer to four, four, but a little bit closer to five, it's not, $2+2 = 4$, whether you believe it or not it's still going to be like that, so, that's how I feel about science. (Wendy)

Half of the participants talked about the importance of science, logic, and evidence when evaluating and substantiating knowledge claims. Specifically, they highlighted the necessity of objective, "scientifically right" (Andrew) or "scientifically verifiable evidence" (Wendy) from an "evidence-based point of view" (James). This contrasted with other types of evidence such as "anecdotal evidence" (Wendy).

I'm just nodding, well that's fine but it's still anecdotal evidence, it's hardly... scientific, and I said well why hasn't God revealed himself to me then and she goes I don't know so it's just, so people, people accept experiences that they have, that just apply to them and don't write it off as a little trip into insanity or anything, they just accept that it's their God, but that's fine, they have every right, and good luck to them, just don't try and force my child to pray at school or I'll come down on you like a ton of bricks. (Wendy)

Evidence in the form of "hard, cold facts" and "stats" was particularly important for Angela when attempting to prove her knowledge to others:

we could say "look, we're not making this up, we've got the, we've got the evidence", and it's that thing about when you give people evidence, they might be angry about it but eventually they'll listen because they haven't got anything so, yeah. (Angela)

Half of the participants also saw a need to consider the logic and reason behind a knowledge claim, before accepting or dismissing it. Wendy particularly emphasised the need to use “a bit of logic,” while Tom and Andrew both reported having to “look at, the reasonableness” (Andrew) of a claim.

Moreover, participants highlighted the importance of not just accepting something as knowledge without questioning it. Instead, they asserted the importance of scrutinising what is being presented as knowledge, before drawing a conclusion. Notably, this is something they saw themselves as doing in contrast to other people.

Look I'm open to, it'd have to be, you'd have to stand up, stand up to scrutiny you know, because, because my partner, she likes the old wives' tales and that, she says it's right, you know it's proven to be right and I'm saying no, it's not scientifically right, but if things stand up to scrutiny, I think it's good. (Andrew)

This questioning approach includes considering the veracity of alternative arguments and interpretations and acknowledging that new evidence can lead to different explanations:

They don't necessarily have to, but you know, sort of the problem is that if you don't check out what person B is saying, how do you know that what you're saying is correct? (James)
Well that's good, that's good, I think that is, that is what is, that's what science is all about you know you only need one thing, you only need one way of, one bit of evidence against a theory to throw its whole theory out, you know, so I like that, you know, I'm looking for it all the time, yeah, you know, you know a hundred people said that's right but this person said it's wrong, have they've got a good argument? (Andrew)

More specifically, it was important that knowledge claims were scrutinised by others in an objective process of verification and review. That is, for Wendy, evidence needed to come from “a verified study” that had been “peer-reviewed” and “published,” instead of “some Google search on vaccine

kills kids.” Further, she articulated her understanding of peer-review to demonstrate its role in lending credibility to the outcomes of this process:

Ah peer-reviewed, peer-reviewed, peer-reviewed reports, peer-review is where you’ve done a report, you or your group has done a report, you’ve submitted it for publication and it gets checked by people at the top of that industry that you’re in, and it’s not just one person giving it a once over, it’s several people looking at your, your publication and checking your results, checking your citations, checking your sources yourself, that you’ve sourced for that publication and checking that your, that, your mathematics is right, checking that your assumptions are right, your citations are correct, checking that your conclusions are actually applicable to the, the study that you’ve done and it’s not done just by like I said, not done just by one person checking your work, it’s done by a raft of people that are already in that field. That’s what I think peer-review is. (Wendy)

By people who know what that work is, it’s not just by some odd bod who’s never looked at a physics paper before or, or a biochemistry paper, it’s done by other people who’ve done the work before and know what they’re doing. (Wendy)

Discussion

Participants discussed various understandings and definitions of knowledge and knowing as well as those processes that they saw as more or less appropriate with which to obtain knowledge. There was a strong metacognitive aspect to this theme, with the subthemes of *definitions and characteristics of knowledge*, *critique of alternative approaches to knowing*, and *valid, appropriate approaches to knowing*, comprising the participants’ thoughts and judgements on knowledge and their own knowing, the knowing of other people, and about knowing in general. These are illustrative of Barzilai and Zohar’s (2014) term “epistemic metacognitive knowledge,” which includes epistemic metacognitive knowledge about persons. More specifically, this includes three main

categories of meta-knowledge about the individual as knower, about other people as knowers, and about human knowledge in general.

Definitions and characteristics of knowledge and knowing. From the interviews, it was clear how some of the participants defined knowing, understanding, and beliefs, and how these related to formal definitions of such terms. For instance, Wendy's discussion of 'knowing' highlights that memory is a source of justification to her. That is, she appears to say that if she remembers something, then she knows that she knows it. This contrasts with philosophical accounts of knowing, which would imply an individual has evaluated a claim's evidence and accepted it as sufficient to be deemed as knowledge (Greene et al., 2016a). In contrast, Beverly's differentiation between knowing and understanding is consistent with formal definitions that "understanding is a deeper level of accomplishment and conceptual achievement than acquiring knowledge alone" (Greene, Copeland, et al., 2018, p. 142) and involves grasping connections and seeing how items of information fit together (Chinn et al., 2011). The participants also differed in their usage of the word 'belief', which in philosophy indicates that the person has accepted the claim as true without having evidence for it (Greene et al., 2016a). Wendy defined belief as accepting "something as true without evidence," which paralleled Andrew's definition of faith, as well as philosophical definitions. In contrast, Beverly saw knowing as a precursor to believing and that belief in something was associated with confidence in it.

Wendy and Tom's discussion of the different types of knowing and knowledge that vary by field and role appears to reflect their understandings of formal epistemologies (Barzilai & Weinstock, 2015), that is, their epistemological knowledge of these disciplines and specific domains that they have gained through their education and experiences (Buehl & Alexander, 2006; Hammer & Elby, 2002, 2003; Sandoval et al., 2016). In particular, it demonstrates their awareness of the nature of knowledge in these areas, such as its certainty, alongside the reliable processes for sourcing, creating, and justifying knowledge in these disciplines. It also demonstrates their awareness that the nature of knowledge and knowing differs by discipline, consistent with claims of the domain-

specificity of knowledge (e.g., Muis et al., 2006). While not setting out to study this, an understanding of participants' knowledge of different epistemic systems is nonetheless relevant to consider and has important implications. That is, as highlighted by Greene and Yu (2016), "the challenges of the modern world make it clear that today's students need to know more than just *what*, but also *why* and *how*" (p. 2). Individuals therefore need to know the epistemology of science, including its limits, complexity, and tentativeness, alongside content knowledge of science (Sinatra et al., 2014). Specifically, it has been found that students who understand how science works (that is, they understand approaches to knowledge and knowing in that discipline) are better able to evaluate different claims related to science-based topics, such as climate change and vaccination, than those who are only taught scientific facts (Sandoval et al., 2014). Wendy demonstrates content her understanding of this in pointing out that, when learning physics, she will have to learn the why and how of it.

The absoluteness of knowledge was also discussed by participants. Specifically, some viewed knowledge as a reality that could be found, while others were less certain about its ultimate attainability. Such views about the certainty of knowledge have been captured in all types of models of epistemic cognition, from developmental to dimensional, integrated, and those based on philosophy. Particularly, the participants' views of knowledge reflect the dimension 'certainty of knowledge' under the area of 'nature of knowledge' as summarised in Hofer and Pintrich's (1997) seminal model. More specifically, this dimension, evident in developmental and dimensional models, concerns the degree to which one sees knowledge as fixed or more fluid, and ranges from viewing knowledge existing as absolute truth with certainty to viewing it as being more tentative and evolving. Wendy and James's perspectives therefore represent those seen at lower levels of developmental models, that is, they represent realist and absolutist views of knowledge (Greene & Yu, 2016; Kuhn et al., 2000). In contrast, the more tentative views of the others represent the perspectives on knowledge seen at multiplist and evaluativist levels.

Beverly's comments that some knowledge is unattainable reflects the stance of scepticism, seen in developmental models such as Perry's and Kuhn's 'multiplists' and King and Kitchener's 'quasi-reflective thinkers' (Greene et al., 2008). Further, Beverly's statements about the Big Bang and living in space, including that "it's just too much for our brains to comprehend, I don't think we're quite capable of grasping it all" reflects her views of knowledge in these areas as complex. This reflects what is seen in the literature as the simplicity of knowledge (Hofer & Pintrich), similarly found under the umbrella of nature of knowledge in developmental models. More recently, Greene, Torney-Purta, and Azevedo (2010) combined the simplicity and certainty of knowledge as a combined ontological dimension, arguing that it is theoretically unlikely for an individual to see knowledge as simple and uncertain, or complex and static. Beverly's views of knowledge as complex and uncertain in this area therefore provide empirical support for this claim. Similarly, Wendy's claims about knowing related to her university studies are also reflective of the simplicity/certainty of knowledge ontological categorisation. That is, she sees knowledge claims in her current studies as facts that need to be memorised and as right/wrong. In contrast to this perspective, however, she expects that knowledge in physics will be more complex and require deeper learning of the how and why, alongside the what. Given these were only evident in Beverly and Wendy's interviews, further research is needed to examine the interplay of the simplicity and certainty of knowledge for individuals across topics and domains, and the implications of these.

More recently, and also consistent with the participants' comments in the interviews, Chinn and colleagues (2011) conceptualised certainty as a stance that an individual might take towards a knowledge claim (with certainty being taken as a stance that a claim is extremely well justified), alongside other stances such as seeing a claim as partly true or a working hypothesis or assumption, to doubting it, seeing it as uncertain or withholding judgement. Further, Chinn et al. (2011) grouped such stances together with justification in their model as they proposed a relationship between the extent to which knowledge claims are viewed as certain and the degree to which those claims are judged to be strongly justified. Tom and Andrew in particular seemed to hold stances towards some

claims as partly true, while at other times Tom withheld judgement (such as when he stated he had not yet drawn a conclusion about the government's asylum seeker policy). This may explain why fewer justifications were provided by them, although this would need further exploration.

Personal processes of knowing. Perhaps related to how participants perceived the certainty (or not) of knowledge, was the subtheme of 'personal processes of knowing'. Whereas the participants' perceptions on the characteristics of knowledge might be described as their beliefs or cognitions about knowing, this subtheme appeared to represent the processes that participants described using to evaluate knowledge claims they came across. While this could be described as their enacted epistemic cognition (Chinn & Rinehart, 2016; Limón, 2006; Sandoval, 2012), given the data were collected by interview and not while engaging in actual epistemic practice, caution is being applied in the use of terminology. The interview data should therefore be triangulated with observations or think aloud data while engaging in reasoning tasks before concluding that these represent their enacted cognition.

Alternatively, given these processes included references to making a decision, drawing a conclusion, weighing up, and making reasonable judgements and rational decisions, this subtheme may also reflect what has been variously described in developmental models as argumentative reasoning, reflective thinking, or reflective judgement. The language used may also be reflective of the issues being discussed, with science-related issues often involving the evaluation and resolution of contradictory knowledge claims (Sinatra et al., 2014). In this case, it may be necessary to ascertain the extent to which the personal processes discussed are directly related to, or distinct from, the epistemic processes the participants actually engage in when reasoning about different issues. Further details of how these specific processes are enacted is therefore a fruitful avenue for further exploration, with Greene and colleagues (2008) highlighting the need to understand how individuals decide between competing knowledge claims and whether they accurately weigh data to make rational decisions or are instead influenced by emotions and other factors.

Critique of alternative approaches to knowing. While not asked about the knowing of other people, most of the participants discussed their thoughts on the knowledge of others. This reflective knowledge of the processes of other people is what Barzilai and Zohar (2014) call meta-knowledge about other people as knowers, a category of metacognitive knowledge about persons. In particular, participants discussed what they saw as the biases of, and barriers to, others' knowing; these add to the earlier list of epistemic vices that were noted as influences on the participants' knowing (theme three). Emotions were similarly seen as a barrier to the approaches of other people; like epistemic vices, these states were said to get in the way of the logical, rational evaluation of knowledge claims.

Further, in discussing their perspectives on the inquiry processes used by others, participants also indicated what they saw as less reliable approaches to knowing. Reliable and unreliable processes for achieving epistemic aims, one of the components in Chinn and colleagues' (2014, 2016) AIR model, will be further discussed in the next subtheme. It is also possible that the participants' criticisms of the approaches of others may have been made in an effort to validate or highlight the superiority of their own approaches.

Valid, appropriate approaches to knowing. In this subtheme, participants acknowledged the existence of different ways of knowing (or alternative epistemologies, Lewandowsky et al., 2017), while highlighting that some approaches are more valid than others. This is representative of the final position in developmental models, such as the evaluativist position, in which objective and subjective views of knowing are integrated (Greene & Yu, 2016). In this stage, individuals consider evidence from different perspectives and judge knowledge claims against various criteria, while acknowledging that others might utilise different criteria (Baxter Magolda, 1992; King & Kitchener, 1994; Perry, 1970). Such knowers understand that people can construct useful, though imperfect, descriptions, or models of reality, but that some are "more right" than others based on argument and evidence. That is, "two people can both have legitimate positions – can both "be right" – but one position can have more merit ("be more right") than the other to the extent that position is better supported by argument and evidence" (Kuhn et al., 2000, pp. 310-312).

This subtheme further comprised participants' comments on what they saw as the most appropriate ways to source, evaluate, justify, and use knowledge. These are consistent with the "reliable processes" component in the AIR model (Chinn et al., 2014; Chinn & Rinehart, 2016), based on the epistemological theory of *reliabilism* which "conceptualizes knowledge as true beliefs produced by a reliable epistemic process that is more likely to produce true beliefs than false beliefs" (Chinn & Rinehart, 2016, p.479). Specifically, this component considers cognitions specifying the reliable and unreliable processes for producing knowledge and achieving other epistemic aims. Notably, these include beliefs about the reliability of inquiry processes used by individuals when seeking knowledge as well as the reliability of the inquiry processes used by others, including experts and peers (Chinn et al., 2011). Examples include individual processes such as observation and memory, epistemic virtues and vices, processes invoking emotion, personal evidence gathering, and processes for reasoning about statistical evidence, and social and institutional processes including peer review processes, survey processes, and media processes (Chinn et al., 2014). As seen in the interviews, participants saw the following processes as reliable: scientific inquiry, reasoning about statistical evidence, the consideration of multiple perspectives, and the peer review process. These reflect processes of knowledge generation and evaluation in the discipline of science. Through their discussion of their own and others' processes, participants also highlighted the processes that they did not see as reliable ways to produce knowledge. These included exposing themselves only to information that supported their perspective (i.e., confirmation bias), being clouded by emotion, the use of anecdotal evidence, and epistemic vices such as close-mindedness, distrust of knowledge producers and susceptibility to conspiracy theories.

Participants also highlighted the conditions under which knowledge producing processes are reliable or not. For instance, not only did Wendy discuss the importance of peer-review in the production of scientific knowledge, but she highlighted the conditions for peer-review to be a reliable process to produce knowledge. That is, peer-review is deemed reliable to Wendy when the sources are verified, the reviewers are qualified and have expertise on the topic, multiple reviewers

are used, and there is a process of checking of assumptions made and conclusions drawn. Wendy further highlights that the reliability of knowledge production at universities depends on the university itself, that is, it has to be a reputable university. Moreover, as noted by some of the participants in the first theme (*justification for knowing*), *seeing as knowing* is not always a reliable justification for knowing, and can be affected by different conditions such as the knowledge being hidden or misrepresented. This is consistent with literature which highlights the conditions under which observation operates successfully to produce true beliefs (Chinn et al., 2014). Other conditions for knowing identified in the interviews include time and access to knowledge. These therefore illustrate how a reliable process is dependent on context and certain conditions.

Beyond highlighting the reliable approaches to knowing, participants provided fine-grain detail about the standards or criteria deemed as necessary for various epistemic products. These fit with the epistemic ideals' component of the AIR model, which are used to evaluate whether epistemic ends have been achieved. For example, some participants outlined the standards for suitable scientific theory, seeing the need for it to stand up to scrutiny, new evidence, and alternative interpretations. The standards for accepting evidence were also highlighted, including the need for objective, scientifically verified evidence, not anecdotal evidence, and the use of "hard, cold facts" and "stats."

Chapter 9: Personal Meaning of Knowing

Results

This theme covered the personal meanings and impacts for the participants associated with having knowledge and gaining more knowledge over time. The impacts of having and acquiring knowledge, especially the accumulation of it over time, were clear. Particularly, increases in knowledge gave the female participants confidence, changed how they saw themselves, and made them feel good about themselves. Participants also identified various aims associated with knowing, such as keeping up with and proving themselves to others. The participants also discussed the importance of using knowledge for good. Lastly, participants discussed how they made sense of the knowing making process through the use of various representations and organisational devices.

From not knowing to knowing: Confidence, power, and change through knowing more. All three of the women alluded to the positive impacts that knowing, in particular gathering knowledge and knowing more than in the past, had on their lives. Gaining knowledge was associated with increasing confidence and positive changes in their lives, including in Angela's professional life, Beverly's personal life, and Wendy's studies and personal life.

Reflecting on her experience, Beverly recounted a journey from not knowing to knowing; from a naïve, insecure young girl who was "very oblivious to what life was about" to a confident survivor who can cope with whatever life throws at her. For her, gaining practical knowledge that helps one survive happens over a lifetime. Today, she sees the importance that gaining such knowledge had had in her life:

I think getting a collection of knowledge is good, it makes you feel good, it gives you a bit of confidence and just, it's a comfort thing that you know that you should be able to cope with almost anything and some things are out of your hands, but things that you can sort of, help your life, good to have knowledge and keep up with things in the paper and life around you.

(Beverly)

Similarly, Wendy spent over 30 years of her life thinking she was “stupid” and justifying to herself that as the youngest in her family, “of course I’m going to not know stuff.” She consequently described herself as a passive receiver of knowledge from others around her, who “fed” her information and “told [her] what to do.” However, studying at university exposed her to different types of knowledge and approaches to knowing, particularly science as “a method of finding out, evidence, finding out what’s observable and working out from there.” This experience not only gave her the evidence to realise that she is not stupid and “maybe I’m smarter than I thought I was,” but the confidence that she should trust her own brain:

I can’t wait to go back, I’m doing physics this year, wow, I can’t believe it, the last 35 years of my life I thought I was stupid and I’m not, which is really nice, a bit of an ego boost there too. (Wendy)

Moreover, attending university and gaining new knowledge also influenced what Wendy knew about her brother. Wendy discussed how she initially thought that climate change was not real because her brother, who she saw as smart, had told her so. When climate change ‘being real’ was first mentioned at university, she was initially sceptical, as accepting this claim would mean accepting that her brother had been wrong. However, she was ultimately confronted with a great deal of evidence to support the claim that climate change is real. Coming to the realisation that her brother was actually wrong led to a change in not only how she saw her brother, but how she saw herself:

Ah good question, I did. My brother, is, very bright, I’ve always looked up to my brother, totally brainiac you know, he was smart to the point of being a social leper, but you know, he’s really, really smart, he thinks it’s all, climate change isn’t real, he says it might be changing but it’s not man-made, but, so, I go to university, accepting what my brother said because, he’s my big brother, he knows everything and a first thing, one of the first units we do, course the lecturers come in and starts talking about climate change and I’m thinking “really?, hang on, this can’t be right, this can’t be right cos my brother’d be wrong” so, we,

the next, I had an opportunity to do a breadth unit and it was called carbon and climate and I thought well this will be, I'll be interested in this, see what, see why we're getting taught this at uni and the evidence is overwhelming that it's anthropogenic. It was, it was just phenomenal. I was, I was tsunami-ed with information on why it's anthropogenic, climate change. I found, like we found every little bit about it, we went from the physics of it, to the chemistry of it, to, the, the, why the journalism and how it's reported, it's a fascinating unit because it covered right through the sciences, social science, journalism, media, it was a fascinating, eye-opening, lot of information and I went back to my brother and had a chat about it and that was an interesting experience too cos I found out my brother was wrong, and that was, that was an epiphany, my brother's never been wrong, aha, my brother was wrong, and wrong, and wrong big time and all he does is exactly the same as my niece, get on the Internet and confirm his biases. It was fascinating. (Wendy)

No and even to this day he can't, he won't. He still thinks we're all getting ripped off. You know it's a big con by the UN to take us over or some conspiracy theory and maybe my brother's not as... oh not as smart, that's not right he's probably as smart as he thinks he is, no he's not as smart as he thinks he is, he's probably as smart as I always thought he was but then maybe I'm smarter than I thought I was. Does that make sense? (Wendy)

Lastly, Angela defined herself through not only what she knows and how she uses knowledge, but what others know about her. It seems that gaining more knowledge gives Angela confidence and power when working with others, and she comes across as someone who is at the forefront of knowledge, both in work and in her everyday life.

I just wake up and it's there. It's usually after a fairly long period of research but I feel myself moving towards it and I, my, I feel my confidence building and then as I say it seems like, it's like everything just kind of falls into place, and I feel very calm, and once I'm there the guys know that there's just no point in going on, because as I say my brain managed to catalogue

everything for me so that I, I I'm not searching for answer or searching for figures or searching for arguments, they're all just there, you know, you know I've convinced myself to start with, I've spent a long time researching everything I can get my hands on, and they are in a position of weakness because, I've done all the work. (Angela)

Wanting to be at the forefront of knowledge – “at the front of the curve” – in her industry particularly gave her the confidence to not only make bold decisions for her business, but to be able to use the knowledge and confidence gained to convince others of the need to make such changes:

I, I dug my heels in about five years ago and said to the guys “that’s it, we’re going online 100%, this is the way the world is going, and we have to be at the front of the curve or we’re going to -” and I have to say, we're still at the front of the curve. (Angela)

Moreover, being able to share knowledge with others was also important in Angela’s work and helping her to get ahead:

you're trying to get people to think the way, you know to, to at least consider the way you think, and from that they gain more knowledge, and some did change their minds about things because you know with argument with prosecutors with good evidence. (Angela)

Aims for knowing. Four of the participants also identified various reasons why knowing, and particularly gaining more knowledge, was important for them. Some participants were motivated to seek out knowledge as it helped them keep up with others and had personal benefits for them. For others, though, gaining knowledge or understanding was not always the main goal. Firstly, two of the participants identified needing to gain more knowledge in order to keep up with others and prove themselves to them. Angela particularly needed to prove herself and what she knew to others to get ahead in her professional life.

So I had to fill myself up with all that information because you never knew what they were going to ask you and it's hard for a woman and this was, a long, you know, started 25 years ago so, it's hard for a woman to walk into a man's world and especially something like bass guitar which is very blokey, I've gotta tell ya and prove yourself and make them trust you so that when you're hoping for the second call back, they feel comfortable asking questions and they're happy to take the answer "I don't know, I'll find out." So, it was immersing myself, it, it was an, it was an immersion, and I didn't feel comfortable talking to these people about this stuff at that level until I'd put that work in and it's been pretty much the same with the administration. (Angela)

James attributed a great deal of his knowledge to his tendency to "read widely" and "read a few things"; in part, this tendency was initially spurred on by a desire to "hold [his] own in the conversation" amongst those he saw as knowing more than he did, including a previous girlfriend of his. He also noted how, when younger, he realised that "the smart, pretty girls know a hell of a lot more than me" and that "if I want to be in the same field and you know have any chance, I've gotta be, be a little bit smarter and learn a bit more." He added how, even from a young age, he was drawn to those who knew more, in a desire to "know why they knew what they knew":

you'd go to school and you'd be reading against people who were, whose capabilities you could tell because you were reading the same texts and you'd suddenly discover the people who had a better reading ability or had a better understanding of it, even as being a seven or eight year old was figuring out that the smartest one in the class was you know, knew, just had a better understanding of what was going on, so sort of you gravitated to them because they, you wanted to know why they knew what they knew. (James)

At other times, James approached the task of knowing just for the sake of knowing; that is "wanting to know knowledge for the purpose of whatever else I can get out of it." This was similar to Beverly

who often wanted to know for interest's sake and for being able to share and discuss new knowledge with her family.

However, for some of the participants knowing in certain areas was not always the ultimate goal. Beverly, for instance, noted preferring to know "how the Earth began" instead of "about Gods or this imaginary rubbish." Similarly, Tom identified how his religious worldview meant that ultimately knowing about climate change was not a priority:

I guess it's the only way to put this in a nutshell is that I have a Christian view of the world and therefore that suggests that the Earth was, has begun and has an end date, so I'm not, I don't believe that we're on a spaceship that's gonna be there forever so my ultimate concern for the climate change isn't a huge issue so I'm not gonna spend much time analysing or worrying about it because I kind of have a belief that overrides that, does that make sense? So pretty much what I guess I'm saying is that when you have a worldview that's based on a revelation about the reality of what you're living, it must intrinsically affect even how you view science... or climate change or any of those problems that we seem to be facing as a human race. You know if I was, if I thought the world was all there was and this is the only chance we've got and this is the one, this is the beginning and end of it all, you know, I'd be pretty, I'd be a bit stressed about climate change but because I have a bigger view than that in which climate change is possible, significant, but not eternally of any great consequence, I don't spend any time thinking too much about it. (Tom)

Furthermore, like his approach to science, Tom is interested in, and values, politics yet is sceptical of these systems and their ability to help us make sense of the world. Regarding knowing about politics, he again pointed to a bigger picture which devalues his ultimate need to know in this area:

I'm, first of all that's again where there's a bigger picture for me, so I guess the bigger picture in this case is that I, I actually believe that any political system is quite flawed anyway whether it's, you know, Western capitalism or socialism or any of those systems, I think

they're all flawed and I don't mean to be totally negative about that I just, I'm realistic but ultimately they're the best attempt of humans to try and develop some governance which we all need... So, look, politics to me is an important process of engagement for society but, I don't, I don't get too fussed about it because again my, I guess my global view, my underpinning worldview kind of means that that becomes less significant, I don't see that as a solution so I'm not going to spend an inordinate amount of time worrying about it. (Tom)

Using knowledge for good. Gaining knowledge and being able to share that with others was associated with positive benefits to the participants and those around them. Half of the participants also discussed the importance of using knowledge for the greater good, that is, to help others or for the benefit of society. Both Beverly and Angela see knowledge as a power with which they can help others close to them, whether that is people within their community (Angela) or family (Beverly). For instance, while for Beverly her parents were not seen as supporting her or as sources to provide her with vital knowledge to survive, she sees it as her role to pass on her gained knowledge to help the next generation:

you do gather your, your memory, or your, things you know, don't you, it builds up and by the time you get to this age, you've got it down pat, and then you can hopefully help the younger ones and support them. (Beverly)

James also spoke at length about not only having knowledge within society, but collectively applying it for what he sees as the right reasons. This especially includes the “greater good” and implementing knowledge for the best of the majority of the population, in contrast to using knowledge to suit individuals or the financial agendas of a few corporations.

... it's you like to see what you can actually do, what it can do beyond what it's, given there's an impression in what I can do, about smart phones and things like that, that they can use it for, you know minimalist stuff, but it's what it can do as a greater good. (James)

... so yes, it is better for the majority of the population, and unfortunately, we're a mass communal society, so we have to work on that basis as in, what is in the benefit to the greater good. (James)

He specifically highlighted using knowledge of atom bombs for practical purposes that benefit most people. Further, he added that while knowledge can be used for catastrophic, negative purposes, we cannot negate that we have that knowledge; instead, the challenge is to use it to benefit as many people as possible:

having grown up in the era when, you know there was, you know gone out and done the marches for you know disarmament and things like that, sitting next to people who were going 'yeah' let's rally to it and stuff like that, and says, you know, you can't make it go away, it won't even stop the bombs and they go, why?, because people know how to do it now, because you can't unlearn stuff and sort of now that people know how to do it the idea is, let's get rid of the destructive stuff, the stuff you want to do is, you get out there and how do we put this to the purpose that actually serves the greater good... banning the bomb is, you know, idealistically really great, it's just it doesn't, doesn't remove the, you know, the practical purpose of people know how to do things, and the idea is just getting people whose brains are that, who are smart enough to figure out how to, make it destructive, how to use the, the suspense rods and the, the waste from it, how to turn that into a practical purposes for, you know, for instead of it just being something that we worry about for the next 100,000 years, actually to make it useful. (James)

Representations of knowing. Half of the participants also spoke of a process of organising information in their minds or brains. This helped them make sense of the information at hand and convert it to useful, applicable knowledge that is accessible when needed. Various organisational devices in their brain were described, from little boxes and spreadsheets (Angela), to blocks and houses (Wendy), and a pegboard (Tom). Angela detailed the process her brain undertook as taking

all the disparate pieces of information that were floating around the synapses and it had just put it into a beautiful spreadsheet for me where information was there when I needed it in the argument, because I'd done the work. (Angela)

She further highlighted the usefulness of this process and the confidence it gave her:

...as I say my brain managed to catalogue everything for me so that I, I'm not searching for answer or searching for figures or searching for arguments, they're all just there you know, you know I've convinced myself to start with, I've spent a long time researching everything I can get my hands on, and they are in a position of weakness because, I've done all the work. (Angela)

Wendy also outlined her ways of making a vast amount of information more manageable so that she can consolidate it. She described her process as one of putting the information in blocks, or houses, in her head, in an effort to memorise and ultimately know the material for her exam.

I just put in my head, I had to put them in blocks, so put them in little houses in my head of the six different pathways. (Wendy)

Likewise, Tom detailed a similar process of organising information in a way that makes sense to him. Similar to Angela's "spreadsheet," he labelled this organisational process in his mind as "a pegboard."

...then the analytical skills come in, so what I'm doing while a person's talking, even though they're talking all over the place, I'm taking out key information and putting that in the back of my mind almost like a pegboard where I store specific problems that can contribute to this whole crisis and then I, while they're still talking to me and, and the conversation's flowing, I'm reordering those particular items on the pegboard in a way that enables me to deal with what's most urgent. (Tom)

Notably, for some of the participants this was a subconscious process, while for others they acknowledged taking a more active role. More specifically, Wendy discussed her active role in the organisational process, while Angela saw her process as subconscious. As Angela elaborated,

and a lot of this is going on subconsciously, a lot of, you do, as I say you do your research, you find out as much as you can about a person, but I think a lot of the decisions you make are happening while you're asleep, you know, your brain is putting all those things into little boxes and, you know, you go to bed and you're all stressed out and oh what am I gonna do, I can't make a decision, it's a borderline call, you wake up in the morning and you go "yeah, okay, now I know what I'm doing" and it's like it's all settled overnight and it's when the stress gets too much, it's like your brain goes to a place and goes "OK, I wanna do this for you" and it's a kind of, wonderful gift, and a wonderful way that, for me, not all the time but sometimes it'll happen like that and I know, you know that it's, I know I'm doing the right thing because I can feel it.

Lastly, Tom's representations illustrated both active and subconscious processes. Specifically, while he described playing an active role in managing information on his internal pegboard, he also discussed an "internal radar" that he relies on to tell him about others. Similar to Angela, drawing on this radar is an instinctive, subconscious process.

I can't comment on everybody's process but for me it's, again there's that radar that works, you know, that sort of internal radar that says well this is just waffle or, you know, these people are kind of they're way out there on the edge of sanity, that I dismiss it. (Tom)

Discussion

This theme covered the more personal, meaning-making aspects of knowing for the participants, highlighting their personal journeys and relationships with knowing, and representations of knowledge and knowing.

From not knowing to knowing: Confidence, power and change through knowing more.

Evident in the analysis of the female participants' interviews, particularly for Beverly and Wendy, was a progression across their lives from not knowing to knowing, and from being passive receivers of knowledge to active constructors and sharers of knowledge. This pattern parallels the developmental process outlined in Belenky and colleagues (1986) women's ways of knowing model. Beverly, for instance, described a journey from a young age, in which knowledge was kept from her and she felt "naïve" and "oblivious to what life was about." This parallels the position of *silence* in this model, with women in this position often isolated and fearful, as well as socially, economically, and educationally deprived (Love & Guthrie, 1999). It also reflects a position of *not knowing*, in which women view themselves as incapable of thinking or knowing and with no confidence in their ability to learn from experience. Further, women in this position, like Beverly, see themselves as powerless, passive, and dependent on external authority for direction. Over time, and through meeting her partner, however, she developed more knowledge and confidence, in line with the model's suggestions. Now, she sees the importance of sharing knowledge with, and being a source of knowledge to, her family; this recognition of the self as an authority alongside the expertise of others echoes the later stage of *transition to procedural knowing*.

Wendy, with her comments on not knowing as the youngest in the family and thinking she was stupid, demonstrates a similar progression. However, her recognition of the need for procedures for knowing in order to assess the accuracy of external truth and authority currently puts her in the final stage of *procedural knowing*. This progression was likely prompted by time and her university studies. Interestingly, this is in contrast to Belenky and colleagues' suggestion that progression usually precedes university studies. As for the other women, gaining and having knowledge (particularly more knowledge than others) appears to have had a positive impact on Angela's life. Although the final stage in Perry's (1970) developmental model shifts to ethical development and the individual committing to their identity, the interrelationship between knowledge/knowing and identity has not been considered in more recent models. It therefore adds

to the long list of possible outcomes associated with adaptive epistemic cognition and provides an avenue for further research.

Moreover, the progressions identified appear to be influenced by time, education, other people, and epistemic doubt, therefore adding to the literature on possible mechanisms of change. These are therefore worth considering when designing interventions targeted at fostering epistemic change. Moreover, while the role of education and teachers is important to consider in facilitating such change (Greene & Yu, 2016), these results also indicate the need to consider other people playing a significant role in the knower's life, such as family. Finally, it should also be noted that although these progressions were only observed for the female participants, as this was not a focus of the interviews, conclusions cannot be drawn at this time regarding the absence of males in this subtheme.

Aims for knowing. Participants also discussed why knowing and gaining knowledge was important for them, including keeping up with others and proving themselves to others in order to get ahead in life. In their AIR model, Chinn and colleagues (2014, 2016) have argued that individuals differentially enact their epistemic cognition dependent on their goal for knowing, whether that is understanding, wisdom, explanation, models, true beliefs, avoiding false beliefs and so on. They also noted how individuals have non-epistemic aims as well, such as achieving happiness or preserving one's good self-image. The participants' aims for knowing appear to reflect these non-epistemic aims. For instance, Angela and James appear to have non-epistemic aims of wanting to keep up with and prove themselves to others; this has resulted in them adopting strategies to seek out and gain more knowledge for themselves and to convince others that they have this knowledge. At other times it seems that James seeks out knowledge out of interest or to see what he could get out of knowing it; again, this is a non-epistemic aim that involves deploying strategies that are not necessarily related to seeking out true, justified beliefs (i.e., knowledge).

Moreover, some of the participants were not motivated by epistemic goals of attaining knowledge on some topics, such as Beverly not valuing knowledge on God. In these instances, it can

be said that they do not *value* such knowledge. Again, this aspect is important to consider alongside one's aims as it affects how one seeks out (or not) and processes information on those topics. For instance, Tom stated he is not particularly motivated to seek out knowledge on climate change as, due to his religious worldview, he does not see much value in having that knowledge. This research therefore provides support for this aspect of the AIR model and provides examples of some of the non-epistemic aims and epistemic values of adults. It also illustrates how one's aims for knowing (or not) can have an influence on one's approach to knowing.

Using knowledge for good. The currently accepted definition is that epistemic cognition focusses on "knowledge and the processes involved in its definition, acquisition, and use" (Greene, 2008, p. 143). While there has been a lot of debate and research on how knowledge is defined and acquired, less attention has been paid to articulating and understanding how knowledge is used by individuals. This subtheme therefore provides some preliminary insight into what adults use knowledge for. These positive uses and benefits of having knowledge are possibly related to the participants' aims for seeking out knowledge. In particular, this included the ability to use it for good and to help others, both individually and collectively. While research has long been concerned with the outcomes associated with epistemic cognition, these generally focus on the implications for the individual (e.g., educational outcomes) and not on outcomes for other people and communities. Although these results therefore expand on current ideas of epistemic cognition, it could also be argued that they are instead more relevant to one's ethical or moral development and thus beyond the scope of epistemic cognition. What also remains to be seen is how understanding the uses of knowledge relates to the epistemic aims outlined in the AIR model, if at all, and how they specifically influence one's approach to knowing. Further consideration of other uses for knowledge, or motives for knowing, and their influence may also be warranted.

Representations of knowing. The last subtheme included the representations of knowing discussed by the participants. This finding expands beyond current research that explores tacit beliefs about knowing or the individual's enacted practices to consider the meaning making of the

process for the participants. Given Greene and Yu's (2016) contention that "how people interact with the knowledge they encounter is greatly influenced by how they perceive it" (p. 47), this research makes a valuable contribution to our understanding of how individuals perceive knowledge. These findings could be explored further to determine how these perceptions differ by topic, if at all, and the specific relationship between these representations and approaches to knowing.

Chapter 10: General Discussion of Qualitative Study

The aim of this qualitative study was to explore the ways of knowing of six adult participants. More specifically, this study was focussed on understanding the participants' experiences and meanings of knowing to determine, (1) what are the ways of knowing for a group of Australian adults (i.e., how do they know what they know?), and (2) what knowing means to them. Thematic analysis of semi-structured interviews with the participants regarding how they know what they know in various areas identified five themes. These were (a) justification for knowing; (b) sources of knowledge; (c) influences on knowing; (d) knowing about knowing; and (e) personal meaning of knowing.

The question of how adults know what they know was mainly addressed by theme one (justifications for knowing), with additional insights provided by theme two (sources of knowledge). The remaining three themes considered additional areas of relevance to how the participants know what they know, such as the internal and external influences on one's approach to knowing (theme three: influences on knowing). The final two themes (knowing about knowing and personal meaning of knowing) illuminated the participants' understandings and meanings of knowledge and knowing, thus elucidating what "knowing" means for these participants. These meanings of knowing ranged from metacognitive understandings and definitions to personal meanings such as gaining confidence and power from knowing and the representations used to make sense of knowing. Figure 1 provides a visual summary of how people know what they know, based on findings from the interviews. It shows how they know what they know through sourcing and justifying knowledge as a central aspect of knowing. These are likely influenced by what is known about knowing and various internal and external influences. What they know leads to different outcomes, with various associated personal meanings. Further research could seek to explore this possible model of knowing.

As these themes were discussed in the previous chapters, this chapter will focus on the implications, strengths, and weaknesses of this study. This chapter concludes with suggestions for further research.

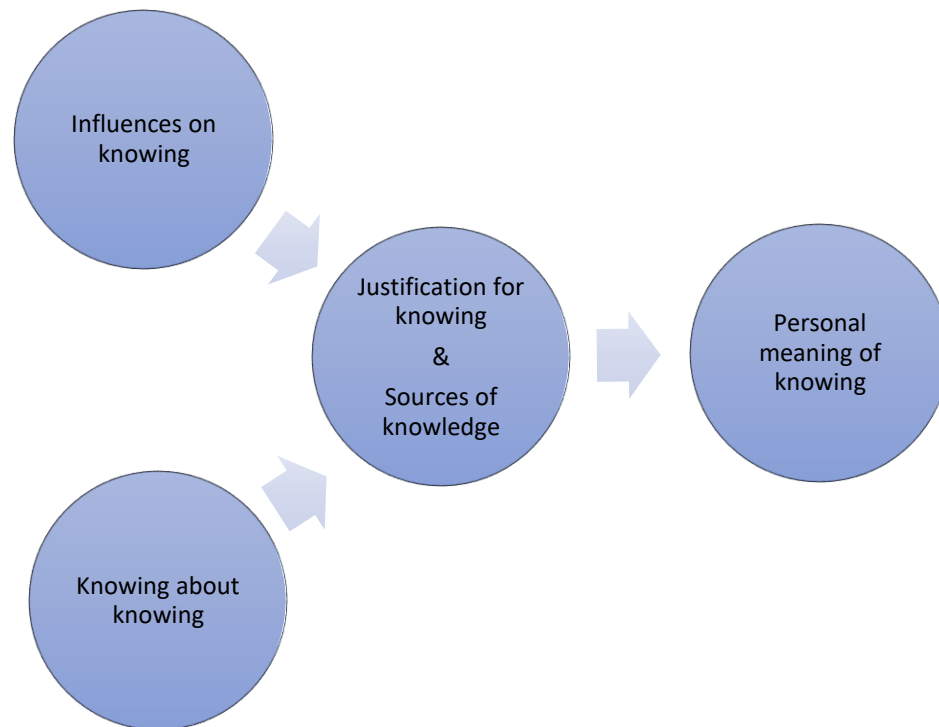


Figure 1. How people know what they know. Causation is not to be inferred by the arrows; instead, they represent proposed relationships between the themes.

Implications

The results from the first theme (justification for knowing) appear consistent with the recent trichotomous justification framework suggested by Ferguson and colleagues (2012, 2013). Further, the results demonstrate that single dimensions of justification, such as from Hofer and Pintrich's framework, are insufficient to capture this phenomenon (Greene et al., 2008). However, the interview results expand on current conceptions of *justification by authority* and *personal justification* through the provision of finer-grained detail alongside the reasons these justifications are utilised. These additional forms of justification include celebrity, religion, and family members (*justification by authority*) and feeling, instinct and sense, seeing as knowing, just knowing, theories, and values (*personal justification*).

The results also indicate which justifications are being used in combination, which arguably provides more detail than just that individuals are using multiple sources to justify their knowledge (as in the trichotomous justification framework). The additional detail that these justifications and their grounds for use add to models can only enhance the predictive validity of the measures that include them. As Chinn et al. (2011) highlighted, such detail is necessary to understand learning and inquiry practices and how individuals reach the conclusions they do when faced with a knowledge claim. Moreover, Chinn et al. (2011) argued that having different grounds for using the same form of justification leads individuals to learn and reason differently, and thus results in different outcomes.

The results also provided preliminary detail regarding the justifications used across different topics. For instance, the participants tended to justify their knowledge on climate change *through others* while evolution was justified by multiple types of justification (*justification through others* and *seeing as knowing*) and *just knowing*. Justification of their knowledge on vaccination tended to differ by person, with some using *seeing as knowing* and another providing multiple justifications, including various people, science, family experience, and evidence alongside logic. These results therefore provide support for the topic-specificity of epistemic cognition while also highlighting individual differences in type and amount of justification use. The consideration of context and in which situations different justifications are utilised by individuals is thus another important aspect needed in models and measures of epistemic cognition. Again, this is because knowing how justification use depends on context has implications for understanding how individuals learn and reason (Chinn et al., 2011).

The justifications used also tended to vary depending on the type of knowledge being asked about. That is, when participants were justifying procedural knowledge (i.e., knowing *how* to work with others, problem solving) they tended to justify their knowledge through personal forms of justification, including *feeling and instinct*, or *experience*, while for conceptual knowledge (i.e., knowing about climate change) they tended to rely on *justification through others*. Again, this further cements the contextual nature of knowing and need to consider knowledge type when

assessing epistemic cognition and conducting interventions. Moreover, while most research on epistemic cognition tends to focus on the acquisition of conceptual knowledge, this research provides detail about the justification of other types of knowledge, thus adding to the field's knowledge base. These findings also complement previous qualitative research that indicated the importance of different types of knowledge. That is, interviews by Greene & Yu (2014) revealed the value ascribed to declarative and procedural knowledge by history and biology professors and the consequent need to explore how individuals acquire and justify such knowledge. Further, while not setting out to do so, the results respond to suggestions that future research in the field could explore how students justify declarative versus procedural knowledge claims (Greene et al., 2016).

It was also noted that several of the topics may have been outside the realm of epistemology (e.g., interests, trusting others). However, Kuhn et al. (2000) argued that people make knowing judgements about different domains, including personal taste, aesthetics, values, and truth. While their model focusses on the coordination of the subjective and objective dimensions of knowing in the development of epistemological understanding, the results from this study provide an indication of how individuals justify knowledge in some of these domains. This included justifying interests (such as for a book) with *feeling and instinct* and *just knowing*, and knowing somebody is trustworthy (or not) through *experience* and consideration of one's *personal values or standards*. As individuals are faced with various types of knowledge every day, whether that be within or outside educational contexts, understanding how they evaluate and justify knowledge across types, topics, and domains (e.g., science or history) is arguably a useful avenue of inquiry. Further, while knowing various types and topics of knowledge may or may not have relevance to learning and reasoning processes in academic contexts, it may have relevance to other areas of individuals' lives (such as indicated in theme five). The practical significance of such knowing should therefore also be considered in future studies.

Similarly, the results from theme two (*sources of knowledge*) expand on models which include sources of knowledge through the greater variety and detail of sources discussed as well as

elaboration of the contexts and topics in which they are used and the reasons such sources are valued over others. These results also add to the literature on multiple source use and source evaluation. Given the use of the Internet these days and the growing need for digital literacy, the results of this study also provide a valuable contribution to our understanding of the use of the Internet as a knowledge source, why it is valued, and how it is used. As with *justification for knowing*, the finer-grained detail obtained from the interviews about sources, alongside their evaluation, can improve the ability of measures to predict an individuals' learning processes and outcomes (Chinn et al., 2011). Measures of epistemic cognition should therefore go beyond asking which sources are trusted and include an assessment of why these are trusted or seen as reliable, under which conditions, and for which topics; the evaluations identified in the qualitative interviews may be a useful starting point. Further research should also seek to better understand how approaches to knowing vary, or not, for those with different reasons for trusting the same source. On a practical level, the results also indicate a need to consider how different types and topics of knowledge are presented, and through which sources, to promote critical thinking on societal issues and maximise uptake of new knowledge.

Training, feedback, school, and university were all mentioned as sources that played a role in the participants coming to know what they know. These could be considered as aspects of learning, which are not included in current models of epistemic cognition. That is, despite beliefs about the processes of learning being considered in early dimensional models (e.g., Schommer, 1990), they were argued by Hofer and Pintrich (1997) to not be epistemic and thus not included in their influential framework. Buckland (2015), however, argues that learning processes are the most important way to gain knowledge and therefore need to be integrated into epistemic cognition models. It may be that *beliefs* about learning, such as whether it is quick or not, may be correlates of epistemic cognition but not central to the construct. In contrast, learning through studying, training, and feedback, as indicated in the interviews, may instead be seen as a reliable process for gaining

and generating knowledge (Buckland, 2015). Such possibilities need further exploration in future studies.

The *influences on knowing* identified in the interviews are important to consider given the recent interest in the field on the development of interventions aimed at fostering adaptive epistemic cognition in learners. For instance, understanding who an influential individual to the prospective learner is might be important to consider when designing and delivering epistemic cognition interventions aimed at fostering adaptive approaches to knowing. It may be that, beyond teachers and scientists, more personal “teachers” are needed to deliver such interventions, including family, friends, work colleagues, and religious leaders.

Of note too is that it should not just be assumed that those utilising ineffective ways of knowing simply need more “education” to fill such gaps or deficiencies and teach them the “right way” to approach knowing (Barzilai & Chinn, 2020). Instead, it needs to be recognised that knowing does not occur in a vacuum, and there are many influences on one’s knowing which need to be recognised and possibly addressed for interventions to be effective (Barzilai & Chinn, 2020; Sinatra et al., 2014). Interventions should also consider how to address barriers and biases to knowing, possibly through awareness raising activities, guided practice, modelling, or direct instruction (Cartiff et al., 2021). Alternatively, explorations into knowing (Chinn et al., 2020) or teaching how to cope with cognitive biases and cultivating epistemic virtues (Barzilai & Chinn, 2020) might be necessary.

In future research the influences identified (e.g., *personal characteristics* and *biases*) need to be measured to investigate how these affect the relationship between epistemic cognition and outcomes (e.g., academic achievement). Moreover, as individuals demonstrating particular epistemic vice or virtue dispositions might respond differentially to epistemic cognition interventions, there is a need to consider these as covariates that are measured alongside other aspects of epistemic cognition. Further, given the potential impact of these dispositions, it might be necessary to consider objective measurement of these rather than relying on self-report, with its inherent risks. Lastly, research also needs to consider how epistemic virtues and vices differ

according to context and whether laypersons' views on epistemic virtues and vices differ from expert views (Chinn et al., 2011).

In theme four (*knowing about knowing*) it was revealed that participants defined terminology associated with knowing differently. These definitions are important to consider given the argument that an individual's approach to learning depends on whether their aim is knowing, understanding, collecting a list of true beliefs and so forth (Chinn et al., 2011). However, it is necessary to not just discover one's aims, but to clarify their meaning behind such goals. That is, while the participants were not asked how they defined such terms, the results nonetheless reveal the importance of clarifying their terminology use. With some participants using "*I know*" when "*I believe*" would be more appropriate (in the philosophical sense) and vice versa, it is necessary to clarify *their* meanings and determine whether these different stances (e.g., knowing versus believing) have different implications, or not. Further, if an individual states (or indicates through their actions) that their epistemic aim is knowing, for instance, it is necessary to ascertain what they take 'knowing' to mean and to discern it from other stances such as believing or understanding. Obtaining a clear understanding of terms used by participants, and not just assuming a shared meaning of a term, will be vital when exploring how aims are linked to one's approach to achieving such aims.

Similarly, the reliable and unreliable processes for achieving epistemic aims have received little research, despite their proposed importance in understanding how individuals engage in learning and other tasks, including the evaluation of knowledge claims made by others (Chinn et al., 2011, 2014; Chinn & Rinehart, 2016). However, while not setting out to study these processes, the interviews revealed the participants' thoughts about such processes, thus providing an avenue for further study of these cognitions. That scientific and evidence-based processes were preferred may be reflective of the individuals in this study. That is, the participants self-selected into this study with many identifying as being interested in, and valuing, science, labelling themselves, for instance, as science geeks. Several also had backgrounds or education in science, which likely influenced what

they saw as appropriate approaches. There may also have been an element of social desirability and needing to show that they know the most "valid" or "right" ways to justify knowledge. The extent to which participants engage in the processes they report as being valid therefore needs confirmation through further studies, including ones that collect data online (i.e., in real time).

It was also identified that participants had different aims for knowing. Chinn et al. (2014) argued that uncovering an individual's aims is important in understanding how that individual processes information and whether epistemic strategies are used, or not. For example, if reading about vaccines on a website, strategies may depend on whether the individual is motivated by the epistemic aim of finding out the truth about vaccines to keep their child safe or whether they are preparing for a debate and are just looking for the strongest arguments (i.e., a non-epistemic aim). Moreover, whether one has epistemic or non-epistemic aims regarding a topic will arguably influence the use and effectiveness of epistemic interventions, and therefore needs to be considered. Understanding the range of epistemic and non-epistemic aims individuals have is therefore important; while the interviews revealed some of these aims, which add to the literature, further research through interviews or probing individuals during think-aloud studies might uncover additional aims.

For others, knowing was not the ultimate goal with regards to some of the topics they were asked about. That is, Beverly was more interested in knowing about how the Earth began than knowing whether God was real or not; in contrast, Tom noted how his faith meant that he was not motivated to seek out absolute truth about climate change. Again, these participants were not motivated by epistemic aims to seek out knowledge about these topics as they did not value such knowledge. Consequently, they did not employ epistemic strategies to seek out such knowledge. Understanding one's aims, values, and reasons to seek out knowledge, or not, are therefore a vital component of epistemic cognition research and should also be considered in the design and implementation of any interventions. That is, assumptions should not be made that an individual is always seeking out knowledge and cares enough about truth (Barzilai & Chinn, 2020), as to do so

may result in interventions being met with resistance. Research may also need to consider whether participants can always articulate their aims (such as through interviews) or if these can be accurately inferred from their actions.

Lastly, the personal focus of knowing in theme five reminds us that people are individuals, have their own relationship with knowledge and knowing that is influenced by factors beyond education, and that knowledge and knowing also have impacts beyond academic achievement and other academic outcomes. This demonstrates the advantages of using exploratory, person-centred, and qualitative approaches, instead of using confirmatory, variable-centred approaches. The implications of these findings are that future studies may need to consider the measurement of outcomes beyond those currently used (e.g., those focussed on academic performance), particularly when exploring the epistemic cognition of adults outside of educational contexts. It may also be the case that fostering more adaptive approaches to knowing can have positive impacts on one's life and identity, as was the case for the female participants in this study. This may open up other avenues for exploration, such as the therapeutic impacts associated with one's knowledge and approach to knowing.

Strengths

There are several notable strengths of this study. The first is that taking an exploratory, qualitative, and inductive approach allowed the identification of areas relevant to knowing beyond those in current models. As noted, this included additional forms of justification and sources, and the reasons these were valued, alongside influences on knowing and other perspectives on knowledge and knowing. Had a deductive approach to coding the interviews been used, it may have confirmed findings of current models but not allowed a consideration of what is missing and what might be added to extend upon or refine such models (Greene & Yu, 2014).

The use of interviews also allowed for a deeper focus on knowing and what it means to the participants. This resulted in the collection of rich data grounded in the participants' meanings, language, and experiences, thus adding the voice of the layman alongside those of philosophers,

epistemologists, psychologists, and educational researchers. The participants were also asked about their actual knowing in different contexts and with regards to various topics. The results were therefore focussed on how they justify or use knowledge and not just focussed on confirming the use (or not) of criteria that philosophers think they *should* be using. This approach also overcomes some of the limitations of asking participants to answer abstract questionnaire items regarding their beliefs about the nature of knowledge and how it should be justified. Grounding future measures in participants' words and focusing on how they engage in epistemic practices may also address current findings of low correlations between abstract measures of epistemic cognition and outcomes such as academic achievement.

Another strength was the use of a sample of adults not currently in an educational setting. Every day, individuals enact their epistemic cognition in multiple situations, such as when searching the Internet, considering issues like vaccination or climate change, making health decisions, or reading the news. It is therefore necessary that research considers how epistemic cognition is used by diverse individuals across the lifespan, in various settings, and both within and outside educational contexts. The use of a nontypical sample (i.e., most research focusses on university or high school age students) in this study therefore addresses a key gap in the literature and adds the voices and experiences of these adults.

Limitations

The use of interviews, while allowing for the collection of rich data, also had some limitations. For a start, a key question revolves around the perspectives of knowing tapped into with the interviews. Particularly, participants may have provided reflections or inaccurate recollections of their knowing, instead of accurate accounts of how they do engage in epistemic practices. Several participants noted that, following their decision to participate in the study, they had been thinking about some of the topics (e.g., because the invitation email had asked “have you ever wondered how you know that climate change is real?”). Therefore, they may have been primed to answer in particular ways, instead of based on how they do justify their knowledge.

More specifically, there is the risk of participants not accurately recalling how they know what they know, whether through the degradation of memory over time, or through the effects of desirability resulting in them reflecting on knowing now and thinking about how they *should* justify their knowledge. As noted by Sinatra (2016), the very act of asking participants to reflect on aspects of knowledge prompts them to make explicit their tacit epistemic cognition. Consequently, instead of accessing their beliefs, it may instead tap into a perspective on knowing that was constructed on the spot. Further, Sandoval et al. (2016) highlighted that “people’s enactment of epistemic cognition can often be different from their expressed reconstruction of that cognition” (p. 479). This is one of the main limitations of the retrospective recall required by the interviews, particularly when participants are asked to rely on their memory of past epistemic cognition. There is therefore a need to investigate whether the responses given by the participants are accurate representations of how they justify or source what they know. As has been noted in the literature, the collection of online data through think aloud studies, observations, or discourse analysis can be used to overcome the risks associated with asking participants to recall or reflect on their processes of knowing (Sandoval et al., 2016). Such data can also be used to triangulate the interview data. Interviews in context or triangulated with results from think aloud studies may also help clarify the type of knowing at hand.

Although the interview was semi-structured, the volume of questions meant that not all were asked to, or answered by, each of the participants. Angela, for example, was not asked about vaccination or evolution, while Tom was not asked how he knows he likes a book, or not. Participants were also not encouraged to give multiple responses to the questions. Definitive conclusions regarding preferences for certain types and amounts of justification, and for which topics, are therefore hard to discern at present. For instance, it cannot currently be concluded that Tom and Andrew do not use *seeing as knowing* or *experience* as a justification or that other participants do not rely on others such as celebrities or family. Such possibilities would need to be explored either through follow up interviews or the collection of data through methods such as observations, think aloud studies, or surveys.

Further, there were instances where participants were not probed sufficiently on the words they used or what was meant by their responses. In those instances, it was harder to categorise their responses and assumptions may have been made about the participants' meanings. Future interviews could be improved by focusing on fewer topics (e.g., limiting focus to socio-scientific topics such as vaccination and climate change that are considered in the extant literature) but in greater depth, allowing the researcher to explore and probe word choices and really drill down precisely into what knowing and knowledge mean to the participants. This could include exploring words and phrases such as "evidence," "science," "I know," and "believe." Planning for follow up interviews would also provide another opportunity to clarify interview responses. Future research should also use further probing in interviews or cognitive interviewing (Karabenick et al., 2007) to elaborate on the meaning of "experience" and clarify whether it refers to introspection, memory, or something else. Further refinement in preparing and delivering interview questions is also necessary to ensure the use of double-barrelled questions is avoided. This would allow participants to focus on one issue at a time and ideally improve understanding and categorisation of their responses. Lastly, care should be taken to ensure interview questions are focussed on eliciting responses about how one justifies knowledge claims, in contrast to questions that could invite opinions on moral matters (e.g., How do you know whether the asylum seeker policy is right/wrong or good/bad?)

Finally, there are limitations with regards to the sample which must be noted. These include that all of the participants were over 50. While the researcher sought to recruit participants of all ages, and had initial interest expressed by younger individuals, only individuals over the age of 50 were ultimately available to participate in the study when it was conducted. Although this adds an understanding of their experiences of knowing to the literature (in contrast to most studies which include younger, college-age participants), it is a key limitation which means that the aim of recruiting a diverse range of voices and perspectives was not achieved. While such a limitation can be remedied through a follow-up quantitative study, it is also necessary to highlight that further qualitative interviews with a broader age range is necessary. Purposive sampling of several

participants from age groups across the life span (e.g., young adults, middle-aged adults, and elderly adults) is also recommended. Collecting further demographic details, including cultural background, on participants would also aid understanding of their different ways of knowing and aid comparisons between them.

Moreover, the participants were a self-selecting group who likely agreed to be interviewed because of their interest in the research at hand as well as their ability to reflect on and articulate their responses to what might seem an abstract topic. In addition, participants had previously participated in related Ways of Thinking research; again, their interest in research on such topics may have influenced their responses. Where possible, future research should consider the recruitment of a group of participants with diverse perspectives on, and attitudes to, knowledge and knowing.

Future directions

Given the centrality of justification to epistemic cognition (Greene et al., 2008), the use of the justifications identified in this study should be tested in a larger, representative sample. Moreover, as previously noted, some of the justifications identified (e.g., *feeling and instinct*) were used for domains (e.g., aesthetics and morality) that could be considered as outside the realm of epistemology. Therefore, exploration of the extent to which these justifications are used for other domains of knowledge, for instance conceptual knowledge about topics such as climate change or vaccination, is therefore also warranted. While providing preliminary details about the use of multiple forms of justification, further research is also needed to draw conclusions about which means of justification are used in combination and for which contexts. Questions also remain regarding whether some justifications are weighted or preferred more than others and how participants manage contradictory evidence (Greene et al., 2008). Consideration also needs to be given to the effects of multiple justification use on outcomes and decision making, such as whether the use of multiple justifications is related to the perceived certainty of a claim or acceptance of its veracity. The participants, for instance, may have provided me with multiple justifications for a topic

to strengthen their claims that it was true knowledge. Alternatively, they may have required multiple justifications themselves before they would accept the claim as certain (i.e., extremely well justified; Chinn et al., 2011) or true, with the multiple justifications functioning in an additive way. It should be noted that, to avoid assuming the relevance of certainty to knowing, participants were not asked how certain or sure they were with regards to their knowledge about different claims. That is, they were not asked how certain or sure they were that climate change was real (or not), for instance. Future research should therefore consider the relationship between justification and certainty of knowledge.

Further research is still needed to explore possible differences between the *justification through others* subtheme and *sources of knowledge* theme. Future research should particularly consider whether *sources of knowledge* should be included as central components of a model of epistemic cognition, or not. It may be the case that *sources of knowledge* can be subsumed under *justification through others* as forms of testimony, alongside the grounds that those forms of testimony are seen as reliable. An alternative consideration is that the *sources of knowledge* theme has more relevance to the field of sourcing and source evaluation, as previously discussed. A further possibility is that sources and justification are more alike than not and go together as reliable processes for evaluating and generating knowledge claims, as per the AIR model. Before this is considered further, the relationship between theme one (*justifications for knowing*) and the (un)reliable processes identified in theme four should be considered.

In particular, theme one included the ways that participants justified their knowledge on specific topics. These appeared to differ from theme four's (un)reliable processes (in subthemes *critique of alternative approaches to knowing* and *valid, appropriate approaches to knowing*), which included what they reported as the most appropriate ways to source, evaluate, justify, and use knowledge, so were categorised separately. However, it would be worth exploring the relationship between these and whether one predicts the other. That is, it is worth considering how the processes they deemed as reliable relate to the means of justification they reported using (as in

theme one). As noted, the participants saw scientific inquiry, reasoning about statistical evidence, the consideration of multiple perspectives, and the peer review process as reliable processes. Similarly, many justified their knowledge by references to science and through multiple forms of justification. However, participants also used justifications such as seeing as knowing, feeling and instinct, and just knowing that they did not articulate as reliable processes. It might be that they are not seen as reliable, highlighting a discrepancy between what is seen as an appropriate approach to generating and evaluating knowledge and the actual practices they reported using.

Alternatively, it may be that these justifications are seen as reliable approaches but were not articulated as such in the interviews; further probing might be necessary in future interviews. Further, it could also be argued that while theme four included representations of the participants' epistemic commitments (i.e., a tendency to act in specified ways) about reliable processes, the justifications identified in theme one represent their epistemic commitments on these processes *in action* (Chinn et al., 2011). That is, their epistemic commitments could be inferred from their regular practices, such as a tendency to justify claims in particular ways (e.g., basing them on personal experience). For instance, a participant like Wendy who justifies knowledge on vaccination through reference to multiple studies conducted by experts might be demonstrating an epistemic commitment that evidence from multiple, qualified sources is a reliable way to justify knowledge on such topics. If this is the case that both theme one and the relevant subthemes from theme four represent their cognitions about reliable processes, then the justifications from theme one could be recategorised as reliable processes, as in the AIR model (Chinn et al., 2014; Chinn & Rinehart, 2016). Future research should seek to confirm this through clarifying participants' meaning behind their word choices (i.e., is there a difference between saying you know that climate change is real because you have seen evidence for it in studies versus saying that knowledge needs to be justified with repeatable, scientifically verifiable evidence?). This should also be backed up by exploring the functional differences, or not, of these. That is, future research should investigate whether the processes from different theme categories are associated with different outcomes, or not.

Similarly, as noted earlier, *sources of knowledge* and *source evaluation* could also be recategorised as reliable processes. For instance, comments about being wary of biased sources might demonstrate the epistemic commitment that knowledge claims generated by media with vested interests are unreliable. Recategorising these would put the justifications and sources identified in the interviews side-by-side as representations of (un)reliable ways to generate and evaluate knowledge claims and possibly overcome issues associated with current definitions and fuzzy distinctions between the two. Moreover, in line with the AIR model, the internal influences of *individual characteristics, personal biases, and emotions* from theme three could also be recategorised as (un)reliable processes. Figure 2 illustrates the relevant themes recategorised as (un)reliable processes as in the AIR model. Therefore, the results from this study, while not setting out to do so, have provided support and real-life examples for the reliable processes component of the AIR model, alongside some detail about the conditions under which the processes are reliable or not. Further research on the processes deemed reliable, or not, by the participants and the conditions under which they are reliable might also provide more detail and better understanding of how such cognitions impact upon learning and other outcomes.

Moreover, while the focus of this research was on how the participants justify knowledge, future research should investigate how they justify other targets of intellectual activity. This could include the various other epistemic and non-epistemic aims identified by this study and in the literature, including proving oneself to others and knowing because of what you might get out of having that knowledge. Other epistemic ends should also be considered such as understanding, explanation, belief, and wisdom (Chinn et al., 2014). Further research should also consider how one's non-epistemic aims influence their epistemic aims and approaches to knowing. Similarly, another issue to clarify is the role of learning and its relationship to epistemic cognition. In particular, some of the participants' responses to questions about knowing and knowledge referred to learning and acquiring knowledge. While Greene et al.'s (2016) definition of epistemic cognition includes the acquisition of knowledge, others (e.g., Hofer & Bendixen, 2012) have argued that for conceptual

clarity, learning needs to be studied separately to epistemic cognition and not assumed to be part of the epistemic cognition construct. This could be explored in future research by probing participants during interviews to determine whether, and if so, how, they differentiate between learning and knowing.

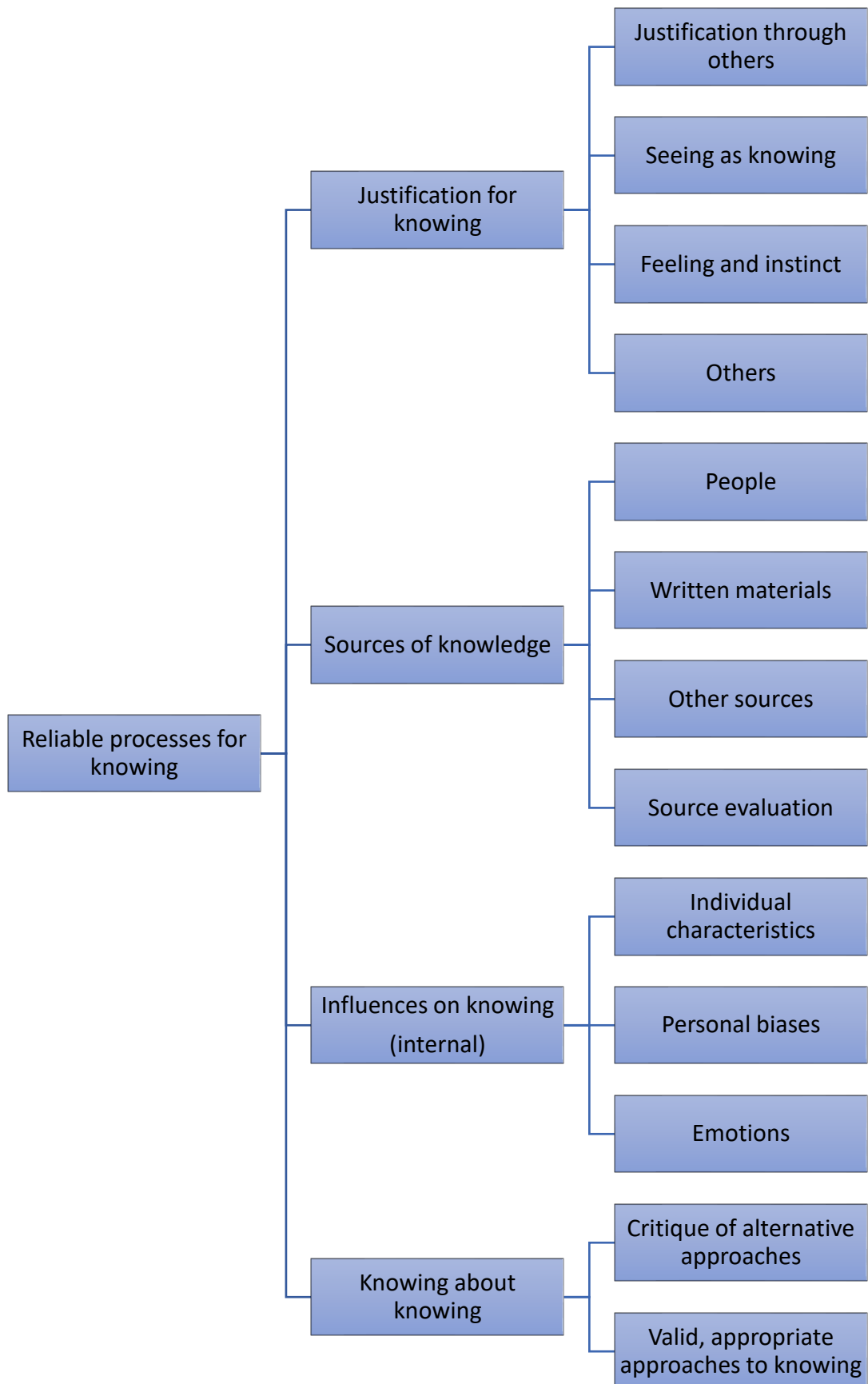


Figure 2. Themes recategorised as (un)reliable processes, as per the AIR model.

Lastly, the participants utilised different forms and amounts of justification to justify their knowledge on the various questions (see Table 8, pp. 103-105). At the same time, there were similarities between some of the participants with regards to how they justified their knowledge across the topics. As previously noted, however, definitive patterns of justification use could not currently be discerned as participants were not asked (nor answered) all of the interview questions. Indeed, recategorisation of some of the quotes attributed as sources to the theme of *justification for knowing* may reveal additional similarities and differences in justification use. A useful avenue for future research would therefore be the exploration of patterns of individual differences in justification use. Moreover, the results provide possible suggestions as to what may be underlying these differences which therefore warrant consideration in future research. These include age (as a proxy for time), education (i.e., access to education and education in a discipline), personal characteristics (e.g., dispositions and interest), biases, and the influence of people around them. As such, person-centred quantitative approaches could be used to complement this qualitative research and explore possible profiles of knowing.

Conclusion

This chapter has discussed the results of the qualitative study which sought to explore how the six adult participants know what they know. The next chapters focus on the quantitative study which seeks to continue exploring how adults know what they know. More specifically, it will focus on following up and testing the justifications identified in this study as well as exploring whether there are different types of knowers.

Chapter 11: Quantitative Method

The qualitative study identified five themes relevant to the ways of knowing and meaning of that knowing for a small group of adult participants. This quantitative phase aims to follow up some of these results and explore whether they generalise to a larger sample. Given the centrality of justification to epistemology (Greene et al., 2008), this phase aims to explore the generalisability of the results from theme one (*justification for knowing*). Particularly, it seeks to explore whether the justifications identified are used by others in a larger sample, alongside how many justifications tend to be used at a time. Further, this study seeks to further investigate the possible overlap between justifications for knowing (specifically *justification through others*) and *sources of knowledge* (theme two). Lastly, given evidence of epistemic cognition profiles in the literature (e.g., Chen, 2012; Dai & Cromley, 2014; Ferguson & Bråten, 2013; Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010; Kampa et al., 2016; Trevors, Kendeou, et al., 2017) and differences in justification use among participants in the qualitative phase (Table 8), this study aims to investigate whether there are qualitatively different profiles of justification (i.e., groups of “knowers”).

Therefore, the research questions guiding this phase of research are:

- Do the results from the qualitative phase generalise to a larger sample?
- Are there types of knowers?
 - If so, how do they differ in their use of justifications?
 - Are there underlying demographic differences between the types of knowers?

Participants

Participants included 345 adults from Australia recruited using Facebook ads. The average age of participants was 56.81 years ($SD = 14.87$) and ranged from 18 to 88 years. Detailed demographic statistics can be seen in Table 11.

Table 11

Demographic Statistics

Demographic Characteristic	<i>n</i>	%
Gender		
Male	131	37.97
Female	208	60.29
Other/Did not say	6	1.74
Age		
18-29	31	8.99
30-39	21	6.09
40-49	22	6.38
50-59	75	21.74
60-69	139	40.29
70-79	48	13.91
>80	5	1.45
Did not say	4	1.16
Country of Birth		
Australia	248	71.88
United Kingdom	44	12.75
New Zealand	11	3.19
USA	6	1.74
Germany	3	0.87
Other	33	9.57
Employment Status		
Full time study	22	6.38
Part time work	81	23.48
Full time work	74	21.45
Not currently in the workforce	38	11.01
Retired	126	36.52
Did not say	4	1.16
Highest Education Level Achieved		
Did not complete high school	33	9.57
Completed high school	41	11.88
Certificates/TAFE	36	10.43
Diploma/associate degree	40	11.59
Undergraduate degree/bachelor	99	28.70
Honours or graduate diploma/certificate	44	12.75
Postgraduate studies/master's degree	33	9.57
Did not say	5	1.45

Materials

The materials included a demographic questionnaire (Appendix D) and the survey questions focussed on the justification of various statements.

Development of survey to test model. The justifications identified in the qualitative phase of research are proposed as a preliminary model of ways of knowing. These are summarised in Table 12, with sample statements based on subthemes and quotes derived from the qualitative study. Note that some of these were reworded for brevity and clarity, with the essential meaning retained. Additional justifications were also developed from the *sources of knowledge* theme, including the Internet, friends, and experts. All statements were reviewed by the student and supervisors and a selection was made to present in the online survey. The ones chosen were viewed as the most representative statements of the ways of knowing to be tested. Again, these were reworded to be clear, brief statements to represent the different means of justification. These included:

- I've seen it for myself
- It's logical
- I read it on the Internet
- I just know it
- It just makes sense
- I've seen the evidence with my own eyes
- I've read the peer-reviewed evidence
- The science
- My faith told me so
- The statistics
- It feels right
- Somebody I trust told me:
 - teacher
 - family member
 - expert
 - friend
 - scientist
 - celebrity

Table 12

Justifications from Qualitative Study and Sample Statements

Subtheme	Sample statements
Justification through others	<p>Just the science</p> <p>The experts in the field</p> <p>The evidence is overwhelming</p> <p>Peer-reviewed evidence</p> <p>They got all the stats for me... we've got the evidence</p> <p>The science</p> <p>From university studies</p> <p>Knowledge in the family</p> <p>Faith</p> <p>It's not just 30 years of science and scientists, thousands of Scientists</p> <p>I was taught it at school/university</p> <p>My parents told me</p> <p>Family experience</p> <p>97% of climate scientists say so</p> <p>Many studies said so</p> <p>Indisputable statistics</p> <p>Celebrity</p>
Seeing as knowing	<p>I've seen it work</p> <p>You could see it happening</p> <p>It's backed up by millions of pieces of evidence I've seen</p> <p>I've seen pictures</p> <p>I could see it happening in real time</p>
Feeling and instinct	<p>It feels right</p> <p>It doesn't irritate me</p> <p>I get a sixth sense about them</p> <p>It engages me</p> <p>I can feel it</p>
Other	<p>It's just logical, logic and evidence</p> <p>It just seems to be logical</p> <p>I know in my heart that it is wrong</p> <p>I know that it goes against my ideals/standards</p> <p>Trial and error</p> <p>Experience</p> <p>I just know</p>

To test the model, a series of questions needed to be developed to allow the researcher to tap into the justifications used by the participants for various topics. This provided the context for the participants to apply their justifications to. That is, while the focus is on justification and how participants know what they know, context is required for them to apply those justifications to. Questions were developed to reflect the diverse topics used in the interviews as well as those commonly discussed in the extant literature, such as climate change, vaccines, evolution, and genetically modified organisms (e.g., Bråten et al., 2009; Brandmo & Bråten, 2018; Chinn et al., 2020; Muis et al., 2021; Sinatra et al., 2014). However, some question types were removed for the purposes of this study. That is, while the results of the qualitative phase did reveal the potential for studying how individuals justify other types of knowledge (e.g., procedural knowledge), such questions were not included in this study to maintain the brevity of the questionnaire and to aid the interpretation of results. Specifically, questions that tapped into conceptual knowledge were retained due to the greater focus of the justification of such knowledge in the extant literature as well as findings that epistemic cognition is a significant predictor of the acquisition of conceptual knowledge (Cartiff et al., 2021). Questions relevant to specific domains and topics (e.g., science, religion, climate change, vaccination, and so on) were written, while those focusing on aesthetics and judgements of morality were also removed as a consideration of the literature revealed these to be viewed as outside the realm of philosophical epistemology (Chinn et al., 2011; Greene et al., 2008).

Therefore, the final list of questions was:

1. I know that global warming is caused by humans
2. I know that vaccines save lives
3. I know that smoking causes lung cancer
4. I know that evolution is real
5. I know that the moon landing was real
6. I know that mobile phones do **not** cause brain cancer in humans

7. I know that global warming is **not** real
8. I know that vaccines cause autism
9. I know that wind turbines cause health problems in humans
10. I know that antibiotics treat the common cold
11. I know that genetically modified organisms (GMOs) cause harm to people
12. I know that homeopathy is an effective treatment for illness
13. I know that a higher power (e.g., God) created the world
14. I know that there is a higher power/God(s)

For each question, the participants were first asked to rate their agreement with each statement on a Likert scale from 1 (*strongly disagree*) to ten (*strongly agree*). Instead of a 5- or 7-point Likert scale, a 10-point Likert scale was used to create more overall score variance (DeVellis, 2017) and reduce measurement error variance (Ping, 2004). Then, with the same question in mind, the participants were asked to justify how they know this. The stem “I know this because...” was followed by the options noted above. Participants were advised they could choose as many answers as needed to complete this stem question. Participants also had the option of selecting “other” and then writing in their own justification. The final survey can be found in Appendix E. The survey was hosted on Qualtrics (<http://www.qualtrics.com>).

Procedure

Data collection was conducted between January 2020 and February 2020. Participants were recruited through social media advertising. Advertisements on Facebook invited Australian adults over the age of eighteen to participate in a study regarding how they know what they know. The advertisement also indicated the chance of winning a gift voucher. A link was provided with the advertisement which would take potential participants to the survey’s Qualtrics page. The initial page included the explanatory statement (Appendix F) which detailed information such as the purpose of the study, requirements, the content and time involved, confidentiality, risks, and data storage. Informed consent was implied through the participants clicking ‘next’ at the bottom of the

page. This would then take them to a page to provide demographic details before commencing the survey questions. At the conclusion of the survey, participants could elect to provide their email address to go into the draw to win one of three \$50 gift vouchers. Participants could also elect to provide their email addresses to be contacted regarding future research. Email addresses were not linked to the results and no other identifying details were collected. The survey was deemed low risk as the focus was on the participants justifying how they know what they know, with no focus on testing what or how much each person knows. It was not anticipated that any of the questions would make any of the participants feel uncomfortable; however, participants were advised that, in the unlikely event of discomfort, they should discontinue the survey and seek appropriate supports. Links to online and phone counselling services were provided in the explanatory statement. Ethical approval for this study was granted by Monash University's Human Research Ethics Committee (Project ID: 21096).

Data analysis

Data was downloaded from Qualtrics and exported to Microsoft Excel (Microsoft 365, Version 2110). From 464 individuals who commenced the survey, 345 completed the full survey. There were no missing data as responses were required for all questions, excepting the demographic questions, with participants encouraged to discontinue at any time if they felt uncomfortable continuing with the survey. There were 1061 responses to the "other" option, with over 68.00% of participants writing at least one response and an average of three responses per participant. Due to the volume of "other" responses, these were not analysed in the present study. Therefore, this category was set aside to be analysed in future studies. For each question (e.g., "I know that global warming is caused by humans"), each of the possible justification responses (e.g., "I've seen it for myself") was given a 1 if endorsed by the participant, and 0 if it was not endorsed. Scores were then added across all of the questions for each form of justification to compute a total score (i.e., a maximum score of 14 for each of the 17 justifications). Data were then exported to SPSS Version 26 (IBM Corp, 2019.) for further analysis.

Hierarchical cluster analysis: Determining the number of clusters. Before conducting the cluster analysis, it is worth considering the possibility that there are no clusters present and that a structure will be artificially imposed on the data (Everitt et al., 2011; Kent, 2015). The patterns of justification evident from the qualitative interviews provide preliminary evidence that there may be natural groupings in the data worth exploring with cluster analysis. To identify these profiles of justification, an agglomerative, hierarchical cluster analysis of the total justification score variables was conducted (Everitt et al., 2011). There were 17 total justification score variables; one of the variables, "somebody I trust" was not used as it was deemed redundant. In other words, it repeated information captured by participants endorsing which people they trusted. No variables were transformed. The distance measure used was the squared Euclidean distance, with Ward's method used as the cluster method. The number of substantive clusters was determined through consideration of the agglomeration schedule, inspection of the dendrogram, and generation of a scree-type plot of the dendrogram's rescaled distances (Clatworthy et al., 2005; Everitt et al., 2011). The agglomeration schedule was examined to determine when there were large increases in heterogeneity when moving from one stage of clustering to the next (Kent, 2015; Pastor, 2010). With no clear elbow in the scree plot, consideration was given to the creation of three, four, and five clusters; these were explored to determine the most interpretable solution. The analysis was then re-run with the specified number of clusters. Cases were also randomised and the analysis re-run to determine any effect of case order on the analysis.

Exploring and naming clusters. Everitt et al. (2011) caution the use of statistical tests (such as analysis of variance) for comparing the clustering variables between clusters, as the clustering process maximises between-cluster differences on these variables. Despite this, a multivariate analysis of variance (MANOVA) was conducted to explore each possible cluster solution (three, four, or five clusters). This was done to aid interpretation of the variables that differentiate the clusters in each cluster solution, instead of relying on graphical representations alone. In such instances, visual differences between clusters can be over-interpreted without objective criteria. Therefore, a

MANOVA was run for each possible cluster solution with the total justification scores as the dependent variables. In determining the most appropriate number of clusters, consideration was also given to the assumptions of MANOVA. Once the most appropriate number of clusters was determined, the MANOVA results were re-examined to aid in naming the clusters. In particular, Tukey post hoc tests were consulted to examine differences between cluster groups ($p < .05$).

Profiling clusters. Cluster profiles were then explored with further analyses to determine any characteristic differences between the profiles. MANOVA was used to investigate the relationship between cluster membership and responses to the questions about knowing (Pastor, 2010), with Tukey post hoc tests used to examine paired differences between cluster groups on these scores ($p < .05$). Further analyses utilising demographic variables were also undertaken to better understand the characteristics of each cluster. MANOVA was also used to explore cluster differences in the frequency of justifications used for each question. An analysis of variance (ANOVA) explored the relationship between age and cluster membership. Chi-square tests for independence were used to explore the relationships between education level and cluster membership, and employment category and cluster membership.

Validating clusters. Discriminant function analysis was conducted to assess goodness of fit and validate the clusters (Pastor, 2010).

Chapter 12: Quantitative Results

Descriptive statistics

Of the 17 forms of justification, “the science” was endorsed most often, with “celebrity” the least endorsed response (see Table 13). Table 14 shows a breakdown of the percentage of participants endorsing each form of justification for each question. As can be seen, multiple forms of justification are used to substantiate knowledge for each topic question.

Table 13

Descriptive Statistics for Justification Variables

Justification	<i>M</i>	<i>SD</i>	Skew	Kurtosis
I've seen it for myself	2.09	1.93	1.03	0.85
It's logical	3.77	3.36	0.92	0.16
I read it on the Internet	1.23	2.45	2.54	6.26
I just know it	0.85	1.70	2.88	9.63
It just makes sense	2.66	2.94	1.41	1.89
I've seen the evidence with my own eyes	2.55	2.19	1.08	1.74
I've read the peer-reviewed evidence	3.94	3.78	0.79	-0.50
The science	7.14	4.18	-0.22	-1.11
My faith told me so	0.47	1.02	2.90	11.92
The statistics	3.41	2.98	0.96	0.42
It feels right	1.01	1.85	3.04	11.94
Teacher	0.47	1.53	4.42	22.07
Family member	0.33	1.20	5.79	42.30
Expert	1.14	2.55	2.96	8.81
Friend	0.28	1.25	6.97	55.94
Scientist	0.90	2.39	3.46	12.41
Celebrity	0.08	0.48	8.67	88.29

Table 14

Percentage of Participants Endorsing each Justification for each Question

Question	Justification																
	Seen it for myself	It's logical	I read it on the Internet	I just know it	It just makes sense	Seen own eyes	Peer review evidence	The science	Faith told me	The statistics	It feels right	Teacher	Family member	Expert	Friend	Scientist	Celebrity
1	24.64	40.00	11.30	2.90	21.74	31.30	44.35	59.13	0.87	39.13	3.77	2.32	1.16	7.54	2.32	6.09	0.00
2	28.12	33.33	8.12	4.64	15.07	33.04	41.74	62.90	0.58	55.94	3.48	4.06	4.06	11.01	0.87	7.25	0.29
3	29.86	31.30	8.70	1.45	16.52	29.86	37.10	62.03	0.29	54.20	2.03	5.22	3.48	11.01	2.61	7.83	0.58
4	8.12	50.43	8.99	5.22	33.04	15.65	35.65	71.01	4.35	12.75	6.38	9.57	3.48	9.28	2.90	9.57	1.74
5	29.57	22.61	8.70	5.22	17.97	36.23	21.74	42.90	0.29	6.67	7.25	6.38	4.93	7.54	2.90	6.96	1.16
6	2.32	13.33	12.17	2.61	11.88	3.19	26.38	40.58	0.29	22.32	4.35	1.16	0.87	5.22	1.16	5.80	0.29
7	31.01	31.88	13.04	6.96	18.26	37.39	40.00	66.67	1.16	39.42	6.09	3.48	2.61	8.41	2.61	8.70	1.74
8	7.25	12.46	11.59	4.35	10.43	10.14	40.87	57.97	0.29	37.39	2.32	3.19	1.74	9.57	1.74	7.83	0.29
9	2.90	21.74	8.99	4.06	19.71	3.77	20.58	38.55	0.29	19.42	6.38	0.87	0.58	4.93	1.74	3.48	0.29
10	11.30	16.23	7.25	5.80	11.59	14.49	27.54	60.87	0.87	11.01	2.90	3.19	4.06	19.71	0.87	9.28	0.58
11	3.19	18.55	10.14	4.93	15.65	5.51	22.32	43.77	0.58	14.49	7.83	1.16	1.45	5.80	1.74	5.80	0.00
12	20.29	21.74	8.70	4.93	19.13	17.39	23.77	41.16	1.74	16.81	7.54	1.16	2.03	6.67	2.32	4.64	0.00
13	3.19	33.91	3.19	13.04	25.51	6.67	6.67	39.71	16.81	6.09	16.23	3.48	1.16	4.64	1.45	4.64	0.29
14	6.96	29.28	1.74	18.55	29.28	10.14	5.22	26.96	18.84	5.22	24.06	2.03	1.16	2.90	2.32	2.32	0.29

Note. Question 1 = Global warming; 2 = Vaccines; 3 = Smoking; 4 = Evolution; 5 = Moon landing; 6 = Mobile phones NOT cancer; 7 = Global warming NEG; 8 = Vaccines and autism; 9 = Wind turbines; 10 = Antibiotics common cold; 11 = GMOs harmful; 12 = Homeopathy; 13 = Higher power created world; 14 = There is a higher power.

Hierarchical cluster analysis

After considering the agglomeration schedule (Appendix G), dendrogram, scree plot (Figure 3), and MANOVA results exploring three, four, and five cluster solutions, it was determined that three clusters offered the most interpretable solution. Moreover, three clusters were deemed suitable as the size of the smallest cluster ($n = 58$) met the assumption of sample size for MANOVA. With four and five clusters, the smallest clusters in each ($n = 16$ for both) were too small in that they violated the requirement to have more cases in each cell than the number of dependent variables (DVs = 17); this violation would have reduced the power of the analysis (Tabachnick & Fidell, 2014). In addition, the formation of a small cluster when specifying four and five clusters points to the retention of a cluster solution with one fewer clusters, that is, three clusters (Pastor, 2010). Randomising the order of cases and then reanalysing the data was not observed to change the outcomes of the analysis.

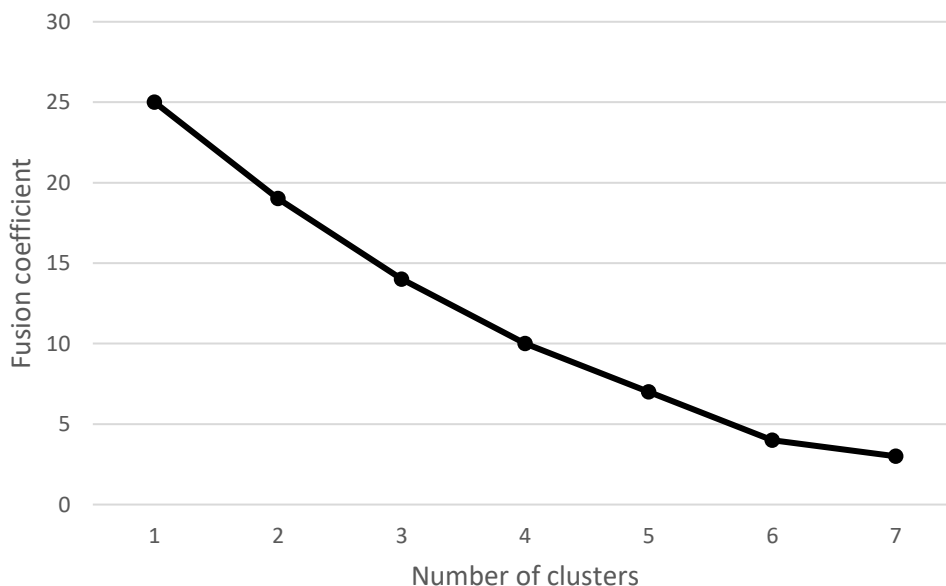


Figure 3. Scree plot of dendrogram.

Cluster exploration and naming. A one-way between-groups MANOVA was performed to investigate cluster differences in justifications used. There were 17 dependent variables, the justifications used, and cluster was the independent variable. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity. With more than 20 cases in each cell (Cluster 1 $n = 200$, Cluster 2 $n = 87$, and Cluster 3 $n = 58$), no violation to the assumption of sample size was observed. Inspection of the matrix of scatterplots between each pair of dependent variables revealed violations to the assumption of linearity, which reduces the power of the analysis (Tabachnick & Fidell, 2014). While consideration was given to the transformation of the deviating variables, transformation was ultimately not undertaken as it increases interpretation difficulty (Tabachnick & Fidell, 2014).

Violations to the assumptions of univariate normality were also observed, with most variables demonstrating substantial positive skew ($> \pm 1$; Table 13). Further, all variables had significant Kolmogorov-Smirnov values ($p < .001$) indicating violation of the assumption of normality. Univariate outliers were observed for all but three of the variables (“it’s logical,” “I read the peer-reviewed evidence,” and “the science”). The assumption of multivariate normality was also violated, with the maximum Mahalanobis distance value of 204.64 larger than the critical value of 40.79 ($\alpha = .001$). Further, 25 cases had Mahalanobis distance values that exceeded this critical value. While the large sample size (> 20 in each cell) ensures robustness against violations of normality (Tabachnick & Fidell, 2014), the presence of both univariate and multivariate outliers was a concern due to the error they can introduce. However, while transformation of the outlying cases can be undertaken, this was rejected because of the increased difficulty in interpretation it would introduce. Deletion of such cases was also considered. However, due to the number of cases that would need to be removed, and the consequent reduction in power, this remedy was also not conducted.

The results of Box’s M test of equality of covariance matrices, $p < .001$, indicated violation of the assumption of homogeneity of variance-covariance matrices. Pillai’s Trace was therefore the

multivariate test of significance reported as it is more robust to violations than Wilks' Lambda and provides adequate statistical power (Tabachnick & Fidell, 2014). Correlations between the dependent variables were inspected to assess the assumption of multicollinearity (Appendix H). A significant Pearson's correlation between the variables, "scientist" and "expert" ($r = .88$) indicated a violation to the assumption of multicollinearity. While consideration was given to removing one of the offending variables, they were ultimately both retained due to the exploratory nature of the cluster analysis and the small number of responses for each form of justification. All other correlations between the dependent variables were below .80, indicating no further reason for concern regarding the correlations between the dependent variables (Pallant, 2016). All of the variables recorded significant values ($p < .05$) on Levene's Test of Equality of Error Variances. Therefore, a more conservative alpha level of .01 was set for determining significance for these variables in the univariate F -test (Tabachnick & Fidell, 2014).

There was a statistically significant multivariate effect of the three justification clusters on the combined justification variables, Pillai's Trace = 1.24, $F(34, 654) = 31.27$, $p < .001$; partial eta squared = .62. With the exception of "my faith told me so," univariate results were also all statistically significant ($p < .001$), using an alpha of .01 (Table 15). Note that given the univariate F -test is a preliminary analysis in MANOVA for description only, an increased risk of a Type I error is tolerable and therefore a Bonferroni adjustment was not undertaken (Olejnik, 2010).

Cluster names were decided through inspection of cluster means and interpretation of post hoc summaries from MANOVA results ($p < .05$). A comparison of the cluster means for each form of justification is summarised in Table 16 and illustrated in Figure 4.

Table 15

One-Way Analyses of Variance in Justification use

Variable	<i>F</i> (2, 342)	Sig.	Partial Eta Squared
I've seen it for myself	13.27	*	.07
It's logical	74.12	*	.30
I read it on the Internet	76.05	*	.31
I just know it	56.78	*	.25
It just makes sense	81.35	*	.32
I've seen the evidence with my own eyes	18.24	*	.10
I've read the peer-reviewed evidence	13.84	*	.08
The science	198.76	*	.54
My faith told me so	1.97	.14	.01
The statistics	39.38	*	.19
It feels right	44.63	*	.21
Teacher	32.50	*	.16
Family member	21.29	*	.11
Expert	57.45	*	.25
Friend	25.35	*	.13
Scientist	59.82	*	.26
Celebrity	17.36	*	.09

Note. * $p < .001$.

Table 16

Means and Standard Deviations for Justification Variables by Cluster

Justification	Cluster 1 (n = 200)		Cluster 2 (n = 87)		Cluster 3 (n = 58)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
I've seen it for myself	2.14 ^a	1.90	1.37 ^b	1.52	2.98 ^c	2.17
It's logical	3.71 ^a	2.94	1.53 ^b	1.68	7.33 ^c	3.62
I read it on the Internet	0.60 ^a	1.39	0.67 ^a	1.58	4.24 ^b	3.81
I just know it	0.43 ^a	0.94	0.54 ^a	1.13	2.72 ^b	2.83
It just makes sense	2.26 ^a	2.32	1.20 ^b	1.37	6.22 ^c	3.68
I've seen the evidence with own eyes	2.85 ^a	2.14	1.40 ^b	1.61	3.22 ^a	2.51
I've read the peer-reviewed evidence	4.53 ^a	3.84	2.16 ^b	2.87	4.57 ^a	3.99
The science	9.26 ^a	2.74	1.98 ^b	1.94	7.59 ^c	4.12
My faith told me so	0.38	0.82	0.60	1.12	0.60	1.41
The statistics	4.15 ^a	3.02	1.20 ^b	1.25	4.19 ^a	3.05
It feels right	0.69 ^a	1.08	0.49 ^a	0.99	2.86 ^b	3.28
Teacher	0.13 ^a	0.45	0.38 ^a	1.35	1.81 ^b	2.91
Family member	0.09 ^a	0.39	0.30 ^a	0.92	1.19 ^b	2.42
Expert	0.52 ^a	1.21	0.67 ^a	1.68	3.98 ^b	4.48
Friend	0.08 ^a	0.49	0.06 ^a	0.28	1.28 ^b	2.71
Scientist	0.34 ^a	0.88	0.39 ^a	1.25	3.60 ^b	4.53
Celebrity	0.01 ^a	0.10	0.01 ^a	0.11	0.40 ^b	1.09

Note. Superscript letters that differ in the same row indicate statistically significant differences in means at $p < .05$.

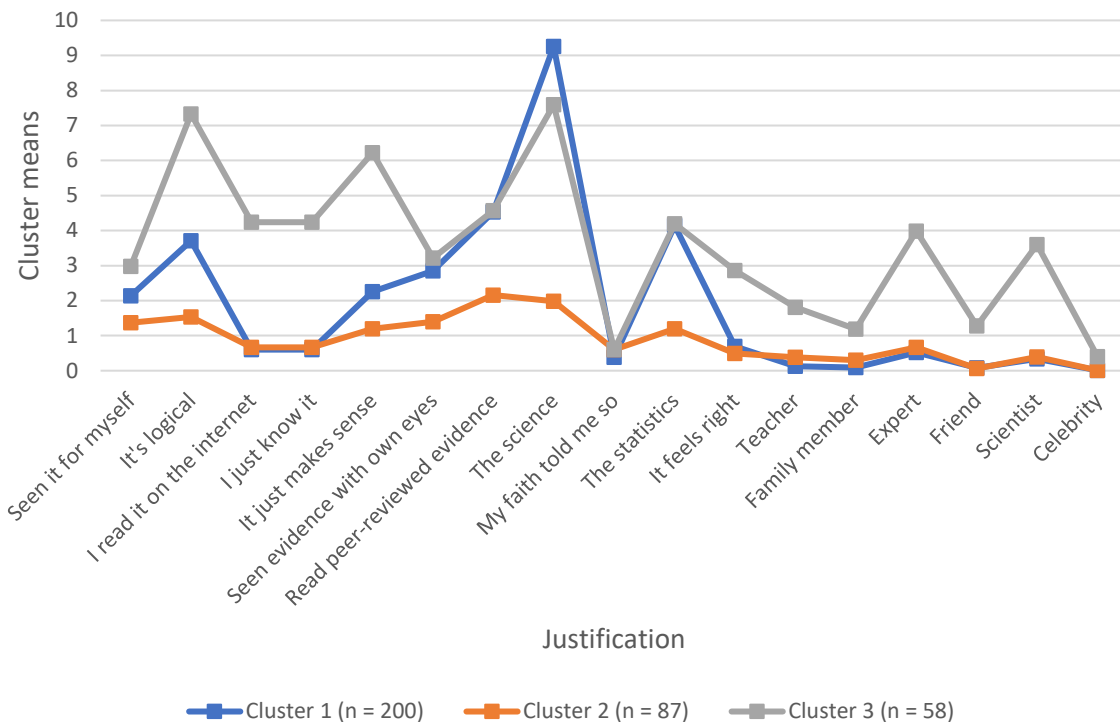


Figure 4. Mean cluster scores for each justification variable.

Cluster 1 (n = 200). This was the largest group, with participants in this cluster utilising “the science” as a justification significantly more than those in the other two groups. This was also their most used form of justification, which was endorsed more than twice as frequently than their next most frequently endorsed forms of justification, “I’ve read the peer-reviewed evidence” and “the statistics.” Their least used forms of justification were all of the ‘somebody I trust’ subcategories, including “celebrity,” “friend,” and “family member,” as well as “I read it on the Internet,” “I just know it,” and “it feels right”; there were no significant differences between clusters one and two on these forms of justification. They endorsed “I’ve seen the evidence,” “I’ve read the peer-reviewed evidence,” and “the statistics” similarly to cluster three. Because of their use of justifications relating to science, evidence, logic, and statistics, over relying on others, sense, just knowing, and what they read on the Internet, this group was labelled *justifiers through formal processes*.

Cluster 2 (n = 87). Not only did these participants endorse each form of justification the least, but they were also quite undifferentiated in their endorsement of the various forms of

justification. Their most used form of justification was “I’ve read the peer-reviewed evidence” followed by “the science.” Their least used was “celebrity” and other people (e.g., experts and friends). This group was labelled *undifferentiated justifiers*.

Cluster 3 (n = 58). In the smallest cluster, participants endorsed the use of most of the justification types significantly more than the other two groups. Their most used forms of justification were “the science,” “it’s logical,” and “it just makes sense”; apart from “the science,” these were significantly higher than for the other clusters. They also endorsed “I’ve seen it for myself,” “I read it on the Internet,” “I just know it” and “it feels right” significantly more than the other two clusters. Participants in clusters one and three similarly endorsed “I’ve seen the evidence,” “I’ve read the peer-reviewed evidence,” and “the statistics.” The least endorsed forms of justification for this group were “celebrity” and “my faith told me so.” Notably, they endorsed all of the ‘someone I trust told me’ subcategories significantly more than the other two groups, including “experts” and “scientists.” This group can be seen to utilise both internal, personal forms of justification (e.g., “I just know it” and “it just makes sense”) and external forms of justification (e.g., trusting other people, “I read it on the Internet” and “the science”) and was therefore labelled as *multiple justifiers*.

Profiling clusters. A one-way between-groups MANOVA was performed to investigate cluster differences in participants’ responses to the questions. See Table 17 for descriptive statistics for the topic questions. There were 14 dependent variables, the topic questions, and cluster was the independent variable. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity. With more than 20 cases in each cell (Cluster 1 $n = 200$, Cluster 2 $n = 87$, and Cluster 3 $n = 58$), no violations to the assumptions of sample size were observed. Inspection of the matrix of scatterplots between each pair of dependent variables revealed violations to the assumption of linearity.

Table 17

Descriptive Statistics for Topic Question Variables

Topic Question	<i>M</i>	<i>SD</i>	Skew	Kurtosis
Global warming	7.66	2.53	-1.11	0.48
Vaccines save lives	9.31	1.56	-3.03	10.44
Smoking	8.94	1.70	-2.14	5.35
Evolution	8.78	2.15	-2.24	4.64
Moon landing	8.81	1.91	-1.85	3.18
Mobile phones NOT cancer	5.88	2.46	-0.01	-0.57
Global warming (NEG)	2.04	2.14	2.42	5.34
Vaccines and autism	2.01	1.81	2.13	4.66
Wind turbines	2.97	2.12	0.97	0.48
Antibiotics and common cold	1.90	2.04	2.79	7.46
GMOs harmful	4.37	2.51	0.39	-0.39
Homeopathy	3.80	2.68	0.65	-0.61
Higher power created the world	3.53	3.21	0.98	-0.52
There is a higher power	4.10	3.34	0.64	-1.10

Inspection of the histograms revealed several of the variables had highly skewed distributions (Table 17). Further, all variables had significant Kolmogorov-Smirnov values ($p < .001$) indicating violation of the assumption of normality; as previously noted, the large sample size guards against such violations. Univariate outliers were observed for half of the variables (vaccines, smoking, evolution, moon landing, global warming [NEG], vaccines and autism, antibiotics and common cold). The assumption of multivariate normality was also violated, with the maximum Mahalanobis distance value of 75.67 larger than the critical value of 36.12 ($\alpha = .001$). Further, 12 cases had Mahalanobis distance values that exceeded this critical value. Despite the presence of outliers, no transformation or deletion of cases was undertaken, for reasons previously noted. The results of Box's M test of equality of covariance matrices, $p < .001$, indicated violation of the assumption of homogeneity of variance-covariance matrices. Pillai's Trace is therefore the multivariate test of significance reported as it is more robust to violations of assumptions

(Tabachnick & Fidell, 2014). Correlations between the dependent variables were inspected to assess the assumption of multicollinearity (Appendix I). A significant Pearson's correlation ($p < .001$) between the variables "higher power created the world" and "there is a higher power" ($r = .84$) indicated a violation to the assumption of multicollinearity. As before, neither of these variables was removed. All other correlations between the dependent variables were below .80, thus indicating no further evidence of multicollinearity. Further, all but three of the variables recorded significant values ($p < .05$) on Levene's Test of Equality of Error Variances. Therefore, a more conservative alpha level of .01 was set for determining significance for these variables in the univariate F -test (Tabachnick & Fidell, 2014). There was a statistically significant multivariate effect of the three justification clusters on the 14 question variables, Pillai's Trace = .21, $F(28, 660) = 2.70$, $p < .001$; partial eta squared = .10 (Table 18).

Table 18

One-Way Analyses of Variance in Topic Question Ratings

Topic Question	$F(2, 342)$	Sig.	Partial Eta Squared
Global warming	21.65	*	0.11
Vaccines	4.42	.01	0.03
Smoking	4.76	.01	0.03
Evolution	6.24	.002	0.04
Moon landing	6.40	.002	0.04
Mobile phones NOT cancer	6.37	.002	0.04
Global warming NEG	19.85	*	0.10
Vaccines and autism	4.43	.01	0.03
Wind turbines	4.03	.02	0.02
Antibiotics and common cold	3.32	.04	0.02
GMOs harmful	6.24	.002	0.04
Homeopathy	8.46	*	0.05
Higher power created the world	3.44	.03	0.02
There is a higher power	2.36	.10	0.01

Note. * $p < .001$.

Given significant differences between cluster groups on the question variables, Tukey post hoc tests ($p < .05$) were conducted to see where these differences lay. Significant paired cluster differences were found (see Table 19 and Figure 5). No significant paired cluster differences were found for “antibiotics” and “there is a higher power.”

Table 19

Means and Standard Deviations for Topic Question Variables by Cluster

Topic Question	Cluster 1 ($n = 200$)		Cluster 2 ($n = 87$)		Cluster 3 ($n = 58$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Global warming	8.12 ^a	2.15	6.21 ^b	3.02	8.28 ^a	2.12
Vaccines	9.49 ^a	1.31	8.91 ^b	1.87	9.26 ^{ab}	1.73
Smoking	9.08 ^a	1.50	8.46 ^b	2.15	9.17 ^a	1.45
Evolution	9.04 ^a	1.86	8.09 ^b	2.58	8.93 ^a	2.20
Moon landing	9.03 ^a	1.60	8.18 ^b	2.38	8.97 ^a	1.92
Mobile phones NOT cancer	6.15 ^a	2.43	5.08 ^b	2.22	6.16 ^a	2.66
Global warming NEG	1.66 ^a	1.58	3.23 ^b	3.01	1.57 ^a	1.57
Vaccines and autism	1.81 ^{ab}	1.62	2.49 ^b	2.16	1.98 ^a	1.74
Wind turbines	2.88 ^{ab}	2.02	3.48 ^b	2.55	2.53 ^a	1.59
Antibiotics and common cold	1.67	1.81	2.31	2.51	2.09	1.91
GMOs harmful	4.18 ^a	2.41	5.15 ^b	2.52	3.84 ^a	2.61
Homeopathy	3.47 ^a	2.61	4.80 ^b	2.53	3.45 ^a	2.81
Higher power created the world	3.41 ^{ab}	3.12	4.23 ^b	3.54	2.88 ^a	2.87
There is a higher power	3.88	3.17	4.77	3.61	3.86	3.38

Note. Superscript letters that differ in the same row indicate statistically significant differences in means at $p < .05$.

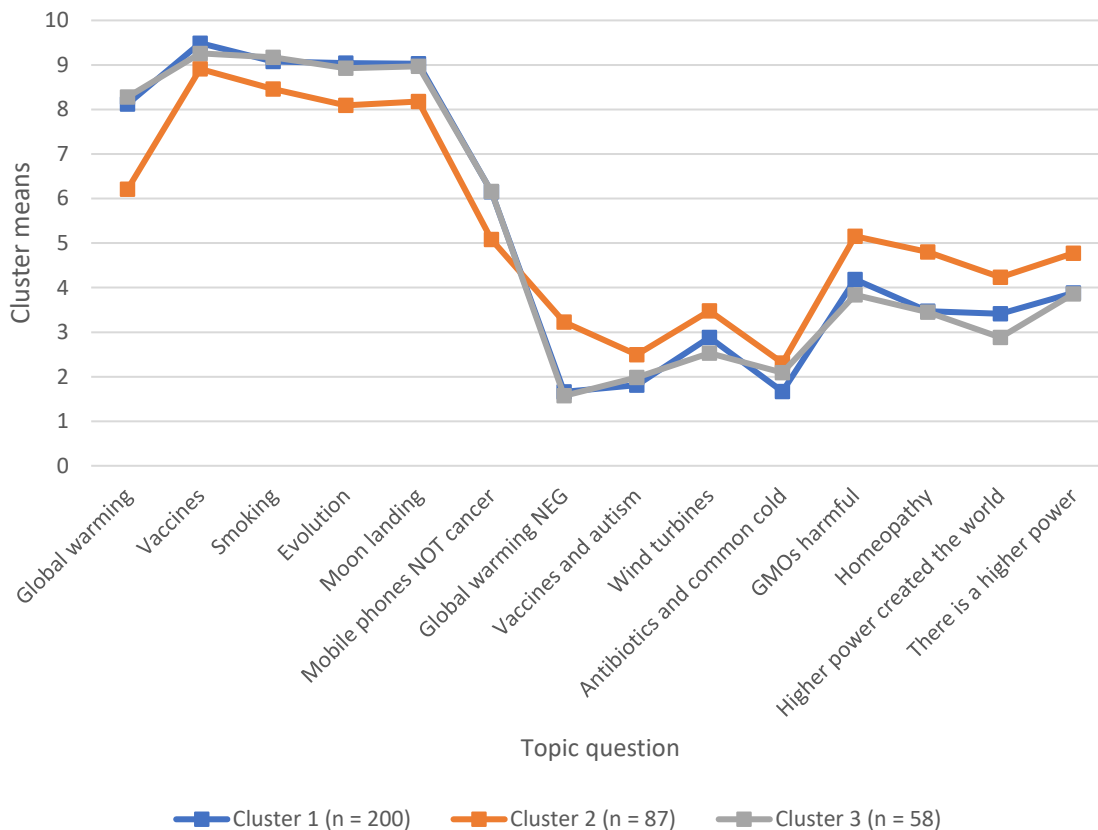


Figure 5. Comparison of mean cluster scores on responses to topic question.

Justification frequency by cluster. The number of justifications endorsed for each question was also calculated for each participant. See Table 20 for descriptive statistics for the number of justifications endorsed for each question. A one-way between-groups MANOVA was then performed to investigate cluster differences in the number of justifications used per question. There were 14 dependent variables, the number of justifications used per question, and cluster was the independent variable. Preliminary assumption testing was conducted. There was no violation to the assumption of sample size, with more than 20 cases in each cell (Cluster 1 $n = 200$, Cluster 2 $n = 87$, and Cluster 3 $n = 58$). Inspection of the matrix of scatterplots between each pair of dependent variables revealed violations to the assumption of linearity, while inspection of histograms revealed all variables were positively skewed and violated assumptions of normality (Table 20). All variables had significant Kolmogorov-Smirnov values ($p < .001$) indicating a violation of the assumption of normality. Inspection of boxplots indicated the presence of univariate outliers for all variables.

Table 20

Descriptive Statistics for Number of Justifications Used per Question

Topic Question	<i>M</i>	<i>SD</i>	Skew	Kurtosis
Global warming	2.99	2.13	0.90	1.07
Vaccines save lives	3.14	2.10	0.94	1.19
Smoking	3.04	2.26	1.81	5.94
Evolution	2.88	2.26	1.81	4.74
Moon landing	2.29	1.89	1.78	4.78
Mobile phones NOT cancer	1.54	1.49	1.87	7.06
Global warming (NEG)	3.19	2.71	1.57	3.72
Vaccines and autism	2.19	1.90	1.67	4.53
Wind turbines	1.58	1.67	2.17	9.57
Antibiotics and common cold	2.08	1.99	2.57	11.62
GMOs harmful	1.63	1.64	1.54	3.69
Homeopathy	2.00	1.89	1.98	6.39
Higher power created the world	1.87	1.97	1.53	2.37
There is a higher power	1.87	1.96	1.65	3.20

The maximum Mahalanobis distance value of 162.90 was larger than the critical value of 36.12 ($\alpha = .001$), indicating the assumption of multivariate normality was also violated. There were 23 cases with Mahalanobis distance values that exceeded this critical value. Despite violations to assumptions regarding linearity, normality, and outliers, no transformation of variables or deletion of cases was conducted. Inspection of the correlation matrix between the dependent variables revealed the absence of multicollinearity. The results of Box's M test of equality of covariance matrices, $p < .001$, indicated violation of the assumption of homogeneity of variance-covariance matrices. Consequently, Pillai's Trace is the multivariate test of significance reported. All of the variables recorded significant values ($p < .05$) on Levene's Test of Equality of Error Variances. Therefore, a more conservative alpha level of .01 was set for determining significance for these variables in the univariate *F*-test.

There was a statistically significant multivariate effect of the three justification clusters on justification frequency by question, Pillai's Trace = .60, $F(28, 660) = 10.19$, $p < .001$; partial eta squared = .30. Results of univariate ANOVAs are presented in Table 21. Given significant differences between cluster groups on the number of justifications used per question, Tukey post hoc tests ($p < .05$) were conducted to see where these differences lay. Significant paired cluster differences were found. A comparison of the cluster means for each form of justification is shown in Table 22 and illustrated in Figure 6.

Table 21

One-Way Analyses of Variance in Number of Justifications Used

Topic Question	$F(2, 342)$	Sig.	Partial Eta Squared
Global warming	60.08	*	0.26
Vaccines	84.22	*	0.33
Smoking	77.81	*	0.31
Evolution	77.57	*	0.31
Moon landing	52.20	*	0.23
Mobile phones NOT cancer	48.89	*	0.22
Global warming NEG	84.58	*	0.33
Vaccines and autism	56.28	*	0.25
Wind turbines	41.78	*	0.20
Antibiotics and common cold	61.91	*	0.27
GMOs harmful	67.14	*	0.28
Homeopathy	59.39	*	0.26
Higher power created the world	30.53	*	0.15
There is a higher power	30.12	*	0.15

Note. * $p < .001$.

Table 22

Means and Standard Deviations for Number of Justifications Used by Cluster

Question	Cluster 1 (n = 200)		Cluster 2 (n = 87)		Cluster 3 (n = 58)	
	M	SD	M	SD	M	SD
1	3.19 ^a	1.75	1.38 ^b	1.56	4.71 ^c	2.43
2	3.28 ^a	1.67	1.46 ^b	1.38	5.22 ^c	2.29
3	3.16 ^a	1.73	1.30 ^b	0.92	5.24 ^c	3.06
4	2.78 ^a	1.57	1.44 ^b	1.34	5.40 ^c	3.15
5	2.35 ^a	1.49	1.07 ^b	0.86	3.93 ^c	2.76
6	1.57 ^a	1.19	0.62 ^b	0.72	2.83 ^c	2.17
7	3.17 ^a	1.89	1.26 ^b	1.47	6.17 ^c	3.74
8	2.23 ^a	1.41	0.95 ^b	0.93	3.93 ^c	2.87
9	1.54 ^a	1.32	0.71 ^b	0.68	3.03 ^c	2.60
10	1.92 ^a	1.37	1.02 ^b	0.93	4.19 ^c	3.10
11	1.51 ^a	1.29	0.71 ^b	0.85	3.41 ^c	2.18
12	1.93 ^a	1.36	0.90 ^b	1.20	3.90 ^c	2.70
13	1.85 ^a	1.85	0.93 ^b	1.10	3.34 ^c	2.47
14	1.71 ^a	1.73	1.17 ^a	1.67	3.48 ^b	2.27

Note. Superscript letters that differ in the same row indicate statistically significant differences in means at $p < .05$.

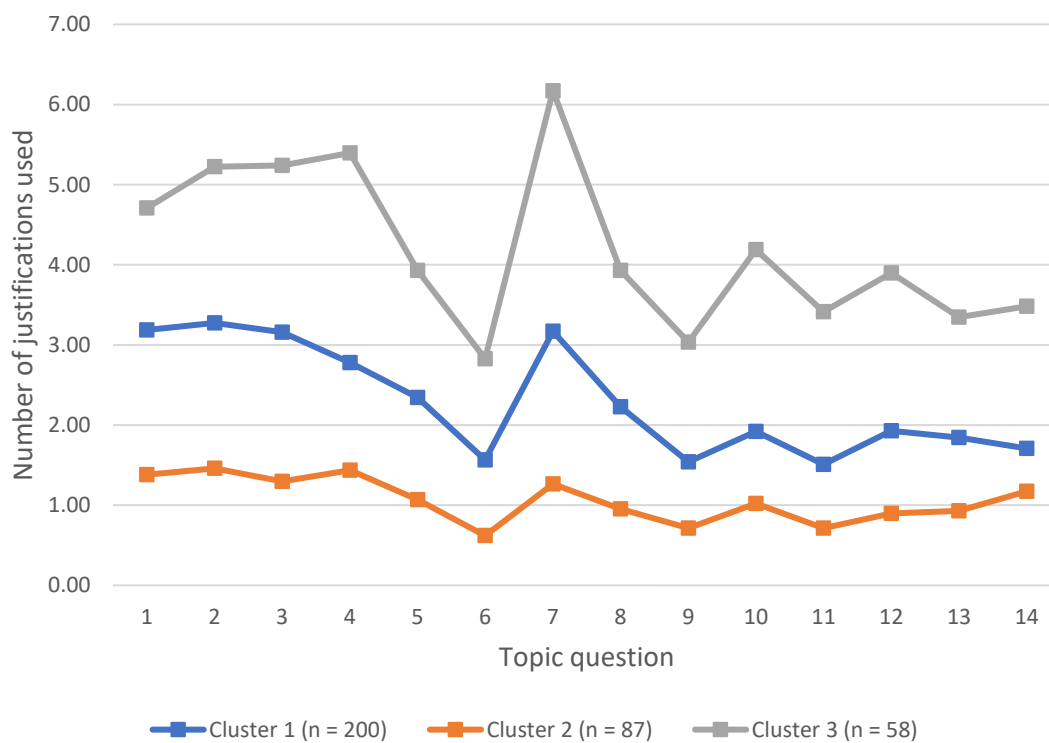


Figure 6. Mean number of justifications used by question for each cluster.

Demographic differences in cluster composition. Demographic characteristics including age, education, and employment were examined in order to gain a better understanding of cluster make up. To investigate the relationship between cluster membership and age, a one-way between groups ANOVA was performed. The means were not normally distributed, with evidence of negative skew and a significant Kolmogorov-Smirnov value ($p < .001$). However, given the sample was larger than 30 it was deemed to be robust to the violation (Pallant, 2016). The Levene's test statistic scored a significance of .36, indicating the assumption of equality of error variances was not violated. There was a statistically significant difference in age for the three cluster groups, $F(2, 338) = 5.08, p = .007$. Despite reaching statistical significance, the actual difference in mean age between the clusters was quite small. That is, the effect size, calculated using eta squared, was .03 (Cohen, 1988, cited in Pallant, 2016). Post hoc comparisons using the Tukey HSD test indicated that the mean age for Cluster 3 ($M = 51.30, SD = 15.90$) was significantly different from both Cluster 1 ($M = 57.40, SD = 14.42$) and Cluster 2 ($M = 59.03, SD = 14.53$).

A Chi-square test for independence was utilised to explore the relationship between highest education attained and cluster membership. The assumption regarding the minimum expected cell frequency was not violated, with more than 80% of cells having expected cell frequencies of five or more (Pallant, 2016). A significant association between education and cluster membership was found, where Chi squared ($14, n = 340$) = 29.91, $p = .008$, Cramer's $V = .21$. This is a medium effect size for three categories (Pallant, 2016). Post hoc analysis of adjusted residuals indicated differences between the clusters for those who had not completed high school. That is, there was a higher-than-expected proportion of participants who had not completed high school in Cluster 2 (54.50%), and a lower-than-expected proportion of participants who had not completed high school in Cluster 1 (27.30%).

A Chi-square test for independence was also employed to explore the relationship between employment and cluster membership. The assumption regarding the minimum expected cell

frequency was not violated, with more than 80% of cells having expected cell frequencies of five or more (Pallant, 2016). No significant association between employment and cluster membership was found, where Chi squared (8, $n = 341$) = 14.90, $p = .06$, Cramer's $V = .15$.

Cluster validation. Discriminant function analysis was used to validate the structure of the clusters derived. Cluster membership was the dependent variable and the types of justification were the predictor variables. A total of 345 cases was analysed. The assumption of sample size was met, with the smallest group ($n = 58$) being larger than the number of predictors (17). As noted in the initial MANOVA results, the assumption of normality was violated, due to skewness and the presence of multiple univariate and multivariate outliers. While transformation or the use of non-parametric classification methods is recommended in such cases (Tabachnick & Fidell, 2014), such methods often render results uninterpretable. Therefore, the analysis proceeded with due consideration being given to the impact of the violation of normality on the results. Inspection of the matrix of scatterplots also revealed violations of the assumption of linearity. However, such violations are not seen as too serious as they reduce power rather than increasing Type 1 error (Tabachnick & Fidell, 2014). Box's M was significant ($p < .001$), indicating a violation of the assumption of homogeneity of variance/covariance matrices. Therefore, separate covariance matrices were used during classification (Tabachnick & Fidell, 2014). As noted earlier, there was evidence of multicollinearity between two predictors ("scientist" and "expert"; $r = .88$); however, SPSS protects against this and excludes those with insufficient tolerance (Tabachnick & Fidell, 2014).

The classification results indicated that overall group membership was accurately predicted for 92.20% of the cases. Further, 92.00% of Cluster 1 cases, 93.10% of Cluster 2 cases, and 91.40% of Cluster 3 cases were accurately classified. The Press' Q statistic value of 537.51 exceeded the critical value of 13.82 ($p < .001$), indicating that the classification of cluster groups using this model of predictors is significantly better than chance.

Chapter 13: Quantitative Discussion

The aim of the quantitative phase of the research was to test the findings from the qualitative phase. In particular, it sought to explore whether the justifications are used, and how much they are used, by participants in another sample beyond the six adults from the qualitative phase. A further aim was the exploration and characterisation of justification for knowing profiles.

Justification use

The participants used all of the justifications available to varying degrees, with multiple forms of justification used to warrant knowledge for each claim. “The science” was the most frequently used justification and endorsed for half of the questions, on average. In contrast, and consistent with the qualitative results, “celebrity,” “friend,” “family member,” and “my faith told me so” were rarely used for any of the questions. These results were not surprising given the science-based nature of the questions. A similar pattern was observed when justification use across the individual questions was considered, with “science” used by the most participants for almost all of the questions (except question 14, when “it's logical” and “it just makes sense” were endorsed by the most participants).

The tendency to use science-based justifications for these questions, which were mostly about scientific knowledge, may indicate that the participants using these understand the epistemology of science. This includes knowing how science knowledge is generated and that scientific claims are substantiated with evidence (Sinatra et al., 2014). An alternative consideration though is that “the science” was used so frequently because it is a catch-all term, used to encompass justifications such as evidence, peer review, scientific testimony, the results of experiments, and different scientific disciplines. In this case, further interviewing to ascertain participant’s interpretation and endorsement of this justification may be warranted. This may result in the addition of finer-grained justifications under the broad area of “science.”

“It feels right” and “I just know it” were also used infrequently for many of the questions. Their similar patterns of use may lend support to the suggestion from the qualitative study that “I just know it” may relate to a process of instinct and be more appropriately categorised alongside “it feels right” in the feeling and instinct category. These results may also suggest that for the topics at hand, participants prefer concrete, external, and science-based justifications over vague, internal ones such as these two. Moreover, alongside “my faith told me so,” these justifications were most often used to justify the questions about religion (questions 13 and 14). Again, these findings regarding the patterns of justification use highlight the importance of context in the use of justifications, as has been identified in the literature (Chinn & Rinehart, 2016; Hammer & Elby, 2002, 2003; Louca et al., 2004; Merk et al., 2018; Muis et al., 2006). Further, the results parallel findings from Greene and Yu’s (2014) qualitative study, in which the means of justification identified by students and professors differed depending on the discipline (i.e., history or biology). In particular, the current results highlight differences in justification use depending on whether the focus is science or religion.

Given the post-truth phenomenon in which individuals tend to prioritise emotions over objective facts (Prado, 2018), it is surprising that “it feels right” was not used often. It may be that the wording is not appropriate to tap into that way of knowing. Another possibility is that individuals who utilise emotion as a way of knowing were not represented in the study, suggesting a need to target their recruitment in future studies. Lastly, it is plausible that individuals do use emotion to justify their knowledge but did not report doing so for reasons of social desirability. This will be further discussed in the section on future research.

“It just makes sense” was used much more frequently to justify the questions than “it feels right.” Of note is that both of these justifications came from the subtheme *feeling and instinct*. The results suggest that participants are possibly differentiating between these two forms of justification, despite being developed from the same subtheme. Moreover, in the qualitative

interviews these were used for topics of taste or aesthetics or for justifying procedural knowledge. The results from this study therefore suggest that this type of justification is used for knowledge beyond those domains and warrants inclusion in future measures. Another possibility worth considering, though, is that participants were taking “it just makes sense” to mean something else than that assumed by the researcher; one possibility is that they took it to mean something like “it's logical.” A similar question was raised in the qualitative discussion regarding whether Wendy's use of the word “logical” implied “it makes sense.” This is an instance where cognitive interviewing (Karabenick et al., 2007) can be used to understand the participants' meaning making of items and fine-tune measures.

The justifications from the *seeing as knowing* subtheme (“I've seen it for myself” and “I've seen the evidence with my own eyes”) were also used frequently in this study, particularly for the questions about climate change, vaccination, smoking, and the moon landing. This provides support for the findings from the qualitative study. It is also consistent with the justification of observation discussed in developmental models (e.g., King & Kitchener, 1994), personal justification in dimensional models (e.g., Ferguson et al., 2012, 2013; Greene et al., 2008; Hofer & Pintrich, 1997), and the philosophical literature on justification (Greene et al., 2008). As for the *feeling and instinct* justifications, the results suggest that it is worth including these justifications that were identified in the qualitative study in future measures.

Participants also differed in their use of the two justifications that referenced evidence. Consistent with the qualitative interviews, participants tended to endorse “I've read the peer-reviewed evidence” more frequently than “I've seen the evidence with my own eyes.” This is also consistent with the social context of knowledge and division of cognitive labour, in which it is recognised that it is not possible for individuals to substantiate every claim they come across, and that it is a reliable process to rely on the testimony of others (Chinn & Rinehart, 2016; Greene, 2016). These results also demonstrate the need to include fine-grained detail in questionnaires (e.g.,

different types of evidence) instead of generic options such as “evidence.” Future research could explore the outcomes associated with the use of these different justifications, to further demonstrate this need. Moreover, to further increase the predictive validity of measures, it is likely that additional forms of evidence may need to be included in measures. This may include those identified in future studies or those discussed in the qualitative interviews, such as evidence from studies, experiments or randomised controlled trials, mathematical proofs, physical evidence, anecdotal evidence, case studies, meta-analyses, or systematic reviews.

The justifications in this study which came from the *sources of knowledge* theme tended to be used less frequently than the other justifications. This was somewhat surprising given claims of the division of cognitive labour (Greene, 2016) as well as the inclusion of sources of knowledge and justification by authority in many models and measures of epistemic cognition (e.g., Conley et al., 2004; Ferguson et al., 2012; Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010; Hofer & Pintrich, 1997). Specifically, the “somebody I trust” subcategory and “I read it on the Internet” were derived from the sources theme. The most “expert” was used was for question 10 (antibiotics and common cold; 19.71%), while the highest endorsement of “scientists” and “teachers” was for question 4 (evolution is real; 9.57%). Similarly, the highest frequency of use for “I read it on the Internet” was 13.04%, which was for the “global warming **not** real” question. Notably, for several of the questions, none of the participants used “celebrity” to justify their knowledge. Again, this is similar to what was seen in the qualitative study, with only one participant using it to justify knowledge relating to parenting.

The less frequent use of these as justifications leads to several possible explanations. Firstly, as in the qualitative study, is the possibility that participants are distinguishing between justifications (i.e., reasons given for accepting a claim) and sources (i.e., where knowledge comes from). In this case, the questionnaire could be refined by removing these justifications. Alternatively, it may be

that these are being used as valid justifications but are just not used as frequently as other justifications; this was also observed in the qualitative study.

Another possibility is that the wording used may also have resulted in their less frequent endorsement as justifications. That is, references to “a scientist” or “an expert” may have been too vague. Participants may instead have responded better to more specific people such as “immunologists,” “doctors,” “climatologist” or “climate scientists”; plurals or multitudes to highlight collective knowledge and expertise, for example “scientists” or “97% of scientists”; or named experts, such as “Dr Karl” (as per Andrew’s interview). Furthermore, there was a high correlation between “expert” and “scientist,” suggesting the presence of multicollinearity (Tabachnick & Fidell, 2014). To reduce redundancy in the model, either one of these justification variables could be removed or they could be combined into one form of justification in future studies.

The word “told” may also have been inappropriate, with possibly more appropriate phrasing being “because scientists have said it is (not) true.” Alternatively, and consistent with the *justification by authority* dimension (Ferguson et al., 2013), more appropriate wording might have focussed on the knowledge products conveyed by such people. These justifications could be rewritten, for instance, as “a report written by a scientist” or “a textbook written by an expert.” This would also make them in a form consistent with the frequently endorsed justification “I’ve read the peer-reviewed evidence.”

With regards to the “the Internet,” it is possible that specific sites or types of sites needed to be included for participants to endorse this type of justification more frequently. Alternatively, the Internet may be seen as a medium for conveying knowledge (i.e., as an information source; Sinatra & Lombardi, 2020). Justification through the Internet might need to instead focus on a specific form of evidence, for instance “reading journal articles online” or “reading peer-reviewed evidence online.” Analysis of the “other” comments provided by participants may shed light on these possibilities. Further research, particularly cognitive interviewing (Karabenick et al., 2007) may also

clarify whether these 'sources' are being used as 'justifications' and how to appropriately word measures.

Notably, there were different patterns of justification use for the two similar, but fundamentally different, questions about climate change. That is, the types of justifications used differed depending upon whether the focus was on climate change being "real" or "caused by humans." This highlights the specificity of justification, even within the same topic, and adds further evidence to claims of the topic-specificity of epistemic cognition (Bråten et al., 2008, 2009; Bråten, Britt et al., 2011; Merk et al., 2018). Given justification use also differed between the science and religion questions, these results also support the domain-specificity of knowledge (Buehl, 2008; Hofer, 2000). Taken together, these results provide support for the theory of integrated domains in epistemology (TIDE) framework (Merk et al., 2018; Muis et al. 2006).

To summarise, the results provide support for the justifications identified in the qualitative study. These findings also support Greene and Yu's (2014) qualitative results and claims that a more diverse set of justifications is needed when measuring epistemic cognition (Chinn et al., 2011; Kitchener, 2011). Moreover, while providing support for the dimensional nature of justification for knowing, these results go further in demonstrating the need for finer-grained dimensions of justification, as proposed by Chinn et al. (2011) and observed in the qualitative study. The variability in justification use across the various questions, even among the science-based questions, provided further support to claims of the topic-specificity of justification for knowing.

Justification for knowing profiles

As a result of applying the person-centred approach, three distinct profiles of justification use were identified. Participants in these clusters not only differed in the means of justification they used, but also with regards to how many justifications they used, their responses to the topic questions, and their backgrounds. There were some parallels between these clusters and the participants in the qualitative study, although it should be noted that as different questions were

used across the two studies, exact comparisons cannot be made. There were also parallels between the clusters identified and the profiles in Greene and colleagues' (2008) EOCD model, so these will also be considered. It should be noted, though, that in the EOCD model the positions reflect *beliefs* in simple and certain knowledge as well as beliefs in the two justification dimensions (i.e., justification by authority and personal justification). This contrasts with this current study which focussed on how participants justify their knowledge on the questions at hand. Moreover, as the current study did not explore a dimension of simple and certain knowledge these comparisons should be viewed with caution.

Participants in Cluster 2 (the *undifferentiated justifiers*) used the fewest justifications across questions and tended to only use one justification at a time. Consequently, they were similar to Angela, Tom, and Andrew from Study 1. This cluster is also similar to the *realists* in the EOCD model, with the epistemic cognition of individuals in this first position of their model "somewhat undifferentiated" (Greene et al., 2008, p. 153). For realists, any means of justification is sufficient; that is, justification can come from their experience or from an authority that has had the requisite experience, although realists would also argue that no justification is needed for their knowledge. This may explain why the participants in this cluster used the fewest justifications per question, and sometimes even did not tick any of the justification boxes, apart from "other." Participants in this group were disproportionately those who had not finished high school, consistent with results from Greene, Torney-Purta, and Azevedo's (2010) study in which realists were more likely to have less educational experience and less likely to be undergraduate or graduate students. Participants in this cluster also tended to be less extreme in their ratings given to the topic questions than the participants in the other clusters (to be further discussed below).

However, it is worth considering that the EOCD proposes that realists have strong beliefs across all three dimensions (i.e., simple and certain knowledge and the two justification dimensions). While comparing beliefs with justification use must be done with caution, with their low use of the

justifications across the questions, Cluster 2 participants might not be as similar to the EOCD realists as first thought. In this case, they might be more similar to clusters identified in a study of engineering students by Barger et al. (2016). More specifically, beyond the four clusters identified that fit with the EOCD, Barger et al. (2016) identified an *uncommitted* group and a *low-all-beliefs* one. The former group had moderate beliefs across the three dimensions, while the latter disagreed with all of the scales and thus were said to have low beliefs. Cluster 2 participants might instead be more like this *low-all-beliefs* profile. These possibilities warrant exploration in future studies.

In contrast, participants in Cluster 1 (the *justifiers through formal processes*) tended to use formal, science-based justifications (e.g., “the science,” “I’ve read the peer-reviewed evidence,” and “the statistics”) to justify their knowledge. On average, they used two forms of justification per question. To an extent, those in Cluster 2 were similar to James and Beverly from the qualitative study, although these two did not mention using peer-reviewed evidence and instead tended to rely on the evidence they had seen themselves. The Cluster 2 profile is similar to the position of *dogmatism* in the EOCD model, which follows on developmentally from the realist position. Specifically, dogmatists are said to rely on statements or evidence from sources of authority, such as teachers or scientists to justify their knowledge, over other, more personal forms of justification, such as experience. Notably, the participants in this cluster did not endorse the “somebody I trust told me” subcategories frequently; possible explanations for this were discussed previously. However, consistent with the *justification through others* subtheme in the qualitative study, they did endorse most frequently what could be said to be *evidence* from these authority figures, such as science, peer-reviewed evidence, and statistics.

Finally, participants in Cluster 3 (the *multiple justifiers*) used a variety of justifications, used both internal and external forms of justification, and used multiple justifications per question. In this way, they were most like Wendy from Study 1. There were also similarities between this cluster and the way Beverly and James justified their knowledge. However, Beverly and James did not tend to

use as many justifications at a time as Wendy or those in Cluster 3 (although as noted earlier, this may have been different had they been encouraged to provide more justifications). Cluster 3 participants are also similar to the *rationalists* in the EOCD model, who are said to take a nuanced, balanced approach towards justification by weighing evidence, personal experience, logic, and justifications from authority before accepting a claim as knowledge (Greene et al., 2008; Greene, Torney-Purta, & Azevedo, 2010). Such individuals see that different forms of justification are more or less valid, depending on context; notably, this echoes a similar point made by James regarding valid (or not) approaches to knowing. This cluster is also similar to the ultimate positions seen in developmental models of epistemic cognition, including evaluativism (Kuhn et al., 2000) and reflective thinking (King & Kitchener, 1994).

Moreover, participants in Cluster 3 tended to use three to six justifications on average per question. This is consistent with Greene et al.'s (2008) claim that rationalists provide a number of different justifications from their experience or credible authority figures to warrant claims, providing these justifications are mutually coherent. However, given the nature of the data collected it is not known whether the multiple justifications used by individuals in this cluster were deemed mutually coherent or not. Of note too is that rationalists tend to have a great deal more educational experience than those in the other positions (Greene, Torney-Purta, & Azevedo, 2010). In the current study, however, higher levels of education were not observed for individuals in this cluster, suggesting a divergence with the rationalist profile in the EOCD. Alternatively, this difference may have been due to the use of education categories in the current study. By operationalizing educational level as the number of years in school instead (as per Greene, Torney-Purta, & Azevedo, 2010), further education differences between the three profiles may have been revealed.

It should also be considered that Greene et al.'s (2008) model also included an additional position. In that model, *skepticism* is one of two possible positions (alongside dogmatism) that follows on from realism. Skeptics, however, are the polar opposite of the dogmatists in that they rely

on personal experience over relying on evidence from authorities to support their claims. Such a profile was not educed in the current results. A consideration of alternative cluster solutions, however, reveals that this position might be evident in the current sample. That is, if the cluster analysis is re-run, specifying four clusters, the current third cluster splits into two smaller clusters of 16 and 42 participants each (Table J1 and Figure J1). Notably, the split appears to be along the lines of use of internal versus external forms of justification.

Of these new clusters ($n = 16$), one had the highest scores on the two evidence justifications, as well as “the science,” “the statistics,” and all of the somebody I trust justifications, except for “celebrity.” This cluster was similar to Cluster 1, except that those in this alternative cluster endorsed trusted people as justifications the most. Notably, they endorsed experts and scientists considerably more than those in the other three clusters (an average of approximately 10 times for each of these). This profile is thus similar to the dogmatists in the EOCD model. The other of these new clusters ($n = 42$) had the highest scores on “it's logical,” “I read it on the Internet,” “I just know it,” “it makes sense,” and “it feels right.” These are mostly internal forms of justification found in the *personal justification* dimension in the EOCD model and the trichotomous justification framework. Consequently, individuals with this profile could be considered similar to the skeptics in the EOCD model. Further research should seek to explore this possibility with a larger sample. Consideration of the differences between these two clusters in terms of responses to the topic questions and any demographic differences would likely also lead to useful insights into these clusters.

Cluster differences to topic questions. Additional insights about the educed profiles can be gleaned by examining responses to the topic questions. For most questions, there was a significant difference between the responses of participants in Cluster 2 and of those in the remaining clusters (Table 19 and Figure 5). These results are best considered by looking at how these responses compare to the scientific consensus on the scientific topics. That is, those responding consistently with the scientific knowledge on these topics would, for instance, be expected to agree that global

warming is caused by humans (Intergovernmental Panel on Climate Change [IPCC], 2013), smoking causes cancer (Gandini et al., 2008; U.S. Department of Health and Human Services, 2010), and evolution is real (Heddy & Nadelson, 2012). They would also be expected to disagree, for example, that global warming is not real, that vaccines cause autism (Flaherty, 2011; Miller & Reynolds, 2009; Institute of Medicine, 2012), and that GMOs cause harm to people (Funk et al., 2015; Heddy, Danielson, Sinatra, & Graham, 2017).

The results indicated that participants in Cluster 2 endorsed agreement levels less consistently with the scientific knowledge than the other two clusters. It could be argued that, by not forming as accurate beliefs about these topics as the other two clusters, participants in Cluster 2 have not achieved the epistemic aim of knowledge (Barzilai & Chinn, 2018; Greene et al., 2021). One possible interpretation then is that they may not be exercising their epistemic competence and have instead used inadequate epistemic criteria and processes for evaluating scientific information and sources relevant to these topics (Barzilai & Chinn, 2020). That is, the type and number of justifications those in Cluster 2 are using may not be the most reliable epistemic processes in these contexts. In contrast, there were no significant differences between the topic scores of those in Clusters 1 and 3. A possible interpretation is that, while different, both these ways of knowing are reliable processes for achieving the aim of knowledge in this context.

In particular, the results may suggest that it is not just the type of justifications, but the number of justifications, that is associated with apt epistemic performance. That is, the aptness of the Cluster 1 and 3 ways of knowing may be attributed to the use of multiple justifications by those participants in these clusters. This is consistent with claims that strong epistemic competence is demonstrated when individuals evaluate and synthesise information from multiple sources (Barzilai & Chinn, 2018). This is also consistent with research that has demonstrated strong beliefs in multiple sources (i.e., the need to cross-check, compare, and corroborate across multiple sources of information to ensure the veracity of claims), to be positively correlated with a range of outcomes

related to academic performance (Ferguson et al., 2012; Brandmo & Bråten, 2018). It is also consistent with Chinn et al.'s claims that "epistemic sophistication lies not in naively thinking that knowledge comes from one source" Chinn et al., 2011, p.15). The use of only one justification on average per question for participants in Cluster 2 may therefore indicate that this profile is not as adaptive as the other two, although this does require following up.

These results also provide support for Greene and Yu's (2014) findings that some individuals require a great deal of evidence before they accept a claim as knowledge. Specifically, in their study they found that experts tend to require multiple forms of justification before they will accept a claim as knowledge, compared to students. However, as the current study was also not able to ascertain which of the participants were experts or novices with regards to the topics at hand, conclusions cannot currently be drawn regarding whether expertise had an effect in this study. Future studies could ascertain this through considering years of study or work experience within a particular discipline as a proxy for expertise. Alternatively, participants can be administered a measure to assess their prior knowledge on the topic (as per Bråten et al., 2009; Mason et al., 2011; Strømsø et al., 2008) and determine whether they are novices or experts on the topic at hand.

However, another consideration is that participants in Cluster 2 do not see their knowledge and epistemic processes as less reliable than other approaches. This cluster may instead represent a knowledge community with different ideals and criteria for evaluating knowledge claims (Barzilai & Chinn, 2020). In particular, these participants may not see the need for such claims to be vetted and evaluated by considering and synthesising multiple scientific sources (Barzilai & Chinn, 2018). To privilege other ways of knowing (i.e., that of Cluster 1 and 3) as more reliable could therefore ignore the reality of these alternative epistemologies (Chinn et al., 2020; Lewandowsky et al., 2017). This possibility is consistent with results from the qualitative study, in which participants reported having their own preferred ways of knowing, yet still acknowledged that other approaches may be acceptable or "valid". Arguably, it could be said that as long as one's approach leads to accurate

conclusions (e.g., that climate change is man-made), such approaches should not be seen as unreliable or less adaptive (Chinn et al., 2020).

It is this final point that leads to an alternative interpretation of score differences on the topic questions. That is, cluster differences on the topic questions may instead be indicative of the certainty with which the participants view this knowledge. As discussed, mean scores for Cluster 2 on questions about smoking, evolution, and the moon landing, for instance, were significantly different to the mean scores of Clusters 1 and 3. However, these score averages could still be argued to represent agreement with those statements. Of relevance too is Chinn et al.'s (2011) argument that there is a relationship between the extent to which knowledge claims are viewed as certain and the degree to which those claims are judged to be strongly justified. In this case, with their significantly higher agreement with the topic statements and use of multiple justifications, participants in Clusters 1 and 3 could possibly be said to be more certain in their knowledge on these topics. In contrast, those in Cluster 2 might not be as certain in their knowledge on these topics.

These possibilities thus raise questions as to what the topic questions are tapping into. Are responses indicative of what one knows and how that knowledge is justified (as planned in the current study)? Or are the participants' responses representative of how certain they view these claims? Understanding how participants are answering these questions is necessary as it will have implications for the types of interventions that are developed. That is, if an intervention focussed on increasing the certainty with which a claim is viewed might focus on teaching how additional evidence can be gathered, evaluated, and synthesised to support such claims. In contrast, an intervention targeting what one knows and aiming to address one's misconceptions through knowledge restructuring will need to be designed based on findings from the conceptual change literature (Sinatra et al., 2014).

Cognitive interviewing (Karabenick et al., 2007) or the use of think-aloud protocols (e.g., Barzilai & Zohar, 2012; Ferguson et al., 2012; Greene, Yu, & Copeland, 2014; Mason et al., 2010b,

2011) would therefore be a useful way to understand how participants are rating the topic questions and what their ratings reflect. For example, take the example of climate change, to which 97% of climate scientists support the view that it is caused by humans (IPCC, 2013). The question to explore then is whether a participant's strong disagreement with the statement "I know that climate change is real" indicates "I know that climate change is NOT real" or "I DON'T know that climate change is real"? Cognitive interviewing could be used to explore these possibilities.

It would also help with understanding endorsement of statements in the middle of the scale (i.e., scores of five or six). For example, the mean score on the "GMOs harmful" question was 5.15 for Cluster 2. The question regarding the meaning of this rating is whether it indicates neither agreement or disagreement, a slight disagreement, lack of certainty, not knowing, or something else? To aid clarity and better represent the contradictory nature of science-related issues (Sinatra et al., 2014), future measures could also ask participants to choose between alternative positions such as "I know that climate change is man-made" or "I know that climate change is naturally occurring" (e.g., Rotshtein, 2019). Participants could then indicate how certain they are of that knowledge before choosing the justifications to warrant that knowledge. It may also be beneficial to have an "I don't know" option for participants to endorse if needed, instead of assuming that participants can and do justify every claim they come across.

Finally, returning to scores on the topic questions, it is worth considering why no significant paired cluster differences were found for "antibiotics" and "there is a higher power." For the "antibiotics treat the common cold" question, it may be that, unlike other controversial topics (e.g., vaccination and climate change; Muis et al., 2021), knowledge on this topic is generally accepted or seen as certain by all these participants. In this case, utilising different ways of knowing (such as different types and amounts of justifications) will still lead to similar conclusions. This could similarly reflect the general health literacy of participants, although such an assumption requires follow up. An alternative though is that those with different knowledge on this topic, such as those who tend to

agree with the statement, did not participate in this study. In that case, conclusions about the type of justifications those participants would use cannot be drawn at present.

Regarding the question “I know that there is a higher power/God(s),” the lack of a significant difference between the clusters on this score could also be due to several possibilities. Again, it could be due to a lack of participants endorsing “agree” on this question, suggesting a need to recruit participants with such knowledge. In particular, such participants may be those who identify as having a religion or with religious worldviews. Given that demographic data on religion was not collected, it is not clear though how many participants had a religion, or not. Future research should consider collecting such data. However, it is also worth considering the declining levels of religiosity in the Australian population. Specifically, while 19% of Australia’s population reported no religion in the 2006 census, this trend increased to 30% in 2016 (Australian Bureau of Statistics, 2017). Therefore, there is the possibility that these results are generally representative of knowledge about religion of the Australian population. Future research may thus wish to explore the model in cultures and countries with greater religious identification.

Lastly, there is also the possibility that the type and combinations of justifications here are not sufficient to differentiate between those with different knowledge on this question. In that case, consideration must be given to the inclusion of additional justifications that account for religious ways of knowing. Future research may also wish to explore profiles of knowing and their relation to knowledge about religious topics without the confound of knowledge regarding socio-scientific topics.

Demographic differences. Employment status had no effect on cluster membership. This was not unexpected, as it has not been proposed in the literature or observed to have an effect on epistemic cognition in studies conducted to date. Future research might instead consider the type of employment or educational background of the individual. That is, as was seen in the qualitative study, whether one has a background, training, or interest in science, compared to other disciplines,

might influence the type of justification that an individual uses, more so than their employment status. Participants in Cluster 1, for instance, with their use of mainly science-based justifications could be hypothesised to have educational backgrounds, training, or work experience in the field of science. Employment could also be coded, for instance, by a scheme such as Holland's occupational type (Holland, 1996). This typology can be used to code one's work or occupational interests (i.e., Realistic, Investigative, Artistic, Social, Enterprising, or Conventional or a combination of these) and consider cluster composition in terms of these occupation types.

Next, there was a significant but small effect of age on cluster membership. Age, or more particularly biological maturation, has long been proposed as necessary for epistemic cognition development alongside educational experience (Hofer & Sinatra, 2010; King & Kitchener, 1994). However, most research has focussed on the relationship between education and the development of epistemic cognition (Greene, Torney-Purta, & Azevedo, 2010). Further, as Greene et al. (2008) has stated, studies of the epistemic cognition of adults not attending tertiary education is required to separate the effects of age and education. While this research therefore addresses this need to explore the epistemic cognition of adults outside of educational contexts, it was however unable to isolate the effect of age from other possible impacts including other experiences, maturation, training, and time of education (i.e., was tertiary education current, recent, or in the distant past?).

Data may have been further confounded by the fact that some of the participants were currently undergoing tertiary education, which is known to have an influence on one's epistemic cognition (Hofer & Pintrich, 1997; King & Kitchener, 1994; Kuhn et al., 2000). Age was skewed as a variable too; future studies should aim to recruit a more representative sample. Moreover, data on highest level of education was gathered and not years spent in education (Greene, Torney-Purta, & Azevedo, 2010). By gathering data on total years spent in education, an analysis of covariance could be conducted to explore any age differences between the clusters while controlling for the effect of education.

In addition, there was a medium effect of education on cluster membership. Specifically, those who had not finished high school were more likely to be in Cluster 2 and less likely to be in Cluster 1. This is not surprising given findings in the extant literature, particularly that higher developmental positions are associated with tertiary education (Hofer & Pintrich, 1997; King & Kitchener, 1994; Kuhn et al., 2000). As previously discussed, Cluster 2 may have parallels with lower developmental positions in current research (e.g., realists) and consequently be a less adaptive position in certain contexts. Further research should however confirm such hypotheses and explore the practical significance of cluster membership, to determine which profiles are more or less adaptive.

Implications

Regarding the use of the justifications identified, the results of this quantitative study confirm the results of the qualitative study. Notwithstanding questions around the low use of the justifications that came from the *sources of knowledge* theme (as previously discussed), the participants consistently used all of justifications that were identified in the qualitative study. These therefore add further, fine-grained detail to the *justification by authority* and *personal justification* dimensions of the EOCD model and the trichotomous justification framework. Researchers might thus consider including all of these justifications in measures based on these models, as their inclusion will arguably increase the predictive validity of such measures (Buckland, 2015; Chinn et al., 2011).

The results also provide support for Ferguson and colleagues' (2012, 2013) *justification by multiple sources* dimension in the trichotomous justification framework. However, the current results extend on this dimension by quantifying how many forms of justification participants tend to use for different topics. It may be that knowing how many justifications individuals use, and which ones they use in combination, is more predictive of outcomes than just knowing the extent of their beliefs regarding the importance of checking multiple external sources in order to justify knowledge

claims. In this case, models may need to be revised to remove the separate justification by multiple sources dimension.

Moreover, while previous studies have used person-centred approaches to explore different profiles of epistemic cognition, these have been focussed on *beliefs* about knowing. This current study is therefore novel in identifying different profiles regarding how individuals *justify* their knowledge on certain topics. While future research (discussed below) needs to confirm these findings and consider which profiles are adaptive in which contexts, these novel findings add to the literature and have promise for the development of specific interventions. That is, person-centred approaches allow a consideration of how different groups of individuals approach knowledge (Barger et al., 2016). This subsequently facilitates the development of interventions targeted at these different groups (Clatworthy et al., 2005; Kusurkar et al., 2021; Roeser et al., 1998), instead of a one-size-fits-all approach. Individuals in Cluster 2, for instance, tended to rely on one justification at a time and to not use science-based inquiry to compare and synthesise evidence from multiple sources. They therefore might not be demonstrating apt epistemic performance with regards to these topics (Barzilai & Chinn, 2018) and may benefit from epistemic education or an intervention to develop more reliable ways of knowing. Alternatively, if it is determined that they see their way of knowing as reliable (i.e., they are identified as being in an alternative knowledge community), instructional practices might need to focus on explorations into knowing that promote productive engagement with deep epistemic disagreements (Chinn et al., 2020).

Strengths

The use of quantitative research in this phase, as part of the overall mixed methods approach, complemented the earlier qualitative study and allowed an exploration of how some of the qualitative results might generalise to a larger sample. The person-centred approach further overcomes some of the limitations of the variable-centred research common in the literature, in which averages of individuals' scale scores are correlated with outcomes (Barger et al., 2016; Chen,

2012). More specifically, the use of cluster analysis allowed for a consideration of patterns of responses to many questions, thus considering a bigger picture of justification than a variable-centred approach alone.

Another strength was the language used in the questionnaire. Firstly, this included the use of the participant's language from the qualitative study to develop the justifications for the questionnaire. Wording items in the language that those in the study population use to communicate about the target construct improves the phrasing of surveys and consequently reduces measurement error (Ping, 2004). This also makes the survey more relatable and accessible than current measures in the field which often include abstract or ambiguous terms and items which are too general or vague (Barzilai & Zohar, 2015). Moreover, the language across this questionnaire was consistent. That is, it is clear the questions are asking about the participant's knowledge on the topic question and how they justify it. This is an improvement on current measures in which the use of various reference points (e.g., "I," "you," and "the teacher" or "a historian") and foci (e.g., one's beliefs, the beliefs about others or general beliefs about knowledge) raises questions about what is being assessed and threatens the psychometric properties of those scales (Mason, 2016).

The recruitment of a more diverse sample than is typically seen in epistemic cognition research (Buehl, 2008; Greene et al., 2008) was another strength of this research. In particular, this included the recruitment of older adults as well as individuals across a broad spectrum of educational experiences, including those not currently in education or who have not participated in tertiary education. Lastly, the research sought to consider how individuals justify their knowledge, and not just their beliefs or thoughts about how knowledge should be justified. This study is therefore novel in its exploration of clusters based on how one justifies knowledge. However, as noted in the qualitative discussion, such results would ideally be triangulated with online data, such as from think aloud studies.

Limitations

While the person-centred approach has advantages over variable-centred approaches, it should be noted, however, that it still relies on averages of a group of people (Chen, 2012). Given natural variability within the different groups (Chen, 2012), there is a need to obtain evidence that such variability is minimal (Chen, 2012). This evidence could be obtained by determining whether these groups differ on a variety of external variables (Pastor, 2010), such as achievement measures, digital literacy, argumentation, or critical thinking skills. This would provide further support for the validity of the final cluster solution.

Another key limitation involves the sample in this study, which was overrepresented by middle-aged individuals. The results may therefore not generalise to the general population. While the use of the social media site, Facebook, to recruit participants may have introduced selection bias to the sample, comparable biases are also seen using traditional recruitment methods (Batterham, 2014). The proportion of younger participants taking part may be increased in future studies through the use of targeted paid ads or alternative social media platforms (e.g., Instagram). Moreover, the results from the current study are limited to Australian adults and may not be generalisable to those from other cultures or who speak other languages. Alternative profiles of justification may instead be observed for individuals from different cultural backgrounds, with evidence showing cultural variation in the dimensionality of epistemic beliefs at both domain-general (for a review, see Buehl, 2008) and topic-specific levels (Bråten et al., 2009).

As was the case with the qualitative study, the sample may also be biased due to other factors. In particular, participants may have been motivated to participate due to their interest in these topics. Given that topic interest has been shown to influence epistemic cognition (Bråten et al., 2009; Mason, Gava, & Boldrin, 2008), it is necessary to firstly measure the topic interest of those participating, and secondly, consider how responses might differ for those less interested in these topics. Moreover, given the violations to the assumptions of normality and observed skew in

responses to the topic questions, it is apparent that those who responded tended to have similar levels of agreement or disagreement to the questions. The results from this study should therefore be interpreted with caution and conclusions not seen as generalisable to the general population. Future research should aim to seek out those from alternative knowledge communities who might respond differently (such as in the opposite direction) to the current participants, in order to explore potential additional profiles of knowing. This is vital too, given that interventions differ depending on the underlying reasons given for individuals not achieving accurate knowledge (Barzilai & Chinn, 2020). This includes whether individuals do not know how to know, have infallible ways of knowing, do not care enough about truth, or disagree about how to know.

The results discussed here should also be interpreted with caution given the presence of multiple univariate and multivariate outliers which introduce error to the analyses (Tabachnick & Fidell, 2014). As noted in the quantitative method chapter, cases with outliers were retained due to the exploratory nature of this research and small sample size. In future, if a larger sample size is obtained the analyses can be run both with and without the cases with multivariate outliers to determine the influence of these outliers on the results.

There are also limitations associated with the justification options in this study. Firstly, the available justifications were overrepresented by those from the justification through others category. Additional options from the other categories therefore need to be included in future studies for balance. This might include the justifications of "experience" and "personal standards and values" that were identified in the qualitative study but not used in this study. Specifically, these two were not included as they were rarely used in the qualitative study and generally only used for justifying procedural knowledge. Therefore, it was determined to exclude them at present in an effort to minimise the list of justifications on offer. However, future research could explore whether they are used to justify conceptual knowledge. Furthermore, as discussed in the qualitative discussion, it might be necessary to determine the participants' specific meanings behind the word

"experience" (e.g., memory or seeing as knowing) before it is included in future surveys.

Additionally, as previously noted, the "other" category was not analysed in this study. Had this category been analysed, additional forms of justification may have been identified and counts of justifications used may have been higher too. The justifications used in this study should therefore not be seen as a final, exhaustive list.

Regarding the topic questions used in this study, these mainly focussed on the discipline of science, although two were focussed on the topic of the existence of God(s). It appeared that the justifications and profiles of knowing herein tend to differentiate knowledge more reliably on controversial, socio-scientific topics. However, given the domain-specificity of epistemic cognition (Muis et al., 2006), the inclusion of questions outside of the domain of science may have introduced error variance to the analyses. Future research may wish to focus solely on questions about science or religion and not combine the two. If questions on religion are included in future studies, a demographic question asking whether one identifies as religious or not needs to be included. Assuming the recruitment of a diverse sample of individuals from a variety of religious backgrounds, the collection of this demographic information would allow exploration of the effect of religion on ways of knowing about religion-specific questions. Moreover, given recent findings of the topic-specificity of epistemic cognition (Bråten et al., 2008, 2009; Bråten, Britt, et al., 2011; Merk et al., 2018), future research may wish to focus on specific topics for the topic questions, such as climate change or vaccination, instead of including several different topics as in this study. A useful avenue for future research also would be to compare how justification profiles change (or not) when different topics are focussed on. This would be necessary to establish the adaptiveness of the profiles in different contexts and the level at which interventions need to be targeted.

Lastly, it would be remiss not to highlight the timing of data collection which limits the generalisability of these results. In particular, data for this study was collected in January and February 2020. Of note is that this is before widespread media coverage of COVID-19 and increasing

discussion and debate about vaccination. Given the polarising debate about COVID-19 vaccines in the media and online, the results would likely have been different were this study conducted during the pandemic, particularly with regards to knowledge about vaccines. As such, the results should be taken to refer to general knowledge about vaccines, with the model unlikely to hold up if replicated during the pandemic.

Future directions

Judgement of a cluster analysis solution rests largely on its usefulness, rather than on a notion of it being “true” or “false” (Everitt et al., 2011). As such, further research is needed to confirm the ultimate usefulness of the cluster solution obtained, particularly regarding its utility as a foundation from which to develop and target interventions at different groups of knowers. Before such considerations, though, steps must be taken to verify the chosen cluster solution. Therefore, to establish the stability of the three-cluster solution, attempts should be made to replicate it in an independent sample (Everitt et al., 2011). This should ideally be one which is representative of the population. Recruiting a larger sample in future research would also allow exploration of the viability of alternative cluster solutions (e.g., four- and five-cluster solutions as indicated by the scree plot and discussed previously). A larger sample would also allow for split-sample validation to assess the robustness and stability of the cluster solution (Everitt et al., 2011). In addition, the possibility remains that the cluster analysis artificially imposed a structure on the data. Future research is thus needed to build a stronger conceptual basis for the existence of such groupings (i.e., profiles of knowers) in the first place (Everitt et al., 2011; Kent, 2015).

It is also likely that the clusters identified may be context specific. Therefore, the cluster solution identified here needs to be considered with regards to alternative contexts, such as through the use of different domain- and topic-specific questions. Such research could explore how justification use changes for the different clusters, or not, as topic questions change. It also needs to be acknowledged that cluster composition is also dependent upon the justifications used in this

study. Should future research identify additional justifications, the cluster analysis will therefore need to be conducted again.

Another possible direction for future research is to explore the meaning of multiple and single justification use, including whether it relates to one's certainty or confidence in the knowledge claim at hand. Research could also consider any other variables that influence the number of justifications used, such as one's expertise or prior knowledge on the topic. Further research also needs to consider how participants who rely on multiple forms of justification rank these and whether particular rankings are predictive of outcomes such as academic success (Greene & Yu, 2014). The practical implications of using multiple justifications also needs to be considered. Again, this would require exploring how these correlate with various outcomes and in different contexts. If it is identified that using more or fewer justifications is adaptive in different contexts, then interventions could be developed to accordingly teach individuals to seek out a specified number of justifications when evaluating knowledge claims.

Future research also needs to go beyond exploring the justifications used in this study to also assess the grounds, or reasons, on which they are used. This could include the grounds (and source evaluations) identified in the qualitative study. Such research could then explore the effects of different grounds for using the same justification. For instance, two participants may justify knowledge on climate change because of testimony from experts but have different grounds for trusting these experts. For instance, from the qualitative study, one might trust this testimony because they know that these experts have spent years studying in their fields and have gathered a great deal of evidence to support their claims. In contrast, the other might trust the expert's testimony because of past experience with that expert in making other knowledge on related subjects understandable. These different grounds for trusting the expert's testimony may lead these individuals to learn and reason differently (Chinn et al., 2011). Research could therefore explore the practical implications of the various grounds associated with different forms of justification. These

grounds could be assessed by adding another layer to the questionnaire to be completed after participants have endorsed the justifications they used to support the claim at hand. While this would add extra time to complete the questionnaire for participants and require additional time and effort for researchers to analyse, this could be minimised by reducing the number of topic questions on hand.

Similarly, additional aspects of epistemic cognition could be included in future studies. These could include characteristics of knowledge identified in the qualitative study, and discussed in the extant literature, such as its absoluteness (or certainty). By including the certainty of knowledge alongside its simplicity in future cluster analyses, clearer comparisons between clusters and Greene et al.'s (2008) EOCD positions might be drawn. One's aims for knowing has also been argued to influence the epistemic processes enacted (Chinn et al., 2014, 2016), and was also identified in the qualitative study. In particular, the underlying assumption of this research that individuals are motivated to achieve knowledge may not be enacted by those individuals. In reality though, they may not care enough about pursuing truth, either because they care more about personal, social, economic, or political goals than epistemic ones or because they become so overwhelmed by misinformation and disinformation that they give up on seeking out the truth (Barzilai & Chinn, 2020). The consequent impacts on outcomes and interventions means it would therefore be worthwhile to assess one's aims when conducting future research into profiles of knowing.

Future research also needs to consider whether the participants' responses to the questions reflect their actual epistemic cognition, that is, the processes they engage in when thinking and reasoning about knowledge claims. In particular, there is the risk in this study that the participants did not respond accurately. As with the qualitative study, this may have been due to the effects of memory or participants responding based on how they *think* they should justify their knowledge (and not necessarily how they actually do justify it). The possible effects of acquiescence and socially desirable responding therefore need to be accounted for in this study. The development and

inclusion of validity scales to be used with the topic questions to measure and account for the effects of these biases may also be warranted. Triangulating the data gathered from this study with data collected from online studies, such as observations, discourse analysis, or think aloud studies, would also be beneficial (Ferguson et al., 2012; Sandoval et al., 2016). Cognitive interviewing can also be used to investigate how the participants are making sense of and answering the questions at hand, and whether these responses align with the researchers' intended meanings (Greene, Torney-Purta, Azevedo, et al., 2010; Karabenick et al., 2007; Muis, Duffy, Trevors, Ranellucci, & Foy, 2014). Research can also consider whether questionnaires asking how participants justify their knowledge are better predictors of outcomes than questionnaires asking about one's beliefs about knowledge.

Furthermore, it needs to be recognised that what an individual knows and how they know that they know it do not occur in a vacuum, particularly with regards to knowledge on socio-scientific issues. Instead, such knowledge is influenced by politics, ideology, social norms, and cognitive biases, as well as social, emotional, and affective reasons, among others (Sinatra et al., 2014). Therefore, the influence of other variables on how one justifies what they know warrants investigation in future studies. This could include those identified in the qualitative study, such as personal characteristics (e.g., biases, dispositions, and interest), one's belief system or religion (as per Tom's comment about frames of reference), and the influence of other people around the individual. It could also include additional possible influences such as politics, ideology (Sinatra et al., 2014), epistemic emotions (Muis et al., 2021), topic interest (Bråten et al., 2009; Mason et al., 2008), and one's expertise (Greene & Yu, 2014; Kuhn, 1991). In addition, the structure of knowledge, such as its complexity (Sinatra et al., 2014) or universality (Chinn et al., 2011) may also influence how one justifies knowledge claims. Further, given the overlap between epistemic cognition and metacognition (Barzilai & Zohar, 2014; 2016), constructs such as cognitive or thinking style (e.g., Costello, 2016; E. Roodenburg, 2015; J. Roodenburg, 2003, 2006; Riding & Rayner, 1998) may

influence epistemic cognition and could also be considered in further research. It would also be useful to seek to identify additional influences which may impact on one's ways of knowing.

Lastly, what needs to be considered is whether the educed clusters resemble developmental positions, or not, and the mechanisms of change from one position to the next (Barger et al., 2016). That is, the combinations of justifications making up each cluster may represent developmental positions (as in the EOCD model). This is worth considering, given the medium size effect of education on cluster membership and parallels between the clusters and the EOCD model's positions. It may be the case that Cluster 2, which had a higher-than-expected proportion of participants who had not completed high school, represents an earlier or less adaptive developmental position. The question then is which cluster might come next in a developmental progression: Cluster 1 or 3? According to the EOCD model, Cluster 1 would come next and be followed by Cluster 3.

As previously discussed, despite justifying their knowledge to these questions in different ways, participants in these clusters endorsed the various questions with similar levels of agreement. Given these two clusters also did not differ with regards to any of the demographic categories, the differences in justification use may indicate a couple of possibilities. The first is that these do signify developmental positions, but that the current data is not sufficient to determine which precedes the other in a developmental progression. An alternative is that they both represent the same level in a developmental scheme, like Greene et al.'s (2008) skeptics and dogmatists. These two possibilities would need to be explored in a larger, more representative sample and through the collection of longitudinal data.

There is therefore a need to determine which, if any, of these profiles is more adaptive than the others, and in which contexts. This would require the assessment of outcomes associated with each profile. In educational contexts, the outcomes assessed often include academic achievement or reading comprehension. However, for adults outside of educational contexts, outcomes worth

assessing may include digital literacy, critical thinking skills, argumentative reasoning, and acquisition of conceptual knowledge (Greene et al., 2014, 2018; Greene & Yu, 2016). Additional outcomes may also include those identified in the qualitative interviews, such as outcomes related to identity, wellbeing, and helping oneself or others.

If the clusters identified do represent positions in a developmental scheme, future research needs to determine how individuals progress from one position to another. This could involve exploring the development of these profiles over time through longitudinal studies. Such research might also assist in understanding the mechanisms of epistemic cognition change and conceptual change and the potential for interventions targeted at these. That is, by identifying which profiles are more adaptive in different contexts, and how individuals progress from one profile to another, interventions may be developed to shift individuals to more adaptive profiles. Research has suggested, for instance, that being able to consider and integrate multiple internal and external forms of justification is the optimal, most adaptive level of epistemic cognition development (Barzilai & Chinn, 2018; Hofer & Sinatra, 2010). These patterns of justification use, which are similar to those used by individuals in Cluster 3 and consistent with the final positions in developmental models (e.g., evaluativism), are more likely to be associated with the critical thinking vital for 21st century success (Greene & Yu, 2016). In this case, explicit instruction or guided inquiry in which individuals are taught how to seek out, evaluate, and integrate different forms of justification may have positive effects (Cartiff et al., 2021).

However, an alternative consideration is that the clusters do not represent a developmental scheme but instead can be conceived of as representing groups (or types) of individual differences in justification use. That is, the results may signify individual differences in one's competencies in justification use. These differences may be due to education, training, socialisation, political or religious affiliation, or any number of factors, as previously discussed. This perspective is consistent with recent research on the goals of epistemic education. In this research, which is informed by the

field of virtue epistemology, reliable processes that enable the achievement of knowledge are seen as cognitive intellectual virtues (Barzilai & Chinn, 2018). More specifically, these virtues are described as multifaceted, developing, and adaptive intellectual competencies or abilities that allow one to discern the true from the false in a certain domain. Alternatively, these individual differences may be similar to cognitive style (i.e., one's preferred way of thinking; Riding & Rayner, 1998), in that they represent one's preferred way of knowing. Given that the development of goals for epistemic education depends upon how epistemic cognition is construed (Barzilai & Chinn, 2018), future research is consequently needed to explore how to appropriately conceive of these profiles of justification.

Chapter 14: Conclusion

Review of studies

The purpose of this research was to further understandings of epistemic cognition to inform and extend upon current models and measures of this construct. It sought to do this from a psychological perspective by exploring how the everyday person (the layperson) knows how they know. The overall research question guiding this work was, “how do people know what they know?” In other words, what criteria or evidence do they use to evaluate, justify, and accept a claim as knowledge (or not)? To address this aim, an exploratory, sequential mixed methods approach was taken. This chapter integrates the findings from both studies to speak to the overall purpose of this research. A brief review of the two studies is first provided, before recommendations for future research are outlined. This chapter closes with a summary of the implications and contributions of this research and closing remarks.

In the initial, qualitative phase of this research, semi-structured interviews were used to explore and understand the experiences of knowing of six adult participants in Australia. The research questions for this phase asked, “how do adult participants know what they know?” and, “what does ‘knowing’ mean to these participants?” Thematic analysis of the interview data revealed five themes: (a) justification for knowing; (b) sources of knowledge; (c) influences on knowing; (d) knowing about knowing; and (e) personal meaning of knowing. Regarding the first research question, the results indicated that adults used a variety of justifications for knowing. These included justification through others, seeing as knowing, feeling and instinct, and other justifications (such as logic and just knowing). Participants also discussed where their knowledge came from and why these sources were trusted or valued, although questions were raised as to whether some of these sources could instead be considered as justifications. For the second research question, the results revealed that knowing meant different things to the participants. This ranged from the more metacognitive definitions and perspectives they provided to the personal meaning that knowing and having

knowledge have on their lives. Additional areas of relevance to the participants' knowing were revealed by the interviews too, such as various internal and external influences on their knowing.

The quantitative study then set out to test the generalisability of some of these results. The aim was to explore whether the justifications identified in the qualitative study are used by other adults and how frequently they are used (i.e., whether multiple justifications are used). Given evidence of difference patterns of knowing from the qualitative study, it also sought to determine whether there are qualitatively different profiles of justification (i.e., groups of "knowers") and the characteristics of these. A sample of 345 Australian adults completed an online survey in which they indicated their agreement with various statements (e.g., "I know that evolution is real") and then justified how they know each of these. As part of the integrative approach of this research, the justification options for endorsement were created utilising themes and quotes from the interviews.

Results from this second study indicated that all of the justifications were used to varying degrees across the topics. This will be discussed further below. Cluster analysis was used to identify three distinct profiles of knowing based on the participants' endorsement of the justifications across several topics. Participants in these clusters not only differed in the means of justification they used, but also with regards to how many justifications they used, their responses to the topic questions, and their backgrounds (i.e., age and highest education attained). Cluster 1 ($n = 200$), the *justifiers through formal processes*, tended to use science-based justifications to substantiate the knowledge claims. They also used two forms of justification per question, on average. Cluster 2 ($n = 87$), the *undifferentiated justifiers*, used the fewest justifications across questions, with only one justification generally used at a time. Cluster 3 ($n = 58$), the *multiple justifiers*, used a variety of internal and external forms of justification, and used approximately three to six justifications per question. Taken together, the results of these two studies revealed that the layperson knows how they know in a variety of ways. These ways of knowing are summarised in Figure 7.

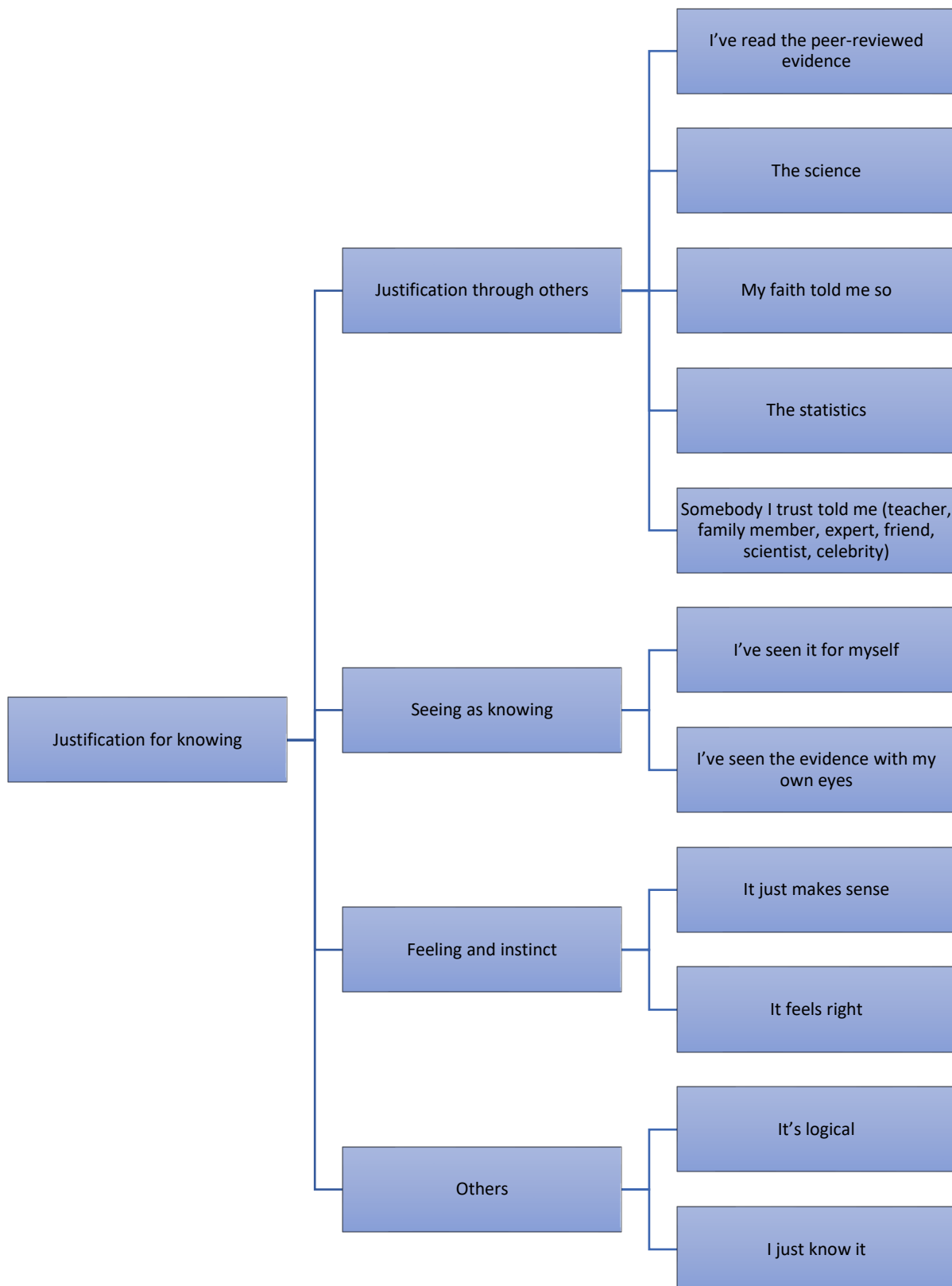


Figure 7. Summary of ways of knowing.

The justifications used most frequently in this research were those developed from the justification by others qualitative subtheme which related to science and scientific practices including “the science,” “I’ve read the peer-reviewed evidence,” and “the statistics”. This is consistent with the justification by authority dimension of several epistemic cognition models and measures (e.g., Ferguson et al.’s [2012, 2013] trichotomous justification belief framework and Greene et al.’s [2008] EOCD). However, given the justifications list was overrepresented by justifications developed from that subtheme, caution must be taken not to assume that other justifications are not relevant or used less frequently by those outside this limited study.

In contrast, “my faith told me so,” which was developed from the justification by others subtheme, was barely used across most of the questions. This may be a function of the questions asked (being mostly science-based ones) or due to the sample (whether participants were religious and utilise religious ways of knowing, or not). Moreover, the justification by authority dimension does not reference faith in any current models or measures of epistemic cognition. Therefore, further exploration of faith as a way of knowing is warranted to determine its possible inclusion in models and under which dimension it fits most appropriately. Alternatively, it may more appropriately be categorised as a source of knowledge and not a way of knowing.

Other less frequently used justifications were those developed from the “sources of knowledge” qualitative theme (e.g., expert and family member) and those from the justification by others subtheme that were about people (e.g., celebrity and scientist). This raises questions about the wording and relevance of these justifications. Questions also remain as to the relationship between the justifications for knowing and sources of knowledge themes and how to overcome, if necessary, the fuzzy distinctions between the two.

The justifications developed from the seeing as knowing (“I’ve seen it for myself” and “I’ve seen the evidence with my own eyes”) and feeling and instinct (e.g., “it feels right” and “it just makes sense”) subthemes were also used less frequently than the scientific justifications of the

justification by others subtheme. From the “others” justification, “logic” was used fairly frequently, whereas “I just know it” was not.

The results of both studies also provide support for the topic-specificity of epistemic cognition while highlighting individual differences in type and amount of justification use. Moreover, given the focus of these studies, there is preliminary support for the notion that the justifications and profiles of knowing herein tend to differentiate knowledge more reliably on controversial, socio-scientific topics. Future research is needed, though, to explore the means of justifications used, and profiles of knowing, when the focus is on topics of other domains (e.g., history or religion).

Future directions

The next steps for this research include further testing and exploration of the justifications outlined in Figure 7. This includes testing the justifications with a representative sample, together with the targeted recruitment of those from alternative knowledge communities. That is, participants with a diversity of knowledge on the topics at hand need to be represented, and not just those who agree with the scientific consensus on these socio-scientific topics. Additional demographic data could be collected in future studies, including years spent in education, religious background (if any), and employment type by Holland’s occupational codes. The collection of data on variables identified as possible influences on knowing is also warranted, as discussed previously. This includes influences identified in the literature and in the qualitative study, such as one’s aims for knowing and their personal characteristics and biases.

There is also a need to establish that the list of justifications is comprehensive yet contains no construct-irrelevant variance (Messick, 1995). The list of justifications will therefore need further exploration and refinement to ensure the inclusion of “*all of the ways individuals justify knowledge*” (Williams, 2001, cited in Greene et al., 2008, p. 156). This may include the addition of further justifications from the qualitative study (e.g., trial and error, experience, whether it meets one’s ideals or personal standards, it stands up to scrutiny) or from an analysis of the “other” comments

from the quantitative study. To account for the ways of knowing of those with alternative epistemologies (Lewandowsky et al., 2017), justifications could also be developed from theme four (knowing about knowing) such as the use of “anecdotal evidence” as a justification. Additionally, interviews could be held with those with different ways of knowing to understand how they know what they know. Other justifications may also come from current measures or models. This could include justifications based on an evaluation of whether the content is consistent with the participant’s current knowledge of the topic (e.g., from the personal justification dimension of the ISEJ; Bråten et al., 2018). The justifications also require testing against different topic questions from various disciplines.

Cognitive interviewing is also needed to understand how the participants are making sense of the justifications provided (Karabenick et al., 2007). This may result in the refinement of the current justifications (e.g., evidence or experience) or addition of further justifications. This can also be used to clarify some of the language used and improve the wording of the “somebody I trust” justifications. Alongside this, validity scales need to be included so the effects of social desirability and acquiescence can be measured and accounted for. Cognitive interviewing, observations, or think aloud protocols may also be used to explore the relationship between, and possible overlap of, the justifications for knowing and sources of knowledge themes.

A strength of this research is that it sought to explore how individuals actually justify their knowledge, and not just their beliefs or thoughts about how knowledge should be justified. While participants reported on their practices of knowledge justification, observational or think-aloud studies are however required to triangulate the participants’ justification use in authentic contexts. This could include while reasoning concerning knowledge about real-world problems. Such approaches would aid in ascertaining whether the justification practices they self-report using accurately represent the processes they use in authentic contexts (Sandoval et al., 2016). Future

research will also need to consider how to account for the social, situated, cultural, contextual, and interactive nature of epistemic cognition (Mason, 2016; Tafreshi & Racine, 2015).

Beyond further expansion and fine-tuning of the list of justifications, there is also a need to remove redundant and poorly performing ones. This is necessary to reduce response burden by ensuring the justification list is not too long. By keeping the list as brief as possible it may be possible to also explore the grounds by which these justifications are trusted, increasing the information obtained and the predictive validity of the measure (Chinn et al., 2011). Factor analysis (Bandalos & Finney, 2010; Pallant, 2016; Tabachnick & Fidell, 2014) may be a useful avenue for exploring the justification list and determining which ones to remove. Factor analysis can also be used to explore and confirm the structure of the model proposed in Figure 7, including under which broader justification category (e.g., seeing as knowing) the justifications are loading. This may also help with the categorisation of the justifications from the “others” subtheme (e.g., “it’s logical”) and in determining the loading of the justifications developed from the sources theme or justification by others subtheme.

Once the justification list has been finalised, it will be necessary to conduct the cluster analysis again. As previously noted, a representative sample needs to be recruited, and ideally including those with divergent views on the topic questions at hand. The stability of any identified cluster solution will also need to be established through replication. Applying a number of clustering methods might also be necessary to provide support for the cluster structure (Everitt et al., 2011).

In addition, the outcomes associated with different profiles will need to be explored, in order to determine which profiles are more or less adaptable in different contexts. This could include 21st century skills of critical thinking (Greene & Yu, 2016), digital literacy (Greene et al., 2014), and scientific literacy (Greene, Cartiff, & Duke, 2018) alongside those outcomes identified in the qualitative interviews, such as identity and wellbeing. Whether or not the profiles represent developmental positions and how individuals move from one profile to another also needs to be

determined (Barger et al., 2016). Alternative considerations also warrant further explorations, such as the profiles representing a typology of knowing or one's preferences for knowing (e.g., epistemic style).

While this research ultimately focussed on the epistemic practice of knowledge justification (one's ways of knowing), it remains to be seen if this is the only component (or dimension) of epistemic cognition (as in Figure 7), or one of many (such as in Figure 1). As noted in the literature review, epistemic cognition is defined as "how people acquire, understand, justify, change, and use knowledge in formal and informal settings" (Greene et al., 2016a, p. 1). Epistemic cognition models have also included various components such as the nature, limits, justification, source, certainty, and simplicity of knowledge. Further construct mapping, research, and agreement on the dimensions that are relevant to psychological studies on epistemic cognition is therefore warranted, as is determining which components are epistemic and which are better regarded as correlates of epistemic cognition. This particularly includes notions of the acquisition of knowledge and beliefs about learning, as previously discussed. It is also worth considering whether use of the phrase "ways of knowing" promotes research and communication between researchers or instead adds to the confusing array of multiple, poorly specified terms in the field (Alexander & Sinatra, 2007).

Implications and contributions

In line with the ultimate purpose of this research, the findings from these two studies can be used to inform and improve upon current models and measures of the epistemic cognition construct. Firstly, the results from these two studies can be used to add further detail to current measures and models of epistemic cognition. This includes the justification by authority and personal justification dimensions of the EOC model (Greene et al., 2008) and the trichotomous justification framework (Ferguson et al., 2012, 2013). The results also build upon Ferguson and colleagues' (2012, 2013) justification by multiple sources dimension in the trichotomous justification framework by quantifying how many forms of justification individuals tend to use for different

topics. The justifications from both studies could also be added to the AIR model (Chinn et al., 2014; Chinn & Rinehart, 2016) as reliable processes. Furthermore, as discussed in Chapter 10, the qualitative themes and subtheme can also provide support for the reliable processes component of the AIR model.

With future refinement and validation, the questionnaire used in this study can be developed into a useful measure of one's ways of knowing. Alternatively, the resulting list of justifications can be added to current measures to increase their predictive validity. Ideally, replicating the focus and language used in this survey (i.e., on the respondent's practices, not on general beliefs or those of others') can also improve current measures. Ultimately, the refinement of epistemic cognition measures can only have positive implications for the advancement of theory and practice in the field. The use of sensitive measures with robust construct validity, for instance, will give greater confidence to findings of associations between epistemic cognition and other relevant variables. This will add to understandings on the actual outcomes associated with different types of epistemic cognition. Robust measures are also vital to allow for the accurate and reliable testing of interventions and their effectiveness.

Notwithstanding the limitations of this research which have been previously discussed, there are many contributions of this research to be acknowledged. In particular, the use of a person-centred, exploratory, mixed methods approach with a broader sample than typically used has allowed this research to uncover many of the ways of knowing of adults in various contexts, without being constrained by current theory or philosophical norms. In doing so, it has also justified appeals in the literature for such approaches. The use of a person-centred approach has also improved on previous variable-centred approaches which have tended to correlate scale scores with outcomes and ultimately described "nobody in particular" (Molden & Dweck, 2006, p. 192).

The approach herein consequently allowed for a more nuanced interpretation of the data. This resulted in a preliminary understanding of how different groups of individuals (or profiles of

“knowers”) utilise various justifications in combination to warrant knowledge claims. This identification of different profiles regarding how individuals *justify* their knowledge on certain topics is therefore a novel contribution to the field. Further exploration also revealed the different characteristics of these groups of knowers. Such findings can lead to the development of targeted interventions, instead of a one-size-fits-all approach (Chen, 2012; Kusurkar et al., 2021).

Concluding remarks

To conclude, the findings of this research can be used to inform research into the ways of knowing which are adaptable in certain contexts and associated with better outcomes, for both individuals and society. Ideally, this can lead to the development of interventions to shift individuals towards using more adaptable ways of knowing and being able to effectively evaluate and substantiate knowledge claims. In a rapidly changing, post-truth world full of misinformation and disinformation, the skills and dispositions to discern truth from fiction and false news are increasingly vital. Now is the time to put our knowledge about knowing to good use.

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Appendices

Appendix A

Ways of Knowing Interview Questions

Domain: Work

- What are the kinds of things you do for work?
 - *Prompt:* Tell me about a typical day and what you would be doing.
 - How long have you been doing this work? How did you get into this work?
- What are the kinds of things you have to know for your job?
 - Describe a time when you had to know something for work.
 - How did you come to know this? From where/when?

Key question:

Can you now tell me about an experience you've had with knowing something at work?

Recall a time when you had to know something at work/for your work.

Please describe, in as much detail as possible, this experience of knowing something for your work.

- *Follow up questions, prompts and probes:*
 - Can you think of a specific incident where you've had to know something at work/for your work? Or when you knew something, or were aware of knowing something? When was this?
 - How is it that you came to know this?
 - How did you know what to do with this knowledge?
 - How, if at all, did/do you know that you knew/know this?
 - Where did this knowledge come from?
 - How long have you've known about this?

- How do you feel about knowing this?

EVERYDAY

- Outside of your work, what are the kinds of things that you need to know?
 - *Prompt:* What knowledge might you come across on a day-to-day basis, such as in your family, hobbies, media, studies, or with friends?
- **Key question: Recall an experience of knowing something in your everyday life. Please describe it, in as much detail as possible.**
 - What was it that you had to know?
 - How is it that you came to know it?
 - Where did this knowledge come from?
 - How did you know what to do with this knowledge?
 - How, if at all, did/do you know that you knew/know this?

Further Questions

Domain: Aesthetics

- Think of a book (or artwork/poem/movie/music) that you like. How do you know that you like it (or not)? How do you know that you like something or not?

How do you know this is a good design, book, way of living, style?

When you buy something or put an outfit on, how do you know that it suits you, or not?

How do you know a particular style/dress sense suits you, or not?

Science/Religion/Creation

How do you know, if at all, the reason we are all here/the beginning of human existence?

How do you account for the beginning of human existence? How do you know this?

How do you know whether there is a God(s) or not?

How do you know that evolution is real or not?

Relational (e.g., self, other, parenting/caring)

How do you know who you are?

How do you know that someone likes/loves you? That you love someone?

For parents: How do you know how to care for your children? How did you come to know this?

Who do you trust? How do you know that you trust them?

How do you know whether somebody telling you something is right?

When you meet someone for the first time, how do you know that you like them (or not)/can trust them (or not)?

Personal/vocational: Education/studies; Career

How do you know: processes and content for work? How to stay up to date with knowledge and practices? That this job is right for you, or not?

How would you say you know this is a good career for you?

How do you know to do/use a theory/practice?

Having chosen your career, how do you know that it is a good choice for you, or not?

Politics/Economy

How do you know who to vote for? Who is a good leader?

How do you know a political party/politician is to be trusted or not?

How do you know whether a government policy is right/wrong for you or the country?

Society (e.g., immigration, welfare)

How do you know whether the Asylum seeker policy is right/wrong?

History

How do you know whether something happened in the past/in history or not?

Health (e.g., medical, diet)

How do you know whether we should vaccinate for diseases, or not?

How do you know that a diet is good for you, or not?

How do you know whether a food is good for you, or not?

How do you know that sunscreen is good for you, or not?

How do you know whether to go to a doctor or not? To take antibiotics or not?

Environmental/socio-scientific issues

How do you know that climate change is real, or not? How did you come to know that?

How do you know that wind turbines cause health problems, or not?

Other

How do you know where to go/what to do when you have a problem to solve?

Or to find out how to do something?

How do you know how to make something?

How do you know the process of doing something?

How do you know what to do when you have to make something?

How do you know what to do when you have a problem to solve?

Final

How did you find talking about this?

How have you found this interview? Has it been helpful? Helpful in knowing yourself and who you are (and what you do/how you make decisions)?

Appendix B

Study 1 Explanatory Statement



EXPLANATORY STATEMENT

Understanding Ways of Knowing

Chief Investigator: Dr. John Roodenburg
 Faculty of Education
 Phone: (03) 9905 1295
 email: john.roodenburg@monash.edu

Research Student: Ms. Karen Bell
Phone: (03) 9902 4883
 email: karen.bell2@monash.edu

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research.

What does the research involve?

Have you ever wondered about what it means to know something? Or how you came to know it? We are researchers from Monash University who are interested in studying this area, and in particular the different ways that people know. Results from this research will also be used as part of the student researcher's Doctor of Philosophy projects.

The research involves taking part in an individual interview with the student researcher. The interview will explore your experiences of knowing in various contexts, such as in your profession, daily life or during your studies, and over time. In no way will we test what you know or how much you know. The student researcher will conduct interviews by phone or in person, depending on what is most convenient to you. Face-to-face interviews will be held at Monash University. The interviews are expected to last approximately one hour.

Why were you chosen for this research?

You were invited to participate in this study because you completed the Ways of Thinking online survey and therewith indicated that you were willing to be contacted in regards to future research.

Consent and withdrawal from the study

Being in this study is voluntary and you are under no obligation to participate. If you feel that taking part in this research would be inappropriate for any reason at any time, whether for cultural or personal reasons, we ask that you decline to take part in the study. You can withdraw from the study at any time.

Confidentiality, storage, and use of data for other purposes

No identifying information such as address or phone numbers will be collected. If you provide the researcher with your phone number in order to complete the interview by phone, please note that it will not be linked to your interview, published in any form, or disclosed to anyone. Absolutely no findings will be published which could identify any individual participant. Transcriptions will be allocated a pseudonym or code and these referred to in any dissemination of results.

By participating in this research, you agree that your de-identified data can be used for research in the future. The researchers will retain the de-identified results of the interview in a secure locked filing cabinet in the Faculty of Education at Monash University for a minimum of five years, after which time they will be destroyed.

Inconvenience/discomfort

It is not anticipated that any of the questions you will be asked will make you uncomfortable; however, the interview will take up some of your time and it is remotely conceivable that you could experience some sort of unease or discomfort as you reflect upon your thoughts and experiences. If you encounter any questions that you are not entirely comfortable with, we encourage you not to answer them. You are free to discontinue the interview at any time. In the unlikely event that the interview raises any problems that you do not feel free to discuss with the interviewer, we suggest that you contact Lifeline (24 hours) on 13 11 14.

Results

It is envisaged that the findings of this study will be published in appropriate academic journals, at conferences, and as part of the student's doctoral thesis. Participants and any other interested persons can contact the researchers for a brief research report.

Thank you for your time,

Dr. John Roodenburg and Ms. Karen Bell
Monash University

If you would like to contact the researchers about any aspect of this study, please contact the Chief Investigator:	If you have a complaint concerning the manner in which this research CF14/1019 – 2014000427 is being conducted, please contact:
<p>Dr John Roodenburg Senior Lecturer Faculty of Education Building 5 Monash University VIC 3800</p> <p>john.roodenburg@monash.edu Tel: (03) 9905 1295</p>	<p>Executive Officer Monash University Human Research Ethics Committee (MUHREC) Building 3a_Room 111 Research Office Monash University VIC 3800</p> <p>muhrec@monash.edu Tel: +61 3 9905 2052 Fax: +61 3 9905 3831</p>

Appendix C

Study 1 Consent Form

CONSENT FORM

Project: Understanding Ways of Knowing (CF14/1019 – 2014000427)

Chief Investigator's name: Dr. John Roodenburg

Student's name: Ms. Karen Bell

Phone: (03) 9905 1295

Phone : (03) 9902 4883

email: john.roodenburg@monash.edu

email: karen.bell2@monash.edu

Please ensure you have read the supplied Explanatory Statement in full and had the project explained to you before deciding whether or not to participate in this research.

Please read each statement below and circle 'yes' or 'no'.

I have been provided with a copy of, and read, the Explanatory Statement for this project.	Yes	No
I understand that my participation in this study is voluntary, that I am under no obligation to participate, and that I can withdraw from the study by choosing at any time to not complete the interview.	Yes	No
I agree to have my interview recorded.	Yes	No
I understand that no identifying information such as my address or phone number will be collected. If my phone number was provided to conduct a phone interview, I understand that it will not be linked to my interview or disclosed to anyone.	Yes	No
I understand that no findings which could identify me or any individual participant will be disclosed in any reports on the project, or to any other party.	Yes	No
I understand that by participating in this research, my de-identified data can be used for further research in the future.	Yes	No
I understand that the researchers will retain the de-identified results of the interview in secure storage and accessible only to the research team. I understand they will be securely stored for a minimum of five years, after which time they will be destroyed.	Yes	No
I wish to be contacted in the future to participate in further research.	Yes	No

Full name: _____

Signature: _____ Date: _____

If you are willing to be contacted to participate in further research, please provide your email address below. Any further research is voluntary and optional and you are under no obligation to participate.

Email address: _____

Appendix D

Study 2 Demographic Questions

Gender:

- Male
- Female
- Other / I'd rather not say

Age in years: _____

Postcode: _____

Country of residence: _____

Country of birth: _____

Primary language spoken at home: _____

Highest educational qualification achieved: _____

Which of the following describes your employment status best:

- Full time study
- Part time work
- Full time work
- Not currently in the workforce
- Retired

Please describe your occupation, or previous occupation if retired or not working, in detail (e.g., if you are a high school chemistry teacher, please state that rather than simply teacher):

Appendix E

Study 2 Survey Questions

Instructions: Rate your agreement with each of the following statements using the following scale

(1 strongly disagree – 10 strongly agree)

Statements:

15. I know that global warming is caused by humans
16. I know that vaccines save lives
17. I know that smoking causes lung cancer
18. I know that evolution is real
19. I know that the moon landing was real
20. I know that mobile phones do **not** cause brain cancer in humans
21. I know that global warming is **not** real
22. I know that vaccines cause autism
23. I know that wind turbines cause health problems in humans
24. I know that antibiotics treat the common cold
25. I know that genetically modified organisms (GMOs) cause harm to people
26. I know that homeopathy is an effective treatment for illness
27. I know that a higher power (e.g., God) created the world
28. I know that there is a higher power/God(s)

Under each statement will be the following tick boxes. Participants will be asked to select as many as necessary to support their response to the statement.

I know this because...

Select from as many options below as relevant:

- I've seen it for myself
- It's logical
- I read it on the internet
- I just know it
- It just makes sense
- I've seen the evidence with my own eyes
- I've read the peer-reviewed evidence

- Of the science
- My faith told me so
- Of the statistics
- It feels right
- Somebody I trust told me:
 - teacher
 - family member
 - expert
 - friend
 - scientist
 - celebrity
- Other: _____

Example of question format:

Rate the following statement using the scale (1 strongly disagree – 10 strongly agree)

I know that global warming is caused by humans

I know this because... (select from as many of the options below as relevant. You can add your own option on the last line)

- I've seen it for myself
- it's logical
- I read it on the internet
- I just know it
- it just makes sense
- I've seen the evidence with my own eyes
- I've read the peer-reviewed evidence
- of the science
- my faith told me so
- of the statistics
- it feels right
- somebody I trust told me:

- teacher
- family member
- expert
- friend
- scientist
- celebrity
- _____

Other: _____

Appendix F

Study 2 Explanatory Statement

EXPLANATORY STATEMENT

Project title: Understanding Ways of Knowing

Project ID: 21096

Chief Investigator: Dr. Shane Costello

Faculty of Education

shane.costello@monash.edu

Phone: (03) 9905 0283

Research Student: Ms. Karen Bell

email: karen.bell2@monash.edu

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research.

What does the research involve?

Have you ever wondered how you know what you know? For instance, how do you know that the sky is blue? That $2+2=4$? That the Earth is round? We are researchers from Monash University who are interested in studying the different ways that people justify what they know, because these have important implications for teaching, learning, critical thinking, health promotion and more. Results from this research will also be used as part of the student researcher's Doctor of Philosophy projects.

If you are aged 18+ and interested in helping us better understand the ways we justify what we know, you are invited to complete this survey. It should take approximately 10-15 minutes to complete.

Why were you chosen for this research?

You were invited to participate in this research because we are interested in understanding how the general public justifies their knowledge.

Consent and withdrawal from the study

Being in this study is voluntary and you are under no obligation to participate. If you feel that taking part in this research would be inappropriate for any reason, whether for cultural or personal reasons, we ask that you decline to take part in the study. Once you go to the survey's page, clicking next will indicate your consent to participate in this research. You can withdraw from the study at any time by not completing the questionnaire. However, once submitted, it will not be possible to identify and remove your data from the rest of the anonymous database.

Possible benefits and risks to participants

By participating in this study, you will be contributing to our understanding of ways of knowing.

The survey focuses on how you justify what you know; in no way will we test how much you know. It is not anticipated that any of the questions you will be asked will make you uncomfortable; however, the survey will take up some of your time and you may experience some discomfort as you reflect upon your thoughts and experiences. If you encounter any questions that you are not entirely comfortable with, you are free to not answer them. Further, if any of the questions cause you discomfort, you may wish seek services to minimise your distress, such as Lifeline (24 hours) on 13 11 14 or www.lifeline.org.au.

Payment

Following completion of the questions, you may choose to enter the draw to win one of three \$50 gift cards. You will need to provide an email address if you wish to enter the draw; however, your email address will not be linked to your results and will not be published.

Confidentiality, storage and use of data for other purposes

No identifying information such as addresses or phone numbers will be collected. No findings which could identify any individual participant will be published. By participating in this research, you agree that your anonymous data can be used for research in the future. The researchers will retain the anonymous results in the Faculty of Education at Monash University for a minimum of five years, after which time they will be destroyed.

Results

It is envisaged that the findings of this study will be published in appropriate academic journals, at conferences, and as part of the student's doctoral thesis. Participants and any other interested persons can contact the researchers for a brief research report.

Complaints

Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics Committee (MUHREC):

Executive Officer

Monash University Human Research Ethics Committee (MUHREC)

Room 111, Chancellery Building D,

26 Sports Walk, Clayton Campus

Research Office

Monash University VIC 3800

Tel: +61 3 9905 2052 Email: muhrec@monash.edu Fax: +61 3 9905 3831

Thank you for your time,

Dr. Shane Costello and Ms. Karen Bell

Monash University

Appendix G

Abridged Agglomeration Schedule

Stage	Cluster Combined			Stage Cluster First Appears		
	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	Next Stage
1	125	135	0.00	0	0	4
2	131	197	1.00	0	0	105
3	138	151	2.00	0	0	50
4	125	213	3.33	1	0	10
5	185	211	4.83	0	0	164
6	13	88	6.33	0	0	19
7	99	339	8.33	0	0	35
8	47	295	10.33	0	0	39
9	62	69	12.33	0	0	80
10	109	125	14.75	0	4	18
11	31	65	17.25	0	0	135
12	39	247	20.25	0	0	32
13	221	233	23.25	0	0	38
14	172	176	26.25	0	0	113
15	37	140	29.25	0	0	41
16	33	104	32.25	0	0	91
17	19	20	35.25	0	0	78
18	109	111	38.30	10	0	105
19	13	316	41.47	6	0	100
20	53	343	44.97	0	0	43
21	202	231	48.47	0	0	52
22	15	191	51.97	0	0	139
23	201	324	55.97	0	0	169
24	208	306	59.97	0	0	44
25	232	285	63.97	0	0	100
26	227	280	67.97	0	0	167
27	34	271	71.97	0	0	63
28	244	268	75.97	0	0	213
29	200	241	79.97	0	0	39
30	171	235	83.97	0	0	115
31	112	192	87.97	0	0	143
32	39	175	92.30	12	0	51
33	267	321	96.80	0	0	103
34	293	308	101.30	0	0	108

Note. Only the first page of the agglomeration schedule is shown here.

Appendix H

Pearson Correlations Matrix for Justification Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. seen_for_self	1																	
2. logical	.34**	1																
3. read_internet	.14*	.37**	1															
4. just_know	.15**	.36**	.38**	1														
5. makes_sense	.24**	.69**	.52**	.49**	1													
6. seen_evidence	.63**	.27**	.12*	.12*	.18**	1												
7. read_evidence	.12*	.18**	.08	-.05	.08	.37**	1											
8. the_science	.17**	.27**	.07	-.02	.13*	.25**	.24**	1										
9. my_faith	.18**	-.01	.10	.23**	.05	.21**	-.02	-.08	1									
10. the_statistics	.15**	.31**	.22**	.08	.25**	.29**	.34**	.49**	.12*	1								
11. feels_right	.18**	.41**	.44**	.59**	.56**	.13*	-.02	.07	.25**	.17**	1							
12. somebody_trust	.10	.18**	.35**	.08	.14*	.14**	.06	.09	.00	.16**	.13*	1						
13. teacher	.06	.10	.32**	.08	.10	.17**	.08	.03	.02	.16**	.17**	.76**	1					
14. family_member	.11*	.16**	.34**	.08	.20**	.19**	.07	-.03	.07	.14**	.31**	.58**	.70**	1				
15. expert	.11*	.20**	.31**	.08	.14**	.16**	.11*	.13*	-.01	.19**	.12*	.95**	.71**	.51**	1			
16. friend	.08	.11*	.30**	.03	.14**	.17**	.09	.09	.07	.24**	.24**	.54**	.69**	.60**	.57**	1		
17. scientist	.12*	.16**	.26**	-.01	.14*	.14**	.14**	.17**	-.04	.20**	.11*	.87**	.70**	.51**	.88**	.54**	1	
18. celebrity	.09	.20**	.34**	.19**	.24**	.12*	.14**	.09	.24**	.17**	.32**	.24**	.32**	.36**	.28**	.46**	.30**	1

Note. * $p < .05$. ** $p < .01$

Appendix I

Pearson Correlations Matrix for Topic Question Variables

Variable	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q1	1													
Q2	.19**	1												
Q3	.36**	.38**	1											
Q4	.28**	.28**	.15**	1										
Q5	.19**	.37**	.34**	.19**	1									
Q6	.19**	.26**	.21**	.22**	.29**	1								
Q7	-.59**	-.17**	-.15**	-.28**	-.20**	-.14**	1							
Q8	-.21**	-.52**	-.21**	-.28**	-.32**	-.37**	.26**	1						
Q9	-.16**	-.10	-.10	-.13*	-.14**	-.26**	.11*	.16**	1					
Q10	-.14**	-.12*	-.04	-.08	.00	-.03	.18**	.09	.14**	1				
Q11	-.17**	-.36**	-.16**	-.19**	-.27**	-.33**	.23**	.37**	.23**	.14**	1			
Q12	-.23**	-.32**	-.19**	-.16**	-.20**	-.34**	.23**	.35**	.22**	.17**	.46**	1		
Q13	-.13*	-.04	.02	-.46**	.03	-.16**	.11*	.13*	.06	.05	.18**	.22**	1	
Q14	-.14**	-.14**	.01	-.44**	-.06	-.21**	.12*	.25**	.08	.09	.25**	.27**	.83**	1

Note. Q1 = Global warming; Q2 = Vaccines; Q3 = Smoking; Q4 = Evolution; Q5 = Moon landing; Q6 = Mobile phones NOT cancer; Q7 = Global warming NEG;

Q8 = Vaccines and autism; Q9 = Wind turbines; Q10 = Antibiotics common cold; Q11 = GMOs harmful; Q12 = Homeopathy; Q13 = Higher power created

world; Q14 = There is a higher power.

* $p < .05$. ** $p < .01$

Appendix J

Table J1

Four-Cluster Solution

Justification	Cluster 1 (<i>n</i> = 200)		Cluster 2 (<i>n</i> = 87)		Cluster 3 (<i>n</i> = 16)		Cluster 4 (<i>n</i> = 42)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
I've seen it for myself	2.14 ^{ab}	1.90	1.37 ^a	1.52	3.00 ^b	2.42	2.98 ^b	2.10
It's logical	3.71 ^a	2.94	1.53 ^b	1.68	5.44 ^c	4.23	8.05 ^d	3.12
I read it on the internet	0.60 ^a	1.39	0.67 ^a	1.58	3.19 ^b	4.25	4.64 ^c	3.61
I just know it	0.44 ^a	0.94	0.54 ^a	1.13	0.56 ^a	1.09	3.55 ^b	2.86
It just makes sense	2.26 ^{ab}	2.32	1.20 ^a	1.37	3.50 ^b	4.26	7.26 ^c	2.86
Seen evidence with own eyes	2.85 ^a	2.14	1.40 ^b	1.61	4.19 ^c	3.60	2.86 ^a	1.87
Read peer-reviewed evidence	4.53 ^{ac}	3.84	2.16 ^b	2.87	6.19 ^c	4.67	3.95 ^{ab}	3.57
Of the science	9.26 ^a	2.74	1.98 ^b	1.94	10.00 ^a	3.60	6.67 ^c	3.96
My faith told me so	0.38	0.82	0.60	1.12	0.56	2.00	0.62	1.15
Of the statistics	4.14 ^{ac}	3.02	1.20 ^b	1.25	5.56 ^c	4.20	3.67 ^a	2.34
It feels right	0.69 ^a	1.08	0.49 ^a	0.99	1.81 ^b	3.73	3.26 ^c	3.05
Teacher	0.13 ^a	0.45	0.38 ^a	1.35	4.94 ^b	3.66	0.62 ^a	1.25
Family member	0.09 ^a	0.39	0.30 ^a	0.92	2.69 ^b	3.75	0.62 ^a	1.34
Expert	0.53 ^a	1.21	0.67 ^{ab}	1.68	10.38 ^c	2.28	1.55 ^{ab}	2.00
Friend	0.08 ^a	0.49	0.06 ^a	0.28	3.38 ^b	4.33	0.48 ^a	0.97
Scientist	0.34 ^a	0.88	0.39 ^{ab}	1.25	10.25 ^c	2.30	1.07 ^b	1.66
Celebrity	0.01 ^a	0.10	0.01 ^a	0.11	0.63 ^b	1.54	0.31 ^c	0.87

Note. Superscript letters that differ in the same row indicate statistically significant differences in means at $p < .05$.

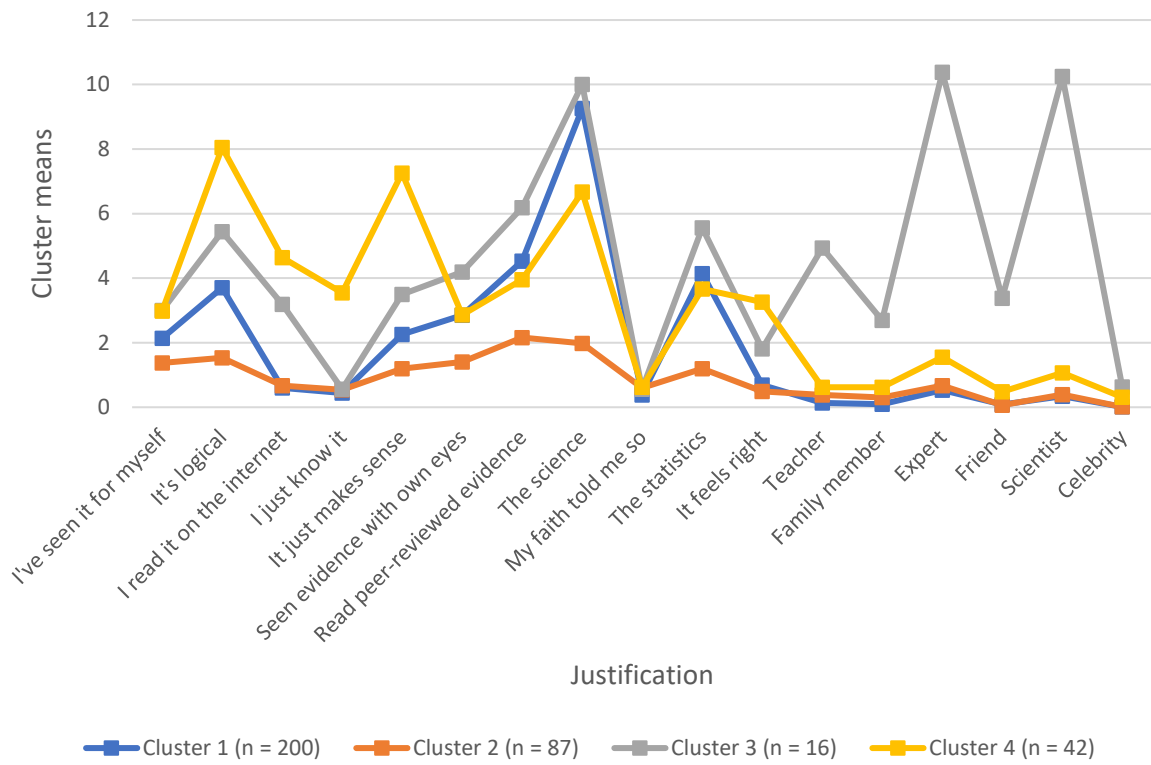


Figure J1. Mean cluster scores for each justification variable.