At the Intersection of Science and Faith: Epistemic Cognition about "Religiously-Loaded" Scientific Issues

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Abstract

Science and religion represent important facets of human experience. Yet, they are related in complex and sometimes conflicting ways. The present study examines how religious people think about the science-religion relations by focusing on their epistemic cognition, i.e. thoughts about the nature and justification of knowledge when making sense of competing claims to truth. The study's main question was whether people express different beliefs with regards to "religiously-neutral" vs. "religiously-loaded" issues in the social-psychological and biological domains. The religiously-neutral issues explored were (a) motivation and work performance, and (b) sugar as the cause of obesity; while the religiously-loaded issues were (c) homosexuality as a disorder, and (d) human evolution. On each of the four issues, undergraduate students from Islamic and Christian backgrounds (N = 317; mean age = 21.4 years; 74.1% female) were asked to express their epistemic beliefs along the three dimensions: (1) ontology, i.e. whether there is a single, objective truth (ontology); (2) fallibility, i.e. whether knowledge of the issue could be wrong; and (3) decidability, i.e. whether there are rational ways to decide on truth. The findings show when thinking about religiously-loaded scientific issues such as homosexuality and evolution, people tend to believe that there is a single objective truth, that their own beliefs are infallible, and that there is no rational method to evaluate knowledge claims. This thinking pattern may be one reason underpinning the difficulty of learning about science concepts which are seen to contradict religious doctrine. Some implications for science education are also entered into the discussion.

Keywords

Conflicts between science and religion present unique challenges for individuals who wish to maintain a religious identity in the modern world (Roth, 2010).[1] Can faith in religion be reconciled with a belief in science? Can a person embrace the scientific worldview, while preserving his/her religious faith?

Such questions can be answered in the affirmative, and with relative ease, if only science and religion occupy distinct domains with clear demarcations. In this view, science reigns over explanation and manipulation of the natural world, while religion has authority over moral values and transcendental truths. By occupying separate domains, the two can further be imagined as being complementary: science is tasked with developing new knowledge and technologies, while religion is consulted upon the ethical applications of those products of science. Thus, in education systems teaching both science and religion, the two can unproblematically be taught as separate subjects by different teachers. There is little need for science teachers to discuss religious beliefs, and vice versa for teachers of religion.

This idyllic picture of the science-religion relationship is, unfortunately, incomplete and perhaps even misleading. Science and religion do intersect problematically because the sacred texts (at least those from the Abrahamic traditions) contain claims about the natural world which can be difficult to reconcile with scientific explanations. Two examples of such problematic intersections were examined in this study: claims about the psychiatric status of homosexuality, and claims about the origin of the human species (Clark, 2014). With regards to the first, the Abrahamic religions regard homosexuality as an abnormality, which is at odds with the scientific consensus (Halstead & Lewicka, 1998; Stm & Gramick, 1989). On the second issue, conventional religious teachings maintain that modern humans were created by God more-or-less in the present form, and thus reject the theory of evolution. In the Indonesian context, the general concept of evolution is included in the science curriculum, while the Biblical/Quranic versions are taught in the religious studies (compulsory for all students, in all schools).

This study seeks to understand the ways people make sense of these "religiously-loaded" scientific issues, and whether and how they differ from their thinking about more "religiously-neutral" ones. In the following section,

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a brief review of educational research, touching upon the science-religion schism, is presented. The review is admittedly selective, but will hopefully suffice to show why understanding people's thinking about the science-religion relationship is essential for education. The next sections then explicate the notion of epistemic cognition, its relevance to understanding how people think about the science-religion relationship, as well as the theoretical model used in the design of this study.

11.1   Religious Beliefs and Science Education

Educational research on the science-religion relationship has mostly examined the teaching and learning about human evolution. Data from the recent survey in the US show that only a minority of biology teachers in the US consider themselves as advocates of evolutionary theory (Berkman & Plutzer, 2011). Sixty percent of the teachers endorse neither creationism nor evolutionary theory, while a significant minority explicitly advocate for creationism (Berkman & Plutzer, 2011). These personal beliefs seem to influence classroom pedagogy, with 17% of biology teachers in the US omitting the topic of human evolution from their teaching (Berkman, Pacheco, & Plutzer, 2008).

Qualitative studies confirm and further illuminate the influence of teachers' religious views on their teaching. An interview-based study conducted in a Protestant context (Brazil) found that pre-service teachers differed in how they negotiate tensions between their religious and scientific knowledge (El-Hani & Sepulveda, 2010). Some pre-service teachers recognize that religious knowledge is as epistemologically distinct from scientific knowledge, and thus can see them as serving different facets of the human needs. Those individuals developed versions of creationism which enabled them to reconcile divine creation with the central tenets of evolutionary theory. Another group of pre-service teachers, however, deliberately reject and hence exhibit a poor understanding of evolutionary theory (El-Hani & Sepulveda, 2010).

A similar study conducted with Muslim pre-service teachers in Egypt resulted in a less diverse picture (Mansour, 2010). That study identified four ways in which Muslim pre-service teachers described the relationship between science and religion: integration, dialogue, independence, and conflict. All four stances, however, subsume scientific knowledge under the domain of religion. Thus, science can confirm and enrich religious beliefs, but can never falsify them. For all pre-service teachers interviewed, conflicts between science and religion will result in a rejection of science. Consequently, they teach evolution

in conjunction with creationism, presenting relevant verses from the holy book to undermine the veracity of evolutionary theory (Mansour, 2010).

Similarly, religious headmasters of secondary schools in Muslim-majority Senegal feel uneasy about having to teach evolutionary theory and the Big Bang theory (Croché, 2015). The headmasters respond by teaching about religion (in the religious sense) and undermining science through one of the three strategies. The three strategies include presenting science and religious discourses as competing "theses"; teaching the official curriculum during formal lessons, but expressing their disbelief after class; and merely failing to teach the scientific theories, and replacing them with religious explanations about the origin of humans and the universe (Croché, 2015).

For the student, the challenge of learning about evolution and other scientific theories which conflict with faith is partly rooted in the biases inherent in human cognition. From this cognitive perspective, religion offers explanations, which are more believable than science. In other words, belief in religion comes more naturally, while scientific theories are more counter-intuitive (Blancke, de Smedt, de Cruz, Boudry, & Braeckman, 2012). Unsurprisingly, studies show that the strength of students' religious belief negatively predicts their understanding of science (Lawson & Worsnop, 1992; Moore, Brooks, & Cotner, 2011). Qualitative studies also show that religious Muslim and Christian students do perceive conflicts between evolution and religion, and that explicitly discussing epistemological tensions could facilitate deeper understanding about evolution (Dagher & BouJaoude, 1997; Yasri & Mancy, 2014).

The tension between science and religion has also played out at the societal level. In the US there is a long history of attempts to include versions of creationism in the science curriculum (Berkman et al., 2008). A similar tug-of-war over the content of biology curriculum has occurred in Muslim-majority but secular Turkey. While in the US the court has sided with proponents of science, the outcome in Turkey has favored the religious faction with the inclusion of an Islamic version of intelligent design theory in the country's science curriculum (Edis, 2009).

Overall, the studies discussed thus far show that religious beliefs influence science teaching and learning in significant ways, particularly with regards to scientific knowledge which conflict with those beliefs. Addressing this challenge requires, among other things, a more profound understanding of how people think about the relations between science and religion. The current study seeks to contribute to developing such an understanding by focusing on epistemic cognition, the facet of thought which is fundamental to reasoning about conflicting claims to truth.

11.2   Epistemic Cognition: Development and Key Dimensions

Epistemic cognition can be defined as thought processes which are pertinent to the consideration of what counts as valid or believable knowledge (Aditomo, 2014; William A. Sandoval, Greene, & Bråten, 2016). Epistemic cognition draws upon assumptions regarding the nature of knowledge and the processes of coming to know. In a seminal article, Kitchener (1983) provided a framework to understand the role of epistemic cognition within the more general process of problem-solving. In Kitchener's view, epistemic cognition means a specific form of metacognition, one which applies standards about what counts as valid knowledge to the task at hand. This view is echoed more recently by other researchers (Barbara K. Hofer, 2004; Moshman, 2011).

This specific form of metacognition becomes crucial when dealing with ill-structured problems which have multiple, possibly conflicting and potentially equally valid solution paths. For example, in reading a book on the science of sexual orientation, an individual may engage in metacognitive processes such as monitoring whether she has enough understanding of one chapter before deciding to move on to the next. This kind of monitoring is sufficient if the goal is merely to understand the text. However, if the individual is reading to decide which side to believe in the debate on homosexuality, then she would also need to consider the trustworthiness of the information sources, the strength of the evidence, the logical connections between different arguments, and so on. In short, she would need to engage in epistemic cognition.

Researchers have documented a general trajectory involving two significant shifts in the development of epistemic cognition. Initially, individuals subscribe to an objectivist epistemology which sees knowledge as certain and absolute truth based upon solid and objective foundation. The first major epistemic shift occurs when individuals discard their objectivist epistemology in favor of a subjectivist one, which views knowledge as personal and having no objective foundation. The second shift occurs when individuals become able to reconcile the subjective and objective nature of knowledge, to see it from an "evaluativist" stance whereby all claims can and need to be assessed based on reason and evidence (Barbara K. Hofer & Pintrich, 1997; Kuhn & Park, 2005).

While prior studies converge on the trajectory of individuals' epistemological development, there is a wide discrepancy in the timing of key shifts in that development. Some studies indicate that the shift from objectivism to subjectivism occur in late adolescence or early adulthood, prompted by the college experience (Perry, 1968). Others locate the shift during the early adolescent years (Hallett, Chandler, & Krettenauer, 2002), or even during pre-adolescence

(Kuhn, Cheney, & Weinstock, 2000). These conflicting findings have led researchers to postulate that epistemological development occurs in a contextualized, domain-specific manner. Epistemological development typically occurs first in the domain of moral values and personal taste, then the domain of the social, and finally the domain of the natural world (Hallett et al., 2002; Kuhn et al., 2000). Hence, it should be common to find an adolescent who expresses subjectivist views about moral and social issues, but a more objectivist view on scientific issues.

Other researchers have proposed that epistemic cognition is dependent upon subtle contextual cues, such that it can vary even within a single domain, topic, and activity (Hammer & Elby, 2002). For example, groups of students may adopt one epistemic stance when listening to lectures but quickly shift to a different stance when given the opportunity to engage in independent inquiry (Rosenberg, Hammer, & Phelan, 2006). Based on such examples, Hammer, Elby and colleagues have proposed that epistemic cognition draws upon fine-grained ideas which do not necessarily form coherent beliefs or stages of development (Hammer, Elby, Scherr, & Redish, 2005).

Another line of research has focused on identifying the main dimensions of belief which comprise epistemic cognition. Some models in this tradition portray epistemic cognition as composed of beliefs about the certainty, structure, source, and justification of knowledge (Aditomo, 2018; Barbara K. Hofer, 2001; W. A. Sandoval, 2009). Other models also incorporate beliefs about the nature of learning or knowledge acquisition (Schommer-Aikins, 2004). These multidimensional models attempt to account for the discrepant findings about the timing of key epistemic transitions by postulating that epistemological development occurs asynchronously across the dimensions. For example, maturity in the belief about the certainty of knowledge does not necessarily correlate with maturity in the beliefs about sources of or how to justify knowledge (Schommer-Aikins, 2004).

11.3   Epistemic Cognition in Cultural and Religious Contexts

Some studies indicate that cultural contexts influence and interact with epistemic cognition. For example, a cross-cultural study found that compared to their American, European, and African peers, Taiwanese students emphasize societal well-being to justify decisions in the face of moral dilemmas (Zeidler, Herman, Ruzek, Linder, & Lin, 2013). The authors speculate that the different reasoning pattern stems from the more interdependent sense of self which

characterize individuals in more collectivist societies (Ziedler et al., 2013). Another study (Karabenick & Moosa, 2005) found that compared to their Western (US) peers, Middle-eastern students are more likely to trust scientific authorities and to view scientific knowledge as simple and certain (unchanging). The authors attributed their findings to the traditional religious (Islamic) values regarding deference to authorities over independent thinking (Karabenick & Moosa, 2005).

The role of religious values and beliefs in epistemic cognition has been explicated further in a study comparing the views of 5th, 9th, and 12th grade students from secular and religious schools with regard to two controversies: first, on the existence of God, and second, on whether children need to be punished when they misbehave (Gottlieb & Mandel Leadership Institute, 2007). The study found that older students tend to be more aware that other people may hold opposing beliefs on the two issues, and that there are no objective/rational ways to resolve differences in opinion regarding both issues. Comparing across the two issues, students were more likely to believe that the God issue had a true/correct answer, that there are no rational ways to arrive at that truth, and that their views about the issue might be wrong (fallible). Comparing between religious and secular students, the study also found different epistemic orientations with regards to the God controversy, but not for the punishment controversy. For the God controversy, religious students were more likely to believe that there is only one correct answer (i.e., more realist), that their own views are correct (i.e., more infallible) and that there should be rational ways to resolve differences in opinion (i.e., more rationalist). This last difference in the epistemological orientations of religious and secular students was interpreted as evidence that individuals draw from their social-cultural communities' ways of knowing (Gottlieb & Mandel Leadership Institute, 2007).

11.4   The Current Study

The current study extends prior research on epistemic cognition by examining "religiously-loaded" and "religiously-neutral" scientific issues from the social-psychological and the biological domains. Religiously-loaded issues deal with questions that have been investigated empirically using scientific methods, but leading to conclusions which contradict religious doctrines. Two such issues were examined in this study: whether homosexuality is a psychological disorder, and whether evolution can explain the origin of the human species. As far as the author is aware of, this is the first study which compares epistemic

cognition on such issues with religiously-neutral ones. Thus, the second question addressed by this study is whether and how epistemic cognition varies across religiously-neutral and religiously-loaded issues.

To address these questions, this study adopted Gottlieb's model of epistemic cognition which focuses on three dimensions of beliefs. The beliefs include *ontology*, i.e. whether there is a single correct answer (realist vs. perspectivist); *fallibility*, i.e. whether one's belief could be wrong (fallibilist vs. infallibilist); and *decidability*, i.e. whether there are rational ways to decide which view is correct (rationalist vs. non-rationalist) (Gottlieb & Mandel Leadership Institute, 2007). Based on findings from Kuhn et al. (2000) and Hallett et al. (2002), young adults, like the participants of this study, should express more objectivist epistemic beliefs with regards to questions about the physical/natural world ("brute facts") than the social world ("institutional facts"), compared to questions about the social world. Translated into this study's framework, participants should express less perspectivist, less fallibilist, and more rationalist beliefs when thinking about the biological issues (evolution and obesity) compared to the social-psychological issues (homosexuality and motivation).

With regards to differences in epistemic beliefs across religious content, the most relevant prior study would be one reported by Gottliet and the Mandel Leadership Institute (2007). Indirectly, their findings suggest that individuals would be less perspectivist, more fallibilist, and less rationalist concerning religious issues than non-religious ones. However, Gottlieb's study focused on comparing students from different communities (religious vs. secular schools), rather than comparing the same individual with regards to different issues. Moreover, the religious claim used in their study (that God exists) can be considered as outside the domain of science. In contrast, the current study is interested in religious issues which can legitimately be addressed through scientific methods. Hence, it remains to be seen whether the pattern of epistemic cognition found in this study replicates those found by (Gottlieb & Mandel Leadership Institute, 2007).

11.4.1 *Method*

11.4.1.1 Design

An online survey was conducted over a period of three months (approximately September to October 2016) to collect background information as well as epistemic orientations with regards to four issues from different judgment domains and with different religious content (motivation, homosexuality, obesity, and evolution; see section on Measures). Prior to the survey, a pilot study was conducted by interviewing six students about their epistemic orientations

along the three dimensions of ontology, fallibility, and decidability regarding the four issues. The purpose was to test whether the issue vignettes could be understood and to explore possible answers to questions about the three epistemic dimensions of ontology, fallibility, and decidability. These possible answers were incorporated as options in the multiple choice questions designed to measure epistemic orientation (see the second column of Table 11.2).

11.4.1.2   Participants

Participants were fourth-year university students from various academic departments in a private university in a metropolitan city in Indonesia. They were invited through personal contacts and social media to complete an online survey administered through a Google form. Participation was rewarded with a chance to win one of twenty cash prizes (approx. equivalent to 5 to 7 US dollars) in a lucky draw. Initially, 369 participants completed the online survey. Of those, 6 participants who considered themselves to be non-religious in response to a screening question were excluded. Also, the analysis only focused on participants from the Islamic and Christian religions, because these religions contain teachings which contradict scientific conclusions about homosexuality and the evolutionary origins of the human species. This process further excluded 46 participants from the Buddhist and Hindu religions. The final sample was composed of 317 participants who were on average 21.4 years, mostly female (74.1%), and who mostly come from Chinese (48.4%) and Javanese (38.8%) ethnic backgrounds. In terms of their academic backgrounds, the participants were studying pharmacy (n = 96), psychology (n = 117), engineering (n = 63), business and economics (n = 35), and law (n = 6).

11.4.1.3   Measures

Background questionnaire. A background questionnaire asked participants to report their gender, age, ethnic background, and religious affiliation. It also included a screening question asking participants to report their level of religiosity, going from "not religious", "religious but somewhat less so than the average person", "just as religious as the average person", and "more religious than the average person".

Scientific issue vignettes. The main data came from responses to vignettes around four issues displayed in Table 11.1. The issues were systematically varied along two dimensions: judgment domain (social vs. biological) and religious content ("loaded" vs. "neutral").

Epistemic cognition prompts. Participants were asked whether they agree or disagree with the fictitious person's claim in each issue vignette. They were

TABLE 11.1   Scientific issue vignettes used as context to assess epistemic cognition

Religious content	Domain	
	Social-psychological	*Biological*
Religiously-neutral	Motivation issue: "… claimed that motivation is more important than skill in determining work performance.	Obesity issue: "… claimed that sugar instead of fat is the main cause of obesity"
Religiously-loaded	Homosexuality issue: "… claimed that homosexuality is not a psychological disorder."	Evolution issue: "… claimed that humans evolved from a common ancestor with the apes"

then presented with close-ended questions assessing orientations regarding the three epistemic dimensions examined in this study: "Do you think there is one right answer on this issue?" (ontology); "Do you think it is possible that your belief about this issue could be wrong?" (fallibility); and "How can you rationally determine which answer is correct regarding this issue?" (decidability). The response options for each question and their coding are displayed in Table 11.2.

11.4.1.4   Analysis

The data was first screened based on participants' religious affiliation and level of religiosity. Only participants from Islamic and Christian (both Catholics and Protestants) who consider themselves as religious were included in further analysis. For those participants, the analysis was first proceeded by aggregating responses to the epistemic questions to become dichotomous orientations, i.e., perspectivist vs. realist for the ontology dimension, fallibilist vs. infallibilist for the fallibility dimension, and rationalist vs. non-rationalist for the decidability dimension. Then, McNemar Chi-Square tests were performed to test whether observed differences in the proportion of epistemic orientations for each belief dimension were statistically significant. Comparisons were first made across domains (social vs. biological issues), but within the type of religious content, and then across type of religious content (neutral vs. loaded), but within each domain. Hence, McNemar tests were performed for 12 comparisons (2 domains × 2 religious content × 3 belief dimensions).

11.4.2   *Findings*

Descriptive results. Table 11.2 shows the proportion of responses for each question assessing epistemic cognition. On the ontology dimension, more participants adopted a perspectivist rather than a realist orientation for social issues, but not for biological issues. On the fallibility dimension, the majority adopted a fallibilist orientation for all four issues. There was a clear overall trend in the decidability dimension as well: most participants adopted a rationalist orientation. Note that the "consulting religious holy text" option was chosen by very few participants with regards to religiously-neutral issues (motivation and obesity), but was much more popular with regards to religiously-loaded ones (homosexuality and evolution).

Epistemic belief across judgment domains. Comparing across domains for the ontological belief dimension, McNemar tests indicate that participants were less perspectivist (i.e., more realist) with regards to biological issues compared to social issues. The differences were relatively large, especially for the non-religious issues. Differences in the fallibility belief dimension across social and biological issues were smaller and only significant for non-religious issues (in the hypothesized direction: less fallible for obesity than for motivation). In other words, when thinking about the cause of obesity, participants were less likely to believe that their views could be wrong, while no such difference was observed when comparing fallibility beliefs across the homosexuality vs. evolution issues. Differences in decidability beliefs were also modest and were statistically significant only for the non-religious issues (again, in the hypothesized direction: participants were more rationalist for obesity than for motivation).

Overall, it seems that domains of knowledge serve as a prompt for participants to adjust their epistemic orientation, especially with regards to the ontological dimension. As hypothesized, participants were less perspectivist (more realist), less fallibilist, and more rationalist when considering a biological issue than a social one. Furthermore, there was an interaction between domain and religious content in prompting epistemic adjustment. For religiously-loaded issues, the difference in epistemic orientation about social vs. biological issues became less prominent (on the ontological dimension) or disappears (on the fallibility and decidability dimensions).

Epistemic belief across religious content. Comparing across religious content for the ontological dimension, the analysis indicated that participants were less perspectivist (i.e., more realist) with regards to the religiously-loaded social issue (homosexuality) than the religiously neutral one (motivation). For the biological domain, however, there was no difference in participants'

TABLE 11.2   Responses for each option within the three epistemic dimensions

Belief dimension	Response options
Ontology: is there one right answer on this issue?	No, the answers regarding this issue are highly personal and cannot be compared
	No, it is difficult to say that one answer is right because this issue is highly subjective
	Yes, it is clear that one answer is right and the other is wrong
	Yes, for this issue, there can be only one right answer
Fallibility: could your belief be wrong?	No, my belief about this issue cannot be wrong
	Yes, although unlikely, my belief could still be wrong
	Yes, it is quite possible that my belief about this issue could be wrong
Decidability: what is the rational way to determine which answer is correct?	There are no rational or objective ways to decide
	By consulting the religious holy texts
	By examining empirical facts/evidence
	By considering the judgments of experts in the relevant academic fields
	By using logic to analyze and further examine the issue

ontological belief. For the fallibility dimension, participants were less fallibilist (i.e., more infallibilist) in their orientation towards religiously-loaded issues than for religiously-neutral ones in both the social and biological domains. For the decidability dimension, differences in orientations with regards to religiously-loaded and neutral issues were even larger, and participants were less rationalist (i.e., more non-rationalist) when considering religiously-loaded issues.

Overall, the findings indicate that the religious content of an issue also prompts shifts in people's epistemological orientations in all three dimensions. For the ontological dimension, the influence of religious content interacted with the domain, with religiously-loaded content prompting less perspectivist (more realist) orientations only within the social domain. For the fallibility dimension, religiously-loaded content prompted fewer fallibilist orientations for both domains. For the decidability dimension, religiously-loaded content prompted a shift away from rationalist orientations (i.e., towards non-rationalist orientations).

Orientation category	Motivation issue	Homosexuality issue	Obesity issue	Evolution issue
Perspectivist	31.9%	27.1%	16.1%	15.8%
Perspectivist	50.8%	35.0%	25.9%	30.9%
Realist	9.8%	22.7%	36.9%	34.4%
Realist	7.6%	15.1%	21.1%	18.9%
Infallibilist	16.7%	32.2%	22.7%	36.6%
Fallibilist	59.3%	39.4%	54.3%	38.8%
Fallibilist	24.0%	28.4%	23.0%	24.6%
Non-rationalist	5.0%	9.5%	0.6%	8.5%
Non-rationalist	0.9%	27.1%	0.9%	30.0%
Rationalist	50.8%	13.9%	13.9%	15.1%
Rationalist	9.5%	30.3%	65.0%	24.3%
Rationalist	33.8%	19.2%	19.6%	22.1%

TABLE 11.3   McNemar Chi-square tests comparing social and biological issues

Issues compared	Ontology		Fallibility		Decidability	
	% difference	Chi square	% difference	Chi square	% difference	Chi square
Motivation vs. Obesity	40.69%	103.36 (p < .0001)	5.99%	4.06 (p = .0440)	4.42%	8.17 (p = .004)
Homosexuality vs. Evolution	15.46%	19.21 (p < .0001)	4.42%	1.92 (p = .1980)	1.89%	0.35 (p = .556)

Epistemic Orientation Across Religious Content
(within Social Issues)

Epistemic Orientation Across Religious Content
(within Biological Issues)
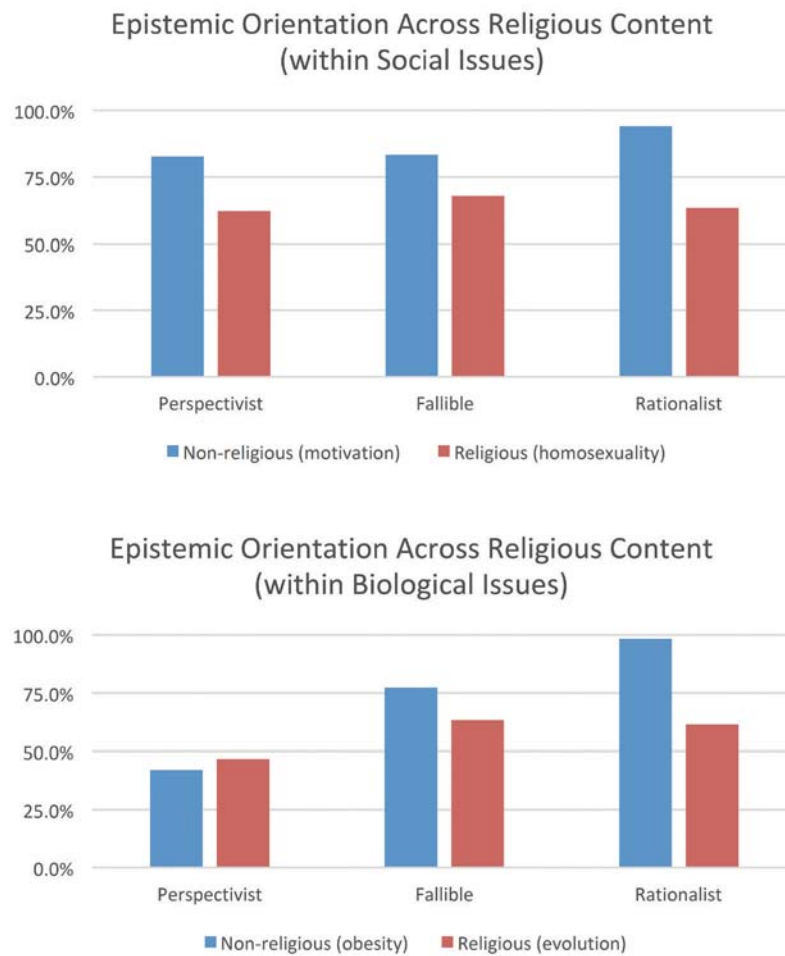
FIGURE 11.1   Epistemic orientations about religiously-loaded and neutral issues

11.4.3   *Discussion and Conclusion*

The purpose of this study was to understand how epistemic cognition about scientific issues vary across judgment domains and religious content. This was done by asking religious, highly educated young adults to report their epistemic orientations about four issues: whether motivation is more important than skill in determining work performance; whether homosexuality is a psychological disorder; whether sugar is the primary cause of obesity; and whether humans are the product of evolution.

TABLE 11.4   McNemar chi-square tests comparing religiously-loaded and neutral issues

Issues compared	Ontology		Fallibility		Decidability	
	% difference	Chi square	% difference	Chi square	% difference	Chi square
Motivation vs. Homosexuality	20.50%	33.30 (p < .0001)	15.46%	21.14 (p < .0001)	30.60%	83.03 (p < .0001)
Obesity vs. Evolution	4.73%	1.41 (p = .24)	13.88%	14.78 (p = .0001)	36.91%	107.65 (p < .0001)

With regards to variations across domains, the findings show that people are more realist, infallibilist, and rationalist with regards to biological issues than social ones. In other words, people are more likely to believe that there are objective truths which can be rationally justified when thinking about issues such as the cause of obesity and human evolution, than issues such as work motivation and sexual orientation. They are also more certain about the correctness of their personal views regarding biological than social issues. This pattern is consistent with prior studies which show that shifts from an objectivist to a subjectivist epistemology occur earlier with regards to "institutional facts" about the social world, than for "brute facts" about the natural world (Hallett et al., 2002; Kuhn et al., 2000; Kuhn & Weinstock, 2002). The current study lends further empirical support for this developmental pattern using topics which have not yet been utilized for this purpose.

In addition to reinforcing previous theories, the current study also produced new insights about how epistemic cognition on scientific issues varies across religious content. The findings indicate that religious content influenced epistemic cognition in systematic ways. For scientific issues which are "religiously-loaded" (homosexuality and evolution), people are less likely to acknowledge the possibility of multiple truths, more likely to be convinced that their views are correct, and less likely to believe that there are rational ways of evaluating competing claims. This pattern is partly consistent with a prior study of Israeli students, which found that students were less likely to be perspectivists and more likely to be non-rationalists about whether God exists, than about whether children should be punished for misbehavior (Gottlieb & Mandel Leadership Institute, 2007).

Interestingly, however, the findings of the current study differ from Gottlieb's concerning the fallibility dimension. Unlike the students in Gottlieb's study,

participants of this study were *less* fallibilist (i.e., less likely to see the possibility of being mistaken) about religiously-loaded scientific issues than neutral ones. This contrast may be due to some yet to be identified socio-cultural differences. For instance, compared to Indonesian students, Israeli students may be more exposed to radically different ideas about religious topics (including the existence of God), such that they are more at ease in acknowledging the fallibility of their beliefs. For the Indonesian context, secular views about homosexuality and the origin of humans have yet to become part of mainstream discourse. As such, Indonesians have fewer discursive resources to draw on when thinking about those issues. Further research needs to be done to examine whether these conjectures have any merit.

These findings are relevant to theoretical issues about the nature and development of epistemic cognition. According to one view, highly educated young adults (such as those who participated in this study) should already have moved away from an objectivist epistemology towards a subjectivist one. Some should even have shifted from a subjectivist epistemology to an evaluativist one, which is considered to be the most advanced stage of development in many models (Greene, Azevedo, & Torney-Purta, 2008; Barbara K. Hofer & Pintrich, 1997; Kuhn & Weinstock, 2002). In the framework of this study, an evaluativist epistemology would be characterized by the view that there can be multiple truths (perspectivism), that one's knowledge could be wrong (fallibilism), and that there are rational ways of determining the validity of knowledge claims (rationalism). This was indeed the general trend found in this study (see Table 11.2). However, this study also concurs with the suggestions that epistemic development does not occur "wholesale". Instead, epistemic development seems to occur in a more contextual and fragmented fashion (Hammer & Elby, 2002). As previous studies have shown, an aspect of context which is important for epistemic development is the judgment domain (Hallett et al., 2002; Barbara K. Hofer, 2000; Kuhn & Park, 2005). This study further shows that even within the same domain, religious content acts as a contextual cue which influences epistemic cognition.

One question which arises from these findings is *why* people become less perspectivist, fallibilist, and rationalist when thinking about religiously-loaded issues. One possibility is that scientific knowledge on such issues poses a threat to religious individuals' worldview and identity. For religious individuals in a religious society, adopting the epistemic orientations observed in this study may serve to affirm and protect valued parts of their worldview and identity. That is, believing that homosexuality is a disorder, or that God created humans in our modern form, affirms their worldview. This worldview is further protected by believing that there are no rational ways to decide between religious

faith and scientific knowledge (hence, pre-empting the possibility of finding evidence which undermines those worldviews). If true, this means that when thinking of religiously-loaded scientific issues, epistemic cognition functions to serve motivated reasoning whose goal is primarily non-epistemic (pursuing not truth, but self-related goals, see (Sinatra, Kienhues, & Hofer, 2014)). Future research could explore this possibility qualitatively using in-depth interviews or quantitatively using models which explicitly include religiosity and goals of reasoning.

Another question this study raises is about what should count as sophisticated epistemic cognition (i.e., the end points of epistemic development). Normatively speaking, should epistemic development always move away from objectivism towards subjectivism, and ultimately to evaluativism? Alternatively, considering that epistemic cognition seems to be embedded within socio-cultural communities, should the end points of epistemic development be expected to vary across communities (Gottlieb & Mandel Leadership Institute, 2007)? The answer to this question may also be contextual. If one's family or community upholds the view that there are absolute truths about theological matters, perhaps it would be more socially adaptive for an individual also to adopt an objectivist epistemology about those matters. However, the same epistemology may be less adaptive in academic contexts, which expect individual to develop conceptual understanding about scientific concepts that may go against religious doctrine.

Implications. If students believed only on a single truth which is justified non-rationally and cannot be wrong, then it would not be surprising that they find it difficult to develop a deep understanding about scientific concepts which go against their personal beliefs. This challenge has been well documented in the case of learning about evolution (Blancke et al., 2012; Lawson & Worsnop, 1992; Moore et al., 2011). By way of analogy, similar challenges may impede learning about sexual orientation for students of psychology and psychiatry. Hence, direct competition between science and religion may not be the most productive way forward. That is, presenting scientific knowledge as the ultimate truth to replace religious beliefs about matters such as human evolution and homosexuality may lead to the rejection of science altogether. As prior studies have shown, many teachers in religious societies tend to undermine or de-legitimize scientific knowledge which are perceived to conflict with religious faith (Croché, 2015; El-Hani & Sepulveda, 2010; Mansour, 2010).

How, then, should educators address this challenge? If part of the difficulty is indeed underpinned by epistemic cognition, then addressing it would need to involve stimulating epistemic growth. For example, it may be important

for teachers to help students to see multiple truths (become less realist and more fallibilist) on various matters. It may also be important to develop students' intellectual humility and acknowledge that one's belief could be wrong, even when it is founded upon religious texts. Students may perhaps need to develop the belief that there are legitimate methods to evaluate competing claims, even if those methods cannot provide access to an objective reality or absolute truths. To overcome the challenges associated with negotiating tensions between science and religion, this kind of epistemic development likely needs to occur with regards to religion as well as science. In other words, in the context of religious societies, reform is needed simultaneously in the teaching of religion and science.

Conclusions. Overall, it can be concluded that not only is epistemic cognition about scientific issues sensitive to variations in judgment domains, but also to variations in religious content. On matters where religious claims conflict with scientific knowledge, people tend to adopt a more objectivist epistemology typified by realist, infallibilist, and non-rationalist orientations. While this pattern of epistemic cognition may be socially or culturally adaptive in the context of religious communities, it may represent a significant barrier to the learning and teaching in some areas of science.

Limitations and future research. In considering the findings and conclusions of this study, readers should be aware of several limitations. Methodologically, this study measured epistemic cognition using a nominal scale, thus limiting the analysis which could be performed. The model used in this study (which included three dimensions of epistemic orientations: ontology, fallibility, and decidability) proved to be fruitful to capture meaningful variations in people's responses. Hence, future studies should attempt to assess the three epistemic dimensions using either more in-depth qualitative methods or using quantitative instruments which could yield data at the interval level of measurement. Another methodological limitation was the order of presentation of the four issues. In this study, all participants received the issues in the same order (motivation, homosexuality, evolution, and then obesity). Although remote, the order of presentation may have biased responses in systematic ways. Future studies should examine whether the findings replicate when the order of presentation is controlled/counter-balanced. Last, this study was designed to serve exploratory purposes. The study succeeded in finding meaningful patterns of epistemic cognition, but could not provide insights as to *why* such patterns exist. Qualitative studies using interviews and/or observations of cognition-in-action would be useful for further understanding of why certain epistemic beliefs are adopted with regards to religiously-loaded scientific issues.

Acknowledgement

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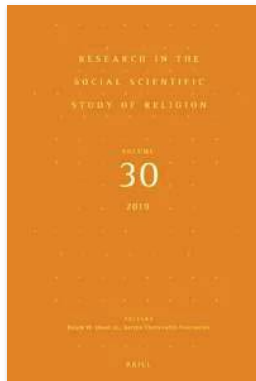
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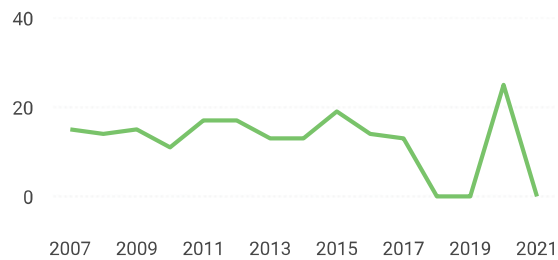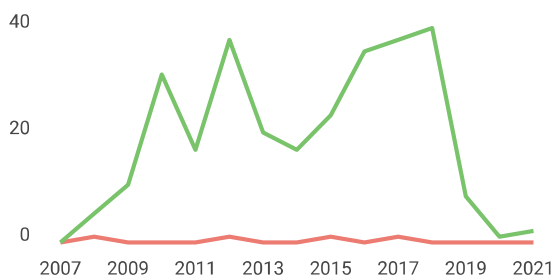
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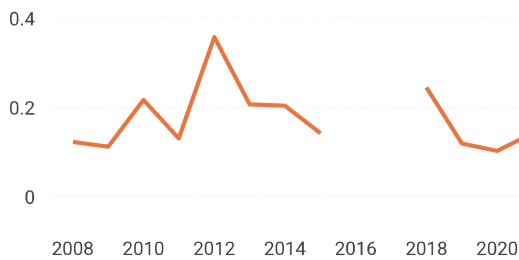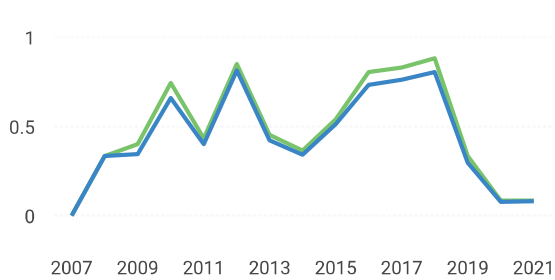

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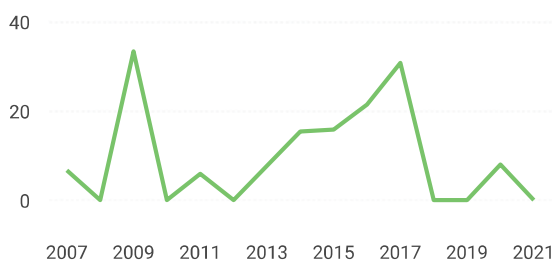
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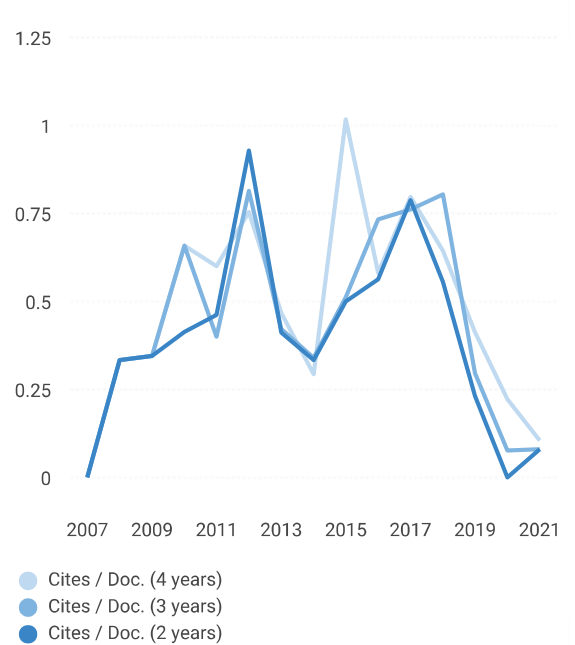
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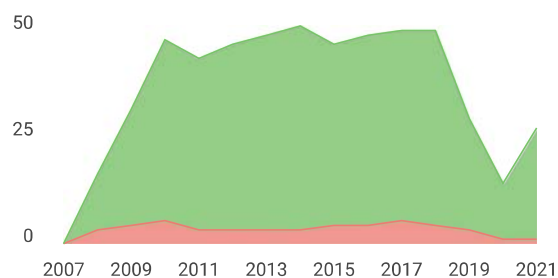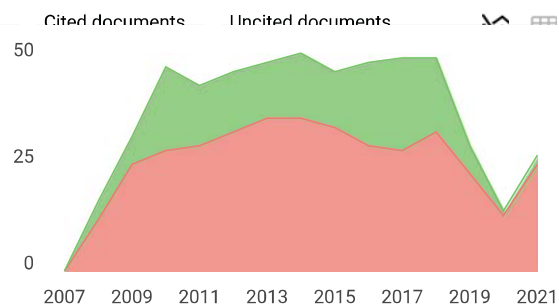
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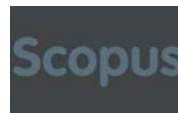
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