# On the Relationship Between Science and Religion

## Theory, Measurement, and Early Evidence for the Psychological Mechanism

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**Rizqy Amelia Zein**

aus **Mataram**

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**Erstgutachter:** Prof. Dr. Mario Gollwitzer

**Zweigutachterin:** Prof. Dr. Friederike Funk

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# 1 Abstract

While some people may prefer to think of a conflict between science and religion, others may believe that it is not necessarily the case. Drawing on Ian G. Barbour's taxonomy of the science-religion relationship, this dissertation offers an examination through three pillars: theoretical integration, measurement practice, and mechanistic testing. The first pillar integrates theoretical work and empirical evidence from various scientific disciplines to illustrate the psychological process of relating these domains via a flowchart. This process can lead people to adopt one of five conceptualizations: Conflict, Compartment, Context-Switch, Complementary, or Consonance. The second pillar aims to develop a measure that captures these conceptualizations by assuming that the construct is unidimensional and bipolar, and that people respond to the scale items according to an unfolding response process. The third pillar experimentally tests how these mental models affect people's evaluation of the utility of scientific or religious explanations. The results show that perceptions of conflict and religiosity predict evaluations of religious, but not scientific, explanations. This asymmetry suggests that scientific explanations are primarily evaluated on their epistemic merits, while religious explanations are filtered through pre-existing beliefs. This dissertation, which consists of one theoretical paper and four empirical studies, offers novel insights into how people navigate competing belief systems and has some practical implications for science communication.

[214 words]

*Keywords*: perceptions of the science-religion relationship, explanatory coexistence, unfolding response process, goal system theory, motivated reasoning

## 2 Deutsche Zusammenfassung

Manche Menschen bevorzugen es, sich einen Konflikt zwischen Wissenschaft und Religion vorzustellen, während andere diese Sichtweise nicht teilen. Ausgehend von Ian G. Barbours Taxonomie der Wissenschafts-Religions-Beziehung (1998, 2002) bietet diese Dissertation eine umfassende Untersuchung, die sich auf drei Säulen stützt: theoretische Integration, Messpraxis und Untersuchung der Mechanismen.

Die erste Säule integriert theoretische und empirische Erkenntnisse aus verschiedenen wissenschaftlichen Disziplinen und veranschaulicht in einem Flussdiagramm den psychologischen Prozess, durch den Menschen diese Bereiche zueinander in Beziehung setzen. Dieser Prozess kann zu fünf möglichen Konzeptualisierungen führen: Konflikt (die Sichtweise, dass Wissenschaft und Religion grundsätzlich unvereinbar sind), Domänentrennung (die Sichtweise, dass Wissenschaft und Religion unterschiedliche, voneinander getrennte Domänen darstellen), Kontextwechsel (die Sichtweise, dass man je nach Situation zwischen wissenschaftlichen und religiösen Erklärungen wechseln kann), Komplementarität (die Sichtweise, dass Wissenschaft und Religion unterschiedliche, sich ergänzende Aspekte desselben Phänomens erklären) und Konsonanz (die Sichtweise, dass Wissenschaft und Religion vollständig vereinbar sind und sich gegenseitig bereichern).

Die zweite Säule zielt darauf ab, ein Messinstrument zu entwickeln, das diese Konzeptualisierungen erfasst, wobei davon ausgegangen wird, dass es sich um ein eindimensionales, bipolares Konstrukt handelt und dass Personen auf die Skalenpunkte entsprechend eines Entfaltungsprozesses reagieren (Carter et al., 2010; Roberts et al., 1998). Es wurden Daten von deutschen (N=2.920) und US-amerikanischen (N=1.197) Teilnehmenden analysiert, wobei zwei konkurrierende Messmodelle verglichen wurden: ein Dominanzmodell (generalisiertes Partial-Credit-Modell) und ein Entfaltungsmodell (generalisiertes gestuftes Entfaltungsmodell). Die Ergebnisse zeigten, dass das Entfaltungsmodell die Daten besser erklärte als das Dominanzmodell, was die Annahme unterstützt, dass diese mentalen Modelle qualitativ unterschiedlich sind, aber auf einem eindimensionalen Kontinuum von Konflikt bis Kompatibilität angeordnet werden können. Die Analyse der Itemparameter bestätigte die Anordnung dieser Modelle mit Konflikt an einem Ende, gefolgt von Domänentrennung, Kontextwechsel, Komplementarität und schließlich Konsonanz am anderen Ende.

Personen, die eher einen Konflikt zwischen Wissenschaft und Religion wahrnehmen, sind mit geringerer Wahrscheinlichkeit religiös, identifizieren sich weniger mit einer Religion oder sind seltener religiös erzogen worden. Sie sind eher Atheisten, identifizieren sich stärker mit der Wissenschaft und haben ein höheres Maß an Glauben an die Wissenschaft. Bemerkenswert ist, dass die Analyse der differentiellen Itemfunktion (DIF) signifikante kulturelle Unterschiede zeigt, wobei US-amerikanische Teilnehmende mit ähnlichen latenten Ausprägungen Wissenschaft und Religion eher als im Konflikt stehend wahrnehmen als deutsche Teilnehmende.

Die dritte Säule untersucht experimentell, wie diese mentalen Modelle die Informationsbewertung beeinflussen. In dieser Studie wurden konkurrierende psychologische Annahmen getestet, wie Menschen wissenschaftliche und religiöse Erklärungen bewerten. Dabei wurden zwei Hypothesen geprüft: die „Instrumentalitäts" – oder „Verdünnungseffekt"-Hypothese (ob der Zugang zu mehreren Erklärungen den wahrgenommenen Nutzen jeder einzelnen Erklärung verringert, siehe Jackson et al., 2024) und die Hypothese des „motivierten Denkens" (ob Menschen Erklärungen auf der Grundlage ihrer bereits bestehenden Überzeugungen und nicht aufgrund der Anzahl der Erklärungen bewerten, siehe Kunda, 1990). Den 719 deutschen Teilnehmenden wurden wissenschaftliche und religiöse Erklärungen für drei Ereignisse (Überschwemmung, Krieg und Klimakrise) präsentiert, wobei die Anzahl der Erklärungen (eine, zwei oder vier) variiert wurde, während gleichzeitig ihre Religiosität und ihre Wahrnehmung der Beziehung zwischen Wissenschaft und Religion erfasst wurden.

Entgegen der Verdünnungseffekt-Hypothese zeigten die Ergebnisse, dass die Präsentation mehrerer Erklärungen die wahrgenommene Nützlichkeit einzelner Erklärungen nicht verringerte. Stattdessen unterstützten die Ergebnisse die Hypothese des motivierten Denkens: Religiosität und die Wahrnehmung eines Konflikts zwischen Wissenschaft und Religion sagten stark voraus, wie die Teilnehmenden religiöse Erklärungen bewerteten, hatten aber keinen Einfluss auf die Bewertung wissenschaftlicher Erklärungen.

Diese Ergebnisse deuten auf eine Asymmetrie in der Verarbeitung wissenschaftlicher und religiöser Erklärungen hin: Wissenschaftliche Erklärungen werden nach ihrem Inhalt bewertet, während religiöse Erklärungen stärker von Identität und bereits bestehenden subjektiven Präferenzen abhängen. Diese Ergebnisse werden mit der Theorie von Van Leeuwen (2014) interpretiert, wonach faktische (wissenschaftliche) Überzeugungen und religiöse Überzeugungen unterschiedliche Eigenschaften aufweisen und auf unterschiedliche Weise erworben, bewertet und angewendet werden.

Zusammenfassend trägt diese Dissertation zum Verständnis bei, wie Menschen Wissenschaft und Religion in Beziehung setzen, indem sie einen integrativen theoretischen Rahmen, ein validiertes Messinstrument und empirische Erkenntnisse über die zugrunde liegenden psychologischen Mechanismen liefert. Die Dissertation erweitert das theoretische Verständnis, indem sie frühere Evidenz integrativ zusammenträgt und aufzeigt, dass Menschen wissenschaftliche und religiöse Erklärungen auf einem messbaren Kontinuum von Konflikt bis Kompatibilität verorten. In forschungspraktischer Hinsicht trägt die Dissertation dabei auch ein validiertes Messinstrument für weitere Forschung bei. Zudem weist sie auf eine asymmetrische Informationsverarbeitung hin, wobei religiöse Erklärungen stärker von subjektiven Faktoren beeinflusst werden als wissenschaftliche. Diese Ergebnisse haben wichtige Implikationen für die Wissenschaftskommunikation – beispielsweise könnten Wissenschaftskommunikatoren mehr Vertrauen aufbauen, indem sie anerkennen, dass Menschen die Beziehung zwischen Wissenschaft und Religion auf unterschiedliche Weise konzeptualisieren.

## 3 Statement of Authorship

This dissertation includes an introduction, two manuscripts that have been published in a journal and an unpublished manuscript, as well as final discussion. I thereby declare that I have primarily conceived and written all parts of this dissertation. I independently proposed the idea, developed and planned research design – including writing pre-registrations, collected, analyzed, visualized, and interpreted the data of all empirical studies reported in this dissertation.

To improve the presentation of the introduction and final discussion in this dissertation (i.e., correcting grammatical, typological, spelling, and punctuation errors), I used a neural machine translation service (DeepL) and a large language model chatbot (Claude, model Sonnet 4). The German summary (*Deutsche Zusammenfassung*) presented in this dissertation was originally written in English, translated to German using DeepL, and was edited for language precision and clarity by Katharina Dürmeier and Marlene Altenmüller. Statements about the use of AI-assisted tools for individual manuscripts can be found in the respective manuscripts.

I discussed the outline and received extensive feedback for Manuscript 1 from my co-authors, Mario Gollwitzer and Marlene Altenmüller. I received feedback for Manuscript 2 from my co-authors, Mario Gollwitzer and Moritz Heene. And finally, for Manuscript 3, I received feedback from my co-author Mario Gollwitzer.

**Manuscript 1**

Zein, R. A., Altenmüller, M. S., & Gollwitzer, M. (2024). Longtime nemeses or cordial allies? How individuals mentally relate science and religion. *Psychological Review*, *131*(6), 1459-1481. https://doi.org/10.1037/rev0000492

**Manuscript 2**

Zein, R. A., Heene, M., & Gollwitzer, M. (2025). Stage 2 Registered Report: Measuring How Individuals Relate Science to Religion. *The International Journal for the Psychology of Religion* [under review].

**Manuscript 3**

Zein, R. A. & Gollwitzer, M. (2025). More Than Dilution: Religiosity and Conflict Perceptions Predict Perceived Utility of Religious, but not Scientific Explanations.

## 4 Introduction

One fine evening in a hotel hosting the 1927 Solvay Conference, Werner Heisenberg, Paul Dirac, and Wolfgang Pauli were discussing how quantum physics challenged society's conception of God and religion, rather than quantum theory itself, which was the actual topic of the conference. What began as a discussion of how Max Planck, Albert Einstein, and Niels Bohr viewed God in the light of quantum physics turned into a disagreement between Dirac and Heisenberg. Dirac believed that religion offered "a jumble of false assertions with no basis in reality" (Heisenberg, 1971, p. 87) and that the ethical principles taught by religion were completely irrelevant because they could be derived from pure reason alone. Heisenberg and Pauli disagreed, believing that religion fills a void in *conditio humana* that science cannot. To them, God, religion, and mathematical laws were similar in that they provided useful abstractions; therefore, religious parables and images should be treated differently from science. Religion is described as being more like poetry and less like factual beliefs (Heisenberg, 1971).

This historical exchange highlights the enduring friction between science and religion that continues to shape public discourse today – a tension forming the central focus of this dissertation. From debates over evolution in classrooms to discussions about climate change and pandemics in religious communities, the perceived relationship between science and religion influences how people understand and respond to critical societal challenges. The notion of separation or conflict between natural (scientific) and supernatural (religious) explanations seems natural to us in the modern era. Yet, this notion only began to take shape in the late Middle Ages ($12^{th}$ –$13^{th}$ century) when theologians distinguished between God's ordinary workings through natural laws and extraordinary interventions through miracles (Harrison, 2025).

Nevertheless, the same question continues to interest scholars of various disciplines to this day: Are science and religion fundamentally at odds? The short answer to this question is both yes and no.

Extant evidence shows that the more religious people are, the less they trust science (Chan, 2018; McPhetres & Zuckerman, 2018; Noy & O'Brien, 2016; Simpson & Rios, 2019). The underlying psychological mechanisms responsible for processing scientific and religious explanations also are found to be in conflict. For example, several large cross-cultural studies have robustly demonstrated that reflective and critical thinking, cognitive processes central to scientific reasoning, are associated with greater disbelief in God, with small to moderate effect sizes observed across these large cross-cultural studies (Byrd et al., 2025; Gervais et al., 2018; Ghasemi et al., 2025; Stagnaro & Pennycook, 2025).

Nevertheless, critics of the conflict narrative point out that the negative correlation between religion-related and science-related constructs varies widely across cultures, with some studies showing inverse associations (Cologna et al., 2025; Payir et al., 2021; Price & Johnson, 2024). In large cross-cultural studies supporting the conflict narrative discussed above, there is substantial heterogeneity in the magnitude and the direction of the correlation between analytical thinking and belief in God across countries (Byrd et al., 2025; Gervais et al., 2018; Ghasemi et al., 2025; Stagnaro & Pennycook, 2025). Furthermore, plenty evidence from cross-cultural and developmental psychology shows the existence of 'explanatory coexistence,' which refers to individuals of different ages in different cultures simultaneously engaging with natural and supernatural explanations to explain a phenomenon (Busch et al., 2017; Legare et al., 2012; Watson-Jones et al., 2015). Explanatory coexistence is also found among scientifically oriented individuals (J. Evans et al., 2025; Haimila et al., 2024).

Both proponents and critics of the conflict narrative present compelling evidence to back up their claims. Taken together, however, this evidence reveals a paradox. In many Western Christian contexts, religious individuals tend to trust science, scientists, and scientific institutions less than nonreligious individuals do, which suggests that science and religion are fundamentally at odds. However, cross-cultural evidence shows that religious individuals can and do engage meaningfully with scientific explanations. In some cultural and religious contexts, religious people even show high levels of appreciation for science. This raises a question: How can we reconcile the fact that religious people trust science less than nonreligious people if they can be receptive to scientific evidence?

In this dissertation, I seek to bridge these dissonant narratives in the literature from two viewpoints. *First*, I argue that the perceptions of the relationship between science and religion should be viewed as a matter of personal preference. That is, some individuals may picture an irreconcilable conflict between the two, while others may not. Specifically, I formulate my arguments for the individual difference account by drawing on Ian G. Barbour's taxonomy of the science-religion relationship (1998).

Building on this foundation of subjective conceptualizations, my *second* viewpoint examines the psychological mechanisms explaining why people conceptualize the relationship differently and how these conceptualizations help people evaluate specific explanations from both domains. The explanatory coexistence literature already provides a mechanism for the former, and two plausible explanations are available for the latter.

*First*, the trust that religious people have in science while maintaining their religious beliefs may be a byproduct of a psychological process that occurs when individuals are faced with multiple means (i.e., science and religion) to achieve an epistemic goal. In this sense, religious people generally want to keep the best of both worlds, resulting in a more favorable view of religion and a less favorable view of science than nonreligious people have. To examine this account, I draw on the goal system theory (Kruglanski et al., 2002). Yet, *second*, I also consider a counterpoint explanation: subjective preferences, which I previously proposed, may instead act here as filters that shape how people evaluate information (Brossard et al., 2009), which paves the way for a motivated reasoning account (Kunda, 1990). When religious people claim to value science and religion equally or when nonreligious people claim to value only science, these claims may simply reflect their preexisting beliefs about conflict or non-conflict. In this dissertation I examine which mechanism – goal systems theory, motivated reasoning, or both – better explains these patterns and under what conditions.

To systematically address these goals, this dissertation presents the three pillars. The *first* pillar integrates theoretical work and empirical evidence to address the 'subjective preference' account and illustrates the psychological process underlying people's conceptualizations of the two domains. The *second* pillar empirically tests and quantifies these subjective conceptualizations by developing a measurement model that captures the various ways people relate science to religion. The *third* pillar is an empirical investigation of how these subjective conceptualizations predict individuals' evaluations of specific scientific and religious explanations. The project directly tests whether goal system theory or motivated reasoning better explains this phenomenon. Yet, it is worthwhile to first emphasize why scientific inquiry into this topic is not only interesting in and of itself, but also practically relevant.

### 4.1 Why the Science-Religion Relationship Perceptions Matter

Some scholars argue that the perception of a science-religion conflict is a primarily Western phenomenon, deeply rooted in specific historical episodes (Elsdon-Baker, 2015; D. R. Johnson et al., 2015). Regardless of whether a substantive, inherent conflict exists, this perception nevertheless has real-world consequences.

Let us take a case in point. In early 2020, the Shincheonji Church of Jesus in Daegu, South Korea became the epicenter of the country's first major COVID-19 outbreak. A church member, later known as 'Patient 31,' attended multiple overcrowded services while symptomatic, ultimately leading to thousands of infections (Kim et al., 2021). Despite growing scientific evidence of SARS-CoV-2 transmission, the church continued to hold public prayers in close physical proximity, discouraging mask-wearing, and encouraging attendance despite illness. When public health officials attempted to intervene, church leaders initially refused to provide complete membership lists, which hindered contact tracing efforts during a critical window for containing the outbreak (Noh, 2021).

This case illustrates why understanding how people mentally navigate scientific and religious explanations is not just a scientific endeavor, but rather a matter with real-world consequences. When individuals experience tension between scientific guidance and religious practices, their decisions can affect individual and public health interests. The Shincheonji outbreak here demonstrates that perceptions of conflict can hinder compliance with public health measures, which can ultimately affect infection rates, strain health systems, and result in loss of life. Therefore, studying this issue could help us develop more effective science communication strategies, especially when it is targeted to highly religious audiences. Such research allows us to identify potential points of resistance and design targeted interventions that bridge, rather than exacerbate, these divides. The Shincheonji case demonstrates that, without such understanding, we risk losing not only meaningful and constructive public understanding of science (Catto et al., 2022), but also people's lives in times of crisis.

The Shincheonji case sketched here demonstrates the consequences of promoting conflict beliefs while favoring religion. Previous studies nevertheless have found that endorsing conflict beliefs by favoring science, which is characterized by a high level of trust in science without the corresponding scientific literacy, may paradoxically increase susceptibility to pseudoscientific claims, particularly the non-paranormal ones (Majima, 2015). For instance, O'Brien and colleagues (2021) found that individuals with high levels of trust in science are more likely to endorse and disseminate bogus claims with purported scientific references. Other studies have demonstrated similar results (cf. Rosman & Grösser, 2024): individuals with high levels of trust in science are predisposed to blindly trust science (Graso et al., 2022; Majima, 2015; O'Brien et al., 2021; Xiao et al., 2021), because it prevents individuals from critically evaluating information, which is crucial for decision-making in different contexts. These findings suggest that an exclusive reliance on either science or religion – particularly when coupled with the perception of an inherent conflict between the two, as well as a lack of scientific literacy – may have negative consequences.

Conversely, holding non-conflict beliefs may come with some benefits. One study shows that perceiving science and religion as compatible predicts greater well-being (Price & Johnson, 2024). The study, which included over 55,000 participants from 54 countries, found that perceived compatibility between religious or spiritual beliefs and pro-science beliefs was associated with higher levels of well-being. World regions (i.e., Asia, Middle East, and Eastern Europe) and faith groups (i.e., Hinduism, Islam, Buddhism, Folk/Indigenous beliefs) that have traditionally and historically been characterized by perceiving higher compatibility between science and religion showed stronger positive relationships between perceived compatibility and well-being (Price & Johnson, 2024). These findings suggest that holding non-conflict views may optimize the potential to benefit psychologically from both domains without experiencing the cognitive dissonance and stress associated with perceiving them as inherently conflicting (E. M. Evans, 2008). Taken together, an understanding of how people navigate scientific and religious explanations may have practical implications for improving the quality of science communication strategies, quality of life, and societal resilience, particularly during large-scale societal crises.

### 4.2 Public Perceptions of the Relationship Between Science and Religion

When considering how the relationship between science and religion is perceived by the public, the first step is to look at nationally representative and multinational surveys. Some of these surveys were designed to gauge the opinions of the general public, while others specifically targeted scientists working in universities and other research institutions (e.g., Ecklund et al., 2016; Scheitle & Corcoran, 2021; Stirrat & Cornwell, 2013).

Notably, studies of the relationship between science and religion can be systematically investigated in different ways. *First*, researchers can indirectly infer the relationship between science and religion by correlating science-related and religion-related constructs. However, large-scale surveys often take a more direct approach by asking participants to endorse statements about whether they believe that science and religion are in conflict, the results of which I discuss later in detail in Manuscripts 1 and 2.

Broadly speaking, large-scale surveys, such as the US General Social Survey (GSS), the Wellcome Global Monitor (WGM), the World Values Survey (WVS) and the Pew or Gallup surveys, have taken a direct but general approach, that is, they have formulated their questions by explicitly pitting science against religion (Brennan, 2024; Chan, 2018; Funk & Alper, 2015; Gingras & Talin, 2020; Kostyukov, 2019; Smith et al., 2025). As an example, let us consider an item used in the GSS to measure public perceptions of the relationship between science and religion: "*We depend too much on science and not enough on faith*", to which participants can respond by opting for different options, ranging from 1/strongly agree to 4/strongly disagree (Baker, 2012; Hill et al., 2019). Here, participants who choose "strongly agree" may endorse a conflict view just as much as those who choose "strongly disagree." Those who choose "strongly agree" are most likely to favor religion while those who choose the opposite side may strongly favor science. In this context, researchers implicitly assume that participants agree with the conflict view and then force them to choose their exclusive preference for science or religion, making it difficult to interpret the results.

*Second*, some of these studies have captured broad, general perceptions of the relationship between science and religion (Funk, 2015; Kostyukov, 2019; Smith et al., 2025), while others have focused on domain- or topic-specific foci (e.g., evolutionary biology, abortion, the origins of life, etc. see Brennan, 2024; Masci, 2009). It is worth noting that people's perceptions of a conflict on very specific, often highly controversial issues (Drummond & Fischhoff, 2019; Leicht et al., 2021) do not always translate into general perceptions of a conflict between the two domains (Elsdon-Baker, 2015; Hill et al., 2019; Leicht et al., 2021). In this interpretation, people tend to limit their disagreement with established scientific evidence to specific issues that are perceived to directly contradict their religious beliefs.

It is not surprising, then, that these surveys paint a rather inconclusive picture. Some surveys have found that most people believe that a perpetual conflict exists (Brennan, 2024; Chan, 2018;

Gingras & Talin, 2020), others have concluded that most people believe that no such conflict exists (Baker, 2012; DiMaggio et al., 2018), while some others have claimed that the public is divided between those who believe in a conflict and those who do not (Funk & Alper, 2015; Smith et al., 2025). When researchers offered participants an alternative interpretation of the relationship (i.e., "*Science is about facts and religion is about faith. The two do not overlap*"), the constellation of participants' responses also changed significantly (Hill, 2014; Hill et al., 2019). Those who endorsed statements representing conflict beliefs were also more likely to agree with the notion of science and religion as separate domains (Hill et al., 2019). Taken together, the findings from polls and large surveys here may suggest that the results tell us more about the design of the survey than about how people construe the relationship between the two domains.

I argue, however, that the conflicting results of these surveys point to something deeper than methodological differences. Rather, they suggest that how people understand the relationship between science and religion cannot be adequately captured by the binary 'conflict or compatible' options. This connects to Ian G. Barbour's (1990) proposal – that people's conceptualizations of science and religion exist in qualitatively distinct patterns or 'types,' rather than in the binary category of conflict vs. compatibility. When survey items force respondents to make oversimplified choices, researchers can easily miss these subtle distinctions, which likely explains why different surveys reach such contradictory conclusions when the questions are asked differently. I propose that, to accurately gauge people's perceptions of the relationship between science and religion, it is crucial to account for the nuances described by Barbour (1990) in his taxonomy. In the following section, and in greater detail in Manuscripts 1 and 2, I explore these 'mental models' and how they can be systematically operationalized for empirical research.

### 4.3 Types of Mental Models of Science-Religion Relationship

In his 1966 book "*Issues in Science and Religion*," Barbour first explores the relationship between science and religion by suggesting that they can be viewed as: a contrast (i.e., science and religion are different), a parallel (i.e., science and religion are similar), and a derivation of theology from science (i.e., religion is reinterpreted in light of scientific evidence). Later on, he refines this distinction by introducing a taxonomy of science and religion consisting of *Conflict*, *Independence* (i.e., science and religion as separate domains or non-overlapping *magisteria*, see Gould, 1999), *Dialogue* (i.e., science and religion are distinct but complementary domains), and *Integration* (i.e., science and religion are combined into a unified worldview, see Barbour, 1998, 2000).

In his earlier work, it is not immediately clear whether Barbour is addressing ‘substantive/real’ or ‘subjective/perceptual’ compatibility, but it becomes clearer, in his responses (Barbour, 2002) to Cantor and Kenny (2001). They criticize Barbour’s taxonomy as short-sighted and oversimplified because it largely ignores the historical context of exchanges between the two domains. They are also concerned that Barbour’s taxonomy inadvertently promotes an essentialist view of the interaction between the two domains (Cantor & Kenny, 2001). Barbour (2002) defends his taxonomy by suggesting that it should be seen as a pedagogical tool, not as an ontological claim about the inherent/substantive relationship between science and religion, which of course would ring hollow without the historical context. He also emphasizes that the taxonomy simply illustrates the various ways people interpret relationships, regardless of whether substantive conflicts actually exist. He also affirms that the categories he proposes are not rigid, but rather have fuzzy boundaries. For example, the boundaries separating Dialogue and Integration may be somewhat arbitrary, so people may not fit neatly into one category (Barbour, 1998, 2002). Consequently, the categories in the taxonomy are not fixed characteristics, but can vary depending on the issue and can change over time (Barbour, 2002).

#### *4.3.1 Operationalizing the Types of Mental Models*

Barbour’s description of the taxonomy has been widely debated, discussed and refined (Barbour, 2002; Cantor & Kenny, 2001; Damper, 2022), but its systematic operationalization for empirical studies remains a challenge. To empirically scrutinize Barbour’s taxonomy, researchers have turned to qualitative methods, which are well suited to capturing the nuanced ways in which people conceptualize science-religion relationships. Indeed, numerous qualitative studies, primarily in the learning sciences (Borgerding et al., 2017; Dodick et al., 2010; Fysh & Lucas, 1998; Hokayem & BouJaoude, 2008; Konnemann et al., 2016; Longest & Uecker, 2021; Mansour, 2011, 2015; Pearce et al., 2021; Scheitle, 2011; Shipman et al., 2002; Stones et al., 2020; K. S. Taber et al., 2011; Taşkın, 2014; Vaidyanathan et al., 2016; Yasri & Mancy, 2012, 2016), have successfully demonstrated that lay people interpret the relationship between the two domains in patterns similar to those described by Barbour (1998).

These qualitative investigations have generated rich, detailed, and nuanced descriptions of the categories, which I refer to as 'mental models' later in this dissertation. Importantly, three studies have also extended the taxonomy by identifying a new taxon previously unknown in Barbour's framework, namely the 'Context-Switch,' which refers to the pattern in which individuals alternate between relying on science and religion in different situations, despite an underlying belief that the two domains are in fundamental conflict (Shipman et al., 2002; K. S. Taber et al., 2011; Yasri & Mancy, 2012).

While these qualitative studies have documented evidence for the existence and basic features of Barbour's taxonomy in various contexts, conducting a quantitative test may still be necessary to advance the theory. Quantitative tests offer distinct advantages over qualitative methods: they allow for testing relationships with larger, more representative samples; provide standardized metrics that can be compared across studies; and most importantly, enable researchers to test the core tenet of Barbour's taxonomy and potentially to expand its predictive capacity by examining the relationships between these mental models in the taxonomy and other related psychological constructs that they are hypothesized to predict (i.e., construct validity, see Cronbach & Meehl, 1955). Some of these related constructs are religiosity (DiMaggio et al., 2018) and belief in science (Farias et al., 2013).

Previous attempts to quantify Barbour's taxonomy have generally followed two main patterns. *First*, Marin and Lindeman (2021) asked participants to rate their agreement with statements representing Barbour's categories and then used cluster analysis to group participants' responses. This analysis, however, yielded different grouping patterns than Barbour's original taxonomy, despite using items derived directly from his descriptions. *Second*, other research has employed direct self-identification methods, in which participants are presented with descriptions of mental models and select the one that best represents their view of the relationship between science and religion (K. A. Johnson et al., 2019, 2023; Reid, 2024; Woolley et al., 2023; Yasri et al., 2013).

These studies have attempted to build upon previous qualitative research by systematically grouping individuals' perceptions of the relationship between science and religion and have provided valuable preliminary evidence for the core claims of Barbour's taxonomy. In my view, however, these studies have done more to expose fundamental problems with the assumptions underlying Barbour's taxonomy. In practice, it is difficult to reconcile the richness of qualitative descriptions of these mental models with the need for systematic, quantitative measurement.

In his writings, Barbour (1998, 2002) has made it clear that he was never comfortable with the essentialist idea of grouping people based on their mental models. This contention generally aligns with common objections to taxonomic approaches in modern psychology, since many psychological constructs (e.g., personality and attitudes) are normally distributed in populations. This suggests that these constructs have dimensional rather than discrete, categorical structures (Loevinger, 1957). In this sense, prior studies quantifying Barbour's taxonomy may inadvertently assign individuals to mental models to which they do not truly belong (i.e., false positives) or fail to assign individuals to the correct model (i.e., false negatives). The debate over the *dimensional* vs. *typological* structure of a construct mirrors similar debates in other areas of psychology, such as personality disorders (Widiger & Samuel, 2005) and cognitive styles (Kozhevnikov, 2007).

This does not mean, however, that psychological constructs can only exist as continua. Whether a construct is a dimension or a typology is itself an empirical question worthy of an investigation (Meehl, 1992). In doing so, Meehl (1992) recommends using the 'coherent cut kinetics' approach, i.e., applying multiple statistical test procedures to the same dataset. If the construct is truly a typology, then multiple taxometric tests should produce estimates of statistical parameters that consistently show separation between groups. Meehl (1992) argues that clustering methods, such as those used by Marin and Lindeman (2021), are not suitable for investigating a taxonomy because clustering methods always produce groups regardless of whether a true taxonomy exists and lack effective stopping rules for determining the correct number of classes. By contrast, several variants of latent class taxometric methods can perform 'risky' tests, allowing researchers to scrutinize whether the hypothesized typological structure is real and not merely a statistical artifact (Meehl, 1992, 1995).

If Barbour's taxonomy does exist in people's minds, one might superficially conclude that the measurement and classification approaches described in the quantitative studies of the taxonomy are not a principled way to test Barbour's claims. But critically, is Barbour's taxonomy testable at all? It is puzzling to claim that people's conceptualization of the relationship comes in different types, while at the same time refraining from fitting or forcing people into a single category.

One might then expect that a dimensional approach, which treats these mental models as points along a continuum rather than as discrete categories, may offer a more methodologically sound and theoretically consistent solution. The mainstream dimensional approach, however, faces a critical challenge: it may fail to properly differentiate people holding beliefs in the middle of the continuum (i.e., Independence, Dialogue) from those at the extremes (i.e., Conflict, Integration). This can lead to a ceiling or floor effect when one measures this construct. I address this methodological issue with an alternative measurement approach in Manuscript 2.

So far, the literature has provided evidence that people hold different 'mental models' of the science-religion relationships. However, another question arises: Can these 'mental models' explain the way people evaluate and use actual explanations? Barbour's taxonomy here serves as a proto-theory (i.e., early-stage theoretical framework without explanatory principles, see Fried, 2020) by providing a conceptual framework that organizes perceptions of the science-religion relationship into distinct categories. However, it lacks fully specified mechanisms that explain why individuals adopt particular mental models or how these mental models can predict certain outcomes.

### 4.4 How Individuals Evaluate the Value of Scientific and Religious Explanations

A missing piece in Barbour's proto-theory is the lack of explanation of what specific psychological and behavioral outcomes would result from holding each view. We observe that people assign different values to available scientific and religious explanations when making sense of their personal or collective experiences. More specifically, when people encounter scientific and religious explanations for the same phenomenon (e.g., death, COVID-19 pandemic, etc.), how does their underlying mental model affect which explanation they find most convincing or useful? Some people clearly prefer scientific explanations, some others value religious explanations more, while others may find both equally useful (Jackson et al., 2024). A desirable feature of a theory is its ability to generate testable hypotheses about relationships with other variables (Eronen & Bringmann, 2021), but Barbour has nothing to say about such patterns.

To address this limitation, we need to examine specific psychological mechanisms that may explain people's differential perceptions of utility when evaluating explanations. Two theoretical frameworks in motivation research offer contrasting perspectives on this issue: *First*, the goal system theory treats motivation as fundamentally cognitive, explaining how people evaluate explanations as means to achieve their epistemic goals (Kruglanski et al., 2002). *Second*, research on motivated reasoning examines how prior beliefs, attitudes, and identities influence cognitive processing and potentially bias how people evaluate information (Kunda, 1990). Next, I begin by examining how goal systems theory conceptualizes scientific and religious explanations as means to achieve goals and then discuss why motivated reasoning theory is also relevant in this context.

### *4.4.1 Motivation as Cognition: The Goal System Theory*

Kruglanski and colleagues (2002) propose that motivational processes are fundamentally cognitive. They reject the traditional view that motivation and cognition are two distinct processes, with motivation being primarily emotional and thus belonging to a separate psychological system. Instead, they argue that motivation consists of a specific cognitive structure, and that by understanding motivation as a form of cognitive process, we can better explain how our goals and desires determine our thoughts, feelings, and behaviors (Kruglanski et al., 2002). Here, Kruglanski and colleagues (2002) define 'goals' as mental representations of desired 'ends' that are organized in a hierarchical structure, with subgoals and superordinate goals. Aydin, for example, is a student who wants to get a good grade in math. Therefore, he may also want to get into a good university as a superordinate goal and to understand calculus as a subgoal.

Most importantly, a goal is cognitively connected to its corresponding 'means' for achieving it, creating a network-like configuration between goals and means (Kruglanski et al., 2015). A goal can be connected to more than one means ("*all roads lead to Rome*"), and one means can serve more than one goal ("*hitting two flies with one swatter*"). The central claim of the goal system theory is that the goals-means configuration described here is critically crucial for driving motivation (Kruglanski et al., 2002, 2015).

According to the theory, there are several assumptions about how motivation works (Kruglanski et al., 2002, 2015): *first*, motivation is greater when the association between goals and means is stronger. For instance, if Aydin believes that studying is an effective means to understanding calculus, then he would likely be more motivated to study. If the association between means and goals becomes stronger over time, the properties of the goals can be transferred to the associated means, blurring the boundaries between them. As the association between 'studying math' and 'getting a good math grade' becomes stronger, Aydin may begin to experience studying itself as inherently rewarding, making him intrinsically motivated to study math.

*Second*, our cognitive system is inherently limited but goals and means compete against each other for mental resources. This, in turn, leads to a choice of which goal or means to prioritize, especially when resources are depleted. For example, if Aydin does not have much time to prepare for his upcoming calculus exam, he would probably prioritize 'getting a good math grade' over 'socializing with friends.' In this context, the activation of one goal can suppress another, providing a cognitive mechanism for maintaining commitment and focus on a particular goal.

*Third*, and the most relevant to this dissertation – the configuration pattern between goals and means can affect people's commitment to pursuing a goal and their evaluation of the utility of an associated means. If Aydin feels uneasy, for example, when he reads the news about a war breaking out in another part of the world, and then finds only one (religious) explanation for why the war is happening (e.g., "*the war is happening because of God's will*"), he would probably find this explanation extremely valuable in satisfying his need for explanation. But what if he encounters *alternative* explanations for the cause of war, such as a factual one, like "*war is about consolidating and expanding power*"? Most likely, he would change his assessment of the value of the religious explanation he encountered earlier.

This scenario illustrates what researchers call the 'dilution effect' – a phenomenon in which the availability of multiple means to achieve a goal reduces the perceived utility of any single means associated with that particular goal (Bélanger et al., 2015; Kruglanski et al., 2011). The goal system theory predicts that Aydin would now consider both explanations to be less valuable than when each was the only explanation available. In other words, Aydin's perceived utility of a religious explanation for the cause of the war is now *diluted* in light of an alternative scientific explanation, and vice versa.

Jackson and colleagues (2024) propose that the dilution effect explains why religious individuals reject any claims of conflict between science and their religious beliefs but still report lower levels of trust in science than nonreligious individuals. In four studies, the details of which I discuss in Manuscript 3, Jackson and colleagues (2024) suggest that nonreligious people would be strongly committed to scientific explanations, because it is the only means they deem appropriate to achieve an epistemic goal, whereas religious people would typically avoid extreme reliance on either scientific or religious explanations. In this sense, religious people would be more susceptible to the dilution effect because they would believe that scientific and religious explanations are substitutable and thus would value them equally but only moderately. As a result, religious people value religious explanations more but value scientific explanations less than nonreligious individuals (Jackson et al., 2024).

However, this interpretation assumes that the relationship between religiosity and the evaluation of scientific explanations is primarily driven by the cognitive configuration of goals and means. An alternative perspective comes from research on motivated reasoning, which suggests that prior beliefs, values, and social identities may play a more critical role in how people evaluate the utility of these explanations.

#### *4.4.2 Motivation in Cognition: Motivated Reasoning*

Whereas goal systems theory views motivation as a cognitive structure, research on motivated reasoning examines how motivation directly influences cognitive processes. Motivated reasoning refers to the tendency of people to process information in ways that confirm their prior beliefs, protect their identity, or lead to preferred conclusions (Bayes & Druckman, 2021; Kunda, 1990). Rather than evaluating information objectively based on its epistemic merits, people often engage in biased information processing to maintain consistency with their existing beliefs, social identity (Kahan, 2015), values, social status, social consensus (Bayes & Druckman, 2021), or personal preferences (Ditto & Lopez, 1992).

Motivated reasoning operates through several mechanisms. *First*, people tend to be more skeptical of evidence that challenges their prior beliefs than of evidence that supports them, applying different standards of evidence depending on whether the information is consistent with their preferences (Ditto & Lopez, 1992; C. S. Taber & Lodge, 2006). *Second*, people selectively seek out information that confirms their existing beliefs while avoiding contradictory information, a phenomenon known as confirmation bias (Nickerson, 1998). *Third*, even when exposed to balanced information, people tend to remember belief-consistent information better than belief-inconsistent information (Hennes et al., 2016).

In the context of the relationship between science and religion, motivated reasoning would predict that religious individuals evaluate scientific and religious explanations differently not because of a dilution effect, but because they are motivated to protect their religious beliefs and identity. For example, when religious people encounter a scientific explanation that contradicts a religious explanation for the same phenomenon, they may apply stricter standards to evaluate the scientific explanation while being more lenient toward the religious one (Lobato et al., 2020; McPhetres & Zuckerman, 2017). Similarly, non-religious individuals might be motivated to favor scientific explanations and dismiss religious ones in order to maintain consistency with their secular worldview. In this view, the differential evaluations of scientific and religious explanations by religious and non-religious individuals reflect motivated efforts to maintain belief consistency rather than a dilution effect.

Critically, what appears as a dilution effect among religious individuals may actually reflect an underlying 'non-conflict' mental model, as described in Barbour's taxonomy, in which they view science and religion as compatible domains that can coexist. Their willingness to consider both scientific and religious explanations may stem not from having multiple means to a single goal, but from their fundamental belief that these domains are not in conflict. Conversely, non-religious individuals' strong preference for scientific explanations and dismissal of religious ones may reflect an underlying 'conflict' mental model, in which they view science and religion as inherently incompatible and thus choose science exclusively. In this interpretation, differences in how people evaluate explanations are not simply determined by the number of available explanations, as predicted by the dilution effect, but are reflections of their underlying mental models.

It is worth noting that these two mechanisms outlined by the goal systems theory and motivated reasoning may not be mutually exclusive. Both can operate simultaneously, with different configurations of goals and means being influenced by identity, prior beliefs, values, etc. and vice versa. However, they offer different predictions about how people evaluate scientific and religious explanations that can be empirically tested to determine their relative explanatory power in this context.

### 4.5 The Present Research Program

While Barbour's (1998) taxonomy is exceptionally helpful for guiding interested scholars who study people's perceptions of the relationship, the psychological mechanism that precedes and follows after the taxonomy remains an open question. Barbour's taxonomy describes different ways people conceptualize the relationship between science and religion, but it does not sufficiently explain why individuals adopt particular mental models, nor does it predict how these models influence the way people acquire, evaluate, and use information in the real world. The theoretical and empirical gaps identified above converge on a fundamental challenge: How can we move Barbour's taxonomy from a purely descriptive proto-theory to a testable psychological theory? This dissertation addresses this challenge through *the three pillars*, with each targeting a specific gap: *theoretical integration*, *measurement practice*, and *mechanistic testing*.

Together, these three pillars form a unified research program: theoretical integration provides the conceptual framework, measurement practice transforms theory into testable constructs, and mechanistic testing reveals how mental models predict psychological outcomes. Each pillar addresses a specific gap in the literature, laying an essential foundation for future research and creating a cumulative contribution to our understanding of how people navigate the relationship between science and religion.

In the first project, I integrate theoretical work and empirical evidence supporting Barbour's taxonomy. The taxonomy has been influential and widely explored in many scientific disciplines, but the empirical evidence supporting the taxonomy is by and large fragmented. Manuscript 1 highlights why and under what circumstances people differentially perceive the relationship between the two domains, specifically their preferred 'mental model' in this sense. The project attempts to paint a picture of the underlying psychological mechanisms responsible for the formation of these mental models by illustrating the process with a simplified flowchart. Through this approach, I hope to mediate between theoretical and empirical work on this particular topic, making it fruitful for this current research program and other interested researchers to identify gaps and conduct research that advances our understanding.

The second project scrutinizes if it is possible to empirically test the theory. The goal of this project is to quantify qualitative distinctions of the mental models without losing nuance. To this end, the project specifies a measurement model derived from Barbour's claims, then develops an instrument that mirrors the theoretical descriptions, and tests it with appropriate statistical models. The measurement model outlined here is built upon three assumptions regarding *the* *nature of the construct*, *its structural validity*, and *the response process* (Franco et al., 2022; Tay & Jebb, 2018; Zumbo & Chan, 2014).

*The first assumption* is that the mental models exist as a *latent* psychological attribute that varies between individuals. People's perceptions of the two domains are defined as an underlying tendency to mentally organize and integrate scientific and religious explanations into specific patterns, consisting of five qualitatively distinct mental models. This latent construct represents a mental schema for processing potentially competing explanations and is expected to predict how people interpret, evaluate, and respond to situations in which both scientific and religious explanations are relevant.

For *structural validity*, it is assumed that this latent construct is best represented as a unidimensional bipolar construct along which five qualitatively different mental models (i.e., Conflict, Context-Switch, Compartment, Complementary, and Consonance) can be ordered along a single continuum. Specifically, this project is built on the premise that although these mental models qualitatively differ in type, they can be mathematically represented as regions along a single latent dimension of conflict-compatibility.

*The final measurement assumption* corresponds to *a cognitive process* that individuals typically engage in when responding to the scale items. Specifically, the measure here assumes an *unfolding response process* (Carter et al., 2010) comes into play in the following steps: participants (1) activate their existing mental model for relating science and religion, (2) compare it with the mental model reflected in each scale item, (3) assess the proximity or match between their preferred mental model and the one represents in each item, and (4) indicate stronger agreement when the item closely matches their preference and weaker agreement when the item deviates significantly from their preference in either direction. For this reason, the unfolding process produces nonmonotonic response patterns in which individuals with intermediate positions on the conflict-compatibility continuum (i.e., Context-Switch, Compartment, and Complementary) may disagree with items at both extremes (i.e., Conflict and Consonance) (Cao et al., 2015; Dalal et al., 2014).

The *desiderata* of this second project are twofold: 1) to provide feedback on the theory – if the data fit the statistical model, then it may lend more credibility to the theoretical model (Sijtsma, 2012), but if not, it may signal the need for a theory re-specification, and 2) to develop a reliable tool that allows for a systematic empirical investigation of the Barbour's taxonomy. This step is critical for the next project and beyond because if one cannot reliably measure an attribute placed at the centerpiece of a theory, it would be impossible to build the theory around it (Smaldino, 2019). It is worth noting that since construct validation is an ongoing, cumulative process (Zumbo & Chan, 2014), the second project is only a first step in gathering evidence about whether the current measurement strategy judiciously represents Barbour's taxonomy. Of note, the relationship between science and religion may also be configured differently in different cultural contexts (C. Johnson et al., 2020; Vaidyanathan et al., 2016), so this project also helps to systematically explore these cultural differences, particularly in Germany and the United States.

The final project aims to investigate whether people's mental models of the science-religion relationship can predict how people evaluate the utility of specific scientific and religious explanations. We know that people's conflict beliefs on very specific, often controversial issues do not justify a general conflict belief (Hill et al., 2019; Leicht et al., 2021), but whether this general belief is relevant when evaluating specific explanations remains untested. It is possible that, according to the goal system theory, the mere number of available explanations determines how people evaluate the value of each of these explanations (i.e., the dilution effect), regardless of whether they are scientific or religious (Bélanger et al., 2015; Jackson et al., 2024). By contrast, motivated reasoning account predicts that it is not the number of available explanations that matters, but people's (religious) identity (Nauroth et al., 2017) and preconceived mental models (Ditto & Lopez, 1992; Kunda, 1990; C. S. Taber & Lodge, 2006) that determine which explanations people deem valuable. In this final project, I hope to provide some preliminary evidence that the mental models can affect how people process certain explanations.

In the Final Discussion, I discuss how the three projects together contribute to a better understanding of how people relate science and religion. This includes the individual differences in how people perceive the relationship, why they perceive it differently, the circumstances under which these mental models form, how to operationalize them systematically for empirical research, and how they explain people's evaluations of scientific and religious explanations. Together, these three pillars may be able to transform Barbour's taxonomy into an empirically grounded psychological theory capable of explaining what people believe about the relationship between science and religion, why they hold these beliefs, and how these beliefs shape the way they process information. Ultimately, I hope that this research program trims the rough edges of Barbour's taxonomy and expands its explanatory power, though it cannot promise to do it finely. Therefore, I address some limitations of this research program, as well as potential avenues for future research.

# 5 Summaries of Manuscripts

## 5.1 Summary of Manuscript 1

In this broad, comprehensive review article, we explored how people mentally conceptualize the relationship between science and religion. We provided an integrative review of the literature and identified five distinct mental models that individuals use when relating science to religion, inspired by Barbour's (1998) taxonomy: *Conflict* (i.e., viewing science and religion as fundamentally opposed), *Context-Switch* (i.e., alternating between domains depending on context), *Compartment* (i.e., viewing them as separate but non-conflicting domains), *Complementary* (i.e., seeing them as addressing different aspects of a phenomenon that together form a complete understanding), and *Consonance* (i.e., believing they are fundamentally compatible and mutually reinforcing). Because previous qualitative research examining Barbour's taxonomy has labeled these mental models differently, and because Barbour's original labels for the categories in the taxonomy (i.e., Conflict, Independence, Dialogue, and Integration) are less intuitive to lay readers, we proposed different labels as above for semantic clarity.

We also explored cognitive factors (i.e., cognitive style, epistemic beliefs), motivational factors (e.g., identity and moral beliefs), and contextual variables (i.e., upbringing and intercultural exposure) that shape these mental models. In addition, we presented and reviewed evidence from cross-cultural and developmental psychology that describes a phenomenon namely 'explanatory coexistence' or 'coexistence thinking' (Legare et al., 2012), which suggests that individuals can seamlessly engage with scientific and religious explanations when making sense of phenomena.

The centerpiece of Manuscript 1 is a flowchart that integrates the reviewed evidence to explain the psychological processes underlying the formation of the mental models. This flowchart illustrates how, when confronted with phenomena requiring explanation, individuals first assess whether they are cognitively prepared and motivated to reconcile scientific and religious explanations. Those who are both cognitively prepared and motivated engage in different kinds of 'coexistence thinking' (target-dependent, synthetic, or integrative) that lead to non-conflict views (Compartment, Complementary, or Consonance). Those who lack either the cognitive preparation or the motivation to reconcile the two domains adopt conflict views (Conflict or Context-Switch) instead. The flowchart shows how personality traits (e.g., openness to experience, need for cognitive closure), epistemic beliefs, and social identity can influence each decision point in the process.

In sum, Manuscript 1 shows that: 1) individuals start with the notion of conflict when thinking about the relationship between science and religion, unless they are motivated to reconcile the two domains and are willing to be cognitively flexible, and that 2) when these two conditions are met, coexistence thinking provides a cognitive basis for how people form their preferred mental models when thinking about the relationship between science and religion.

### 5.2 Summary of Manuscript 2

In this registered report, we conducted an empirical test of a core theoretical assumption in Barbour's taxonomy: people's mental models of the science-religion relationship differ in type but are simultaneously ordered along a continuum from conflict to compatibility. While qualitative research has provided extant evidence for the existence of distinct mental models, whether these models are truly distinct categories or anchors that define different regions of a single continuum remain untested. To scrutinize this assertion, we developed a novel measurement instrument and compared two competing response process assumptions: a 'dominance' (Likert-style) model, i.e. assuming monotonic relationships between trait levels and the probability of endorsing a response category, and an 'unfolding' (Thurstonian) model, i.e. assuming non-monotonic relationships where agreement depends on the proximity of item and person locations.

Our analysis of large samples from Germany (total *N* = 2,920) and the United States (*N* = 1,197), collected from three empirical studies demonstrated that the unfolding model provided a superior fit to the data, empirically supporting the notion that participants' responses to the scale followed an unfolding model. There is evidence that while people differ qualitatively in their mental models, these models are "anchors" ordered along a single continuum. Item location parameters (i.e., an item parameter showing the location of an item in a latent continuum) revealed evidence for the ordering of these models, with Conflict at one end, followed by Compartment, Context-Switch, Complementary, and Consonance, which differs from the initial hypothesis laid out in Manuscript 1.

In addition, people with a higher propensity to perceive conflict would be less likely to be religious, personally identify with any religion, and have a religious upbringing, but more likely to be atheists, personally identify with science, and have a higher level of belief in science. Notably, Differential Item Functioning (DIF) analysis revealed substantial cross-cultural differences, with U.S. participants with similar trait levels more likely than German participants to perceive science and religion as being in conflict.

### 5.3 Summary of Manuscript 3

In this experimental study, we investigated competing psychological explanations for how people evaluate the utility of scientific and religious explanations. We tested both the 'dilution effect' hypothesis (i.e., whether having access to multiple explanations reduces the perceived utility of each single explanation, see Jackson et al., 2024) and the 'motivated reasoning' hypothesis (i.e., whether people evaluate explanations based on their pre-existing beliefs rather than explanation quantity). We presented 719 German participants with scientific and religious explanations for three incidents (flooding, war, and climate change), manipulating the number of presented explanations (one, two, or four) participants received, while measuring their religiosity and perceptions of the science-religion relationship.

Contrary to the dilution effect hypothesis, our results showed that the presentation of multiple explanations did *not* reduce the perceived utility of individual explanations. Instead, the results strongly supported motivated reasoning account: religiosity and perceptions of the science-religion conflict strongly predicted how participants evaluated religious explanations, but had no effect on evaluations of scientific explanations. Religious participants and those with non-conflict views evaluated religious explanations more favorably, while scientific explanations were consistently evaluated similarly across groups, regardless of their religiosity or pre-existing conflict beliefs.

These findings suggest an asymmetry in how people process scientific and religious explanations, with scientific explanations being evaluated for their substantive accuracy (i.e., 'truthfulness') and religious explanations being more contingent on identity and subjective preferences. We interpret these results in line with Van Leeuwen's (2014) theory that factual beliefs (i.e., scientific explanations) and religious credence (i.e., religious explanations) have different properties and are therefore acquired, evaluated, and applied differently.

# 6 Manuscript 1

## Longtime Nemeses or Cordial Allies? How Individuals Mentally Relate Science and Religion

Rizqy Amelia Zein[1, 2], Marlene Sophie Altenmüller[1], & Mario Gollwitzer[1]

[1]Department of Psychology, Ludwig-Maximilians-Universität München

[2]Department of Psychology, Universitas Airlangga

**Author Note**

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Correspondence to: Rizqy Amelia Zein, Department of Psychology, Ludwig-Maximilians-Universität München (LMU), Leopoldstraße 13, Munich, Germany 80802

Department of Psychology, Universitas Airlangga, Kampus B Unair Jalan Airlangga 4-6 Surabaya, Indonesia 60286, email to: Amelia.Zein@psy.lmu.de / amelia.zein@psikologi.unair.ac.id

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**Abstract**

Science and religion are influential social forces, and their interplay has been subject to many public and scholarly debates. The present article addresses how people mentally conceptualize the relationship between science and religion and how these conceptualizations can be systematized. To that end, we provide a comprehensive, integrative review of the pertinent literature. Moreover, we discuss how cognitive (in particular, epistemic beliefs) and motivational factors (in particular, epistemic needs, identity, and moral beliefs), as well as personality and contextual factors (e.g., rearing practices and cross-cultural exposure), are related to these mental conceptualizations. And finally, we provide a flowchart detailing the psychological processes leading to these mental conceptualizations. A comprehensive understanding of how individuals perceive the science-religion relationship is interesting in and of itself and practically relevant for managing societal challenges, such as science denial.

[134 words]

*Keywords*: science, religion, perceptions of science-religion-relationship.

## Longtime Nemeses or Cordial Allies? How Individuals Mentally Relate Science and Religion

Human beings are curious creatures in constant search of meaning. Throughout history, science and religion have been indispensable elements of human life, fulfilling our needs to satisfy our curiosity and offering guidance on how to live a good life. Unlike what many would suspect, scientific inquiries are not a dreary, emotionless process. Instead, it evokes a deep sense of elation and fulfillment – almost spiritual – just as Carl Sagan (1995) portrayed in his popular book, "The Demon-Haunted World" (i.e., "Science is not only compatible with spirituality; it is a profound source of spirituality"). In a similar vein, Abdus Salam (1979) quoted a verse from the Quran in his Nobel award speech (i.e., "...the deeper we seek, the more is our wonder excited, the more is the dazzlement for our gaze") as a statement that his religious beliefs had nourished him as a physicist to pursue a career in science. That said, questions such as "are science and religion in a state of irreconcilable war?" or "are science and religion fundamentally compatible?" have been the subject of fierce disputes. Scholars, theologians, and philosophers have long contemplated these questions (Barbour, 2000; Berry, 2000; Draper, 1875; Gould, 2000), but in the public conscience, the most intuitive answer to such questions is that science and religion are always mutually exclusive and, therefore, at odds.

Construing a conflict when thinking about science and religion aligns with the growing gulf between religious believers and science aficionados when it comes to controversial topics such as evolution (Astley & Francis, 2010; Blancke et al., 2013; Unsworth & Voas, 2018; Yasri & Mancy, 2012), anthropogenic global climate change (Arbuckle, 2017; N. E. Landrum et al., 2016; Sharma et al., 2021), human enhancement technologies (Masson, 2014), genetic engineering (Allum et al., 2014; M. D. Mehta, 2001; Scott et al., 2018), vaccination (Keshet & Popper-Giveon, 2021; Pelčić et al., 2016; S. C. Quinn et al., 2020; Reynolds, 2014; Wombwell et al., 2015), and the prevention of infectious diseases (Hill et al., 2020; M. Lee et al., 2022). This divide has led to the notion that conflict exists between science and religion and is supported by survey research indicating that religious individuals generally believe that science conflicts with their religious beliefs (E. Chan, 2018; Gauchat, 2008; Paz-y-Miño-C & Espinosa, 2015).

Some prominent scientists have also doubted whether science and religion can be reconciled. As one example, evolutionary biologist Jerry Coyne has accused religion of contributing to lay U.S. Americans' mediocre scientific understanding (Coyne, 2012) and has argued that "science and religion are not only in conflict – even at 'war' – but also represent incompatible ways of viewing the world" (Coyne, 2018). However, whether the notion that "science and religion are fundamentally in conflict" accurately reflects the full range of viewpoints people hold is worth revisiting.

Contrary to the idea that science and religion are in conflict, there are historical examples of an alliance between these two domains. Several esteemed scientists, such as Johann Gregor Mendel (Richter, 2015), Werner Heisenberg (Heisenberg, 1958), Francis Collins (Collins & Masci, 2008), and Vera Rubin ("Pioneering Jewish Astronomer," 2016) have expressed skepticism about the idea that science and religion are fundamentally at odds. Moreover, there are numerous instances where religious and scientific institutions have cooperated effectively to achieve common social goals. Religious organizations across different groups and denominations have played a crucial role in promoting scientifically-informed policies during health (Burhani, 2020; Cavaliere, 2021; Chen et al., 2022; Falade, 2020; Suyadi et al., 2020), environmental (Kula, 2001; Silalahi, 2022; U.N. Climate Change News, 2021), or social crises (Brittain, 2011; Fagan, 1996; Pargament et al., 2020; Tarusarira, 2014). This line of evidence suggests that the relationship between science and religion is more nuanced than a simple dichotomy of conflict versus alliance.

Empirical investigations have suggested that the commonly held "conflict" view between science and religion does not fully capture the complexity of how people perceive the relationship between the two domains. For example, a nationwide survey conducted by the Pew Research Center found that 59% of U.S. adults subscribed to the "conflict" view (Funk & Alper, 2015). However, subgroup differences further revealed that the "conflict" view was much more common among the least religious, with 76% of nonreligious participants endorsing the "conflict" view compared to 16% of religious participants (Funk & Alper, 2015). Similarly, the National Study of Youth and Religion (NSRY) found that 70% of U.S. participants supported the "conflict" view, with religious skepticism and religious fundamentalism strongly predicting this support (Longest & Smith, 2011). However, the Baylor Religion Survey conducted by the Gallup Organization presented a different perspective, with only 17% of U.S. participants agreeing that science and religion are in conflict (Baker, 2012).

Some suspect that the "conflict" view may be limited to the Western context, which has historically viewed the science-religion relationship primarily through the lens of Christianity (Johnson et al., 2020). Several studies have been conducted to scrutinize this suspicion involving people of different religious affiliations across various countries and continents. For example, a qualitative study conducted in Malaysia and Singapore interviewed 72 Buddhists, Muslims, and Hindus (Johnson et al., 2020): All participants rejected the idea that science conflicts with their religious faith. While Hindu and Muslim participants tended to view science and religion as interrelated and compatible, Buddhist participants were more likely to see science and religion as independent domains. Evidence from the Wellcome Trust Global Monitor, a global survey involving participants from 140 countries, indicates that the prevalence of the "conflict" view varies widely across continents. While only 29% of participants worldwide believe science conflicts with their religious beliefs, more than half of those in Northern America, Southern, and Western Europe endorsed such a "conflict" view (Kostyukov, 2019).

Furthermore, the same survey indicated that Christians across the globe hold quite different opinions on the relationship between science and religion, with more than half of Christians in the U.S. and Southern Europe endorsing the "conflict" view, but smaller percentages of Christians in South America, Southeast Asia, Sub-Saharan Africa, and Eastern Europe (ranging from 12% to 45% per country; Johnson et al., 2020; Kostyukov, 2019). In a similar vein, a study investigating the social attitudes of Muslims in 23 Muslim-majority countries found that approximately 57% of participants did not believe that science conflicts with their religious beliefs (Bell et al., 2013). Overall, these studies suggest that the "conflict" view may not be universal and may depend on cultural and religious contexts. Therefore, further research is needed to understand the factors underpinnings these differences.

Scholars have attempted to test whether religious beliefs (or a lack thereof) are responsible for people's tendency to subscribe to the "conflict" view. This notion is based on the finding that, on the one hand, nonreligious individuals are more inclined to regard science as the only effective means of achieving instrumental goals, contributing to their stronger endorsement of the "conflict" view, and that, on the other hand, religious individuals are more likely to perceive science and religion as equally instrumental (i.e., the instrumentality hypothesis, Jackson et al., 2020a, 2020b). A line of evidence, indeed, substantiates this notion by revealing that religious individuals tend to view scientific and religious explanations as equally instrumental, while nonreligious individuals rely solely on scientific explanations (Jackson et al., 2020a, Study 3; see also Funk & Alper, 2015).

That said, correlating religiosity and endorsement of the “conflict” view has yielded inconsistent findings. For example, one study conducted in 38 countries, featuring participants from ten of the world’s major religions, suggests that the correlation between religiosity and the endorsement of the “conflict” view varies considerably across countries, with its meta-correlation nearly approaching zero ($-.11 \leq r \leq -.05$; Jackson et al., 2020a, Study 2). Another line of research suggests that only specific facets of religiosity, such as religious fundamentalism (J. J. Lee, 2022; Longest & Smith, 2011) or belonging to fundamentalist religious groups (J. H. Evans, 2013, 2018; Noy & O’Brien, 2016; O’Brien & Noy, 2018), are associated with supporting the “conflict” view. This body of literature has sparked a debate over the directionality of the relationship between religiosity and the endorsement of the “conflict” view.

From this vantage, it is interesting to delve deeper into how, why, and under what circumstances individuals differ in their views on the relationship between science and religion. Given that a significant proportion of individuals place great significance on religion as a guiding force in their lives (Mitchell, 2018; Tamir et al., 2020; Theodorou, 2015), a comprehensive understanding of how people conceive the relationship between science and religion can help us paint a clearer picture of public engagement with science. It is worth noting that our aim in this paper is not to engage in the debate about the substantive compatibility (vs. conflict) between science and religion (Catto et al., 2022) but rather to explore the psychological mechanisms underlying individuals’ diverse perspectives on this issue.

Our paper is structured in the following way: First, we discuss a prominent taxonomy of how people can mentally conceptualize the relationship between science and religion (i.e., Ian G. Barbour’s work) and give an overview of the empirical evidence for this taxonomy (i.e., how people conceptualize science and religion). Second, we review relevant theories and research that can explain why different people endorse different conceptualizations. This review covers research on personality traits, cognitive, and motivational factors (i.e., why people conceptualize the relationship between science and religion differently) as well as situational factors such as parenting and cross-cultural experiences (i.e., under what circumstances individuals conceptualize the relationship between science and religion differently). Third and finally, we integrate the reviewed evidence into a flowchart model that describes the conditions and processes under which people may come to endorse one particular conceptualization of the science-religion relationship.

## Mental Representations of Science-Religion Relationships: A Taxonomy

To elucidate the diverse ways individuals conceptualize the relationship between science and religion, scholars from different disciplinary perspectives have proposed a variety of taxonomies. One such taxonomy that has garnered considerable attention is Ian G. Barbour's philosophical work and its various iterations and extensions (1966, 1974, 1990, 1998, 2000). Barbour's taxonomy is one of the earliest and most influential attempts to categorize the ways (i.e., "mental models") in which science and religion can be related to each other.

### *Conflict Views*

Barbour's first proposed model is the "conflict" view, which entails the belief that science and religion are fundamentally adversarial and cannot coexist epistemologically. According to Barbour (1966, 1974, 1990, 1998, 2000), the "conflict" view stems from either biblical literalism, where religious texts are taken literally beyond moral and spiritual teachings, or scientific materialism, which accepts only empirical phenomena verified by scientific methods as the ultimate truth. Nord (1999) expands the "conflict" model by distinguishing between those who prioritize science over religion (science trumps religion) and those who prioritize religion over science (religion trumps science).

The "conflict" view indirectly posits an inverse relationship between religion-related and pro-science-related attitudes and positive relationships between religiosity and anti-science beliefs (e.g., science skepticism, rejection, or denialism). This notion is supported by various findings, including research indicating that religiosity is associated with negative attitudes toward science (Jochman et al., 2018; McPhetres et al., 2020), decreased trust in and support for science and scientists (E. Chan, 2018; O'Brien & Noy, 2018; Stewart et al., 2017), lower levels of science literacy and achievement (Betancur et al., 2018; McPhetres & Zuckerman, 2018), and higher levels of science skepticism (Azevedo & Jost, 2021; Rutjens et al., 2018, 2022; Rutjens & van der Lee, 2020).

That being said, not all studies have found a consistent correlation between religiosity and negative attitudes toward science, as evidenced by a cross-cultural study (McPhetres et al., 2020). Further, as mentioned before, other research has shown that religious individuals are more likely to see compatibility between science and religion (Ecklund & Scheitle, 2018; M. S. Evans, 2012; Falade & Bauer, 2018; Jackson et al., 2020a; Mackey et al., 2023; Vaidyanathan et al., 2016). Non-religious individuals, by contrast, are more likely to hold a "conflict" view (Ecklund & Scheitle, 2018; Funk & Alper, 2015; Marin & Lindeman, 2021), and they tend to underestimate religious individuals' openness to science (Jackson et al., 2020; Study 6). Further, recent studies suggest that religious exclusivism (rather than religiosity alone; see J. J. Lee, 2022) and anti-religious attitudes (Francis et al., 2019) have independently contributed to a stronger endorsement of the "conflict" view. These findings suggest that the association between science-related attitudes and religion-related attitudes may be non-linear. Instead of assuming that people favor science to the extent to which they disfavor religion and vice versa, it appears that a curvilinear (i.e., U-shaped) function is more suitable to explain the relationship between the two: only the most skeptical of religion and the most religious would be more inclined to adopt a stronger conviction of the "conflict" view (Baker, 2012). However, it is quite likely that the exact form of this curvilinear relationship is context-dependent itself. That is, the degree of curvilinearity may be higher in prototypically secular societies compared to prototypically religious societies (Johnson et al., 2020).

In addition, religiosity itself is a broad and multifaceted construct; it has been defined and operationalized in various ways across disciplines and studies (K. A. Harris et al., 2018). Religiosity can be characterized by its "subjective" domains, such as attitudes, cognitions, and emotions, and "objective" dimensions, such as affiliation, demographic criteria, practices, and behavior (Saroglou, 2014b). Further, scholars suggest that religiosity involves not only "individual" components but also "collective/institutional" elements (Pargament, 1999), which are essential in distinguishing it from spirituality (K. A. Harris et al., 2018). The scholarly consensus is that various religiosity constructs share similarities and overlapping components, but each captures unique elements of religious experience (K. A. Harris et al., 2018).

It is worth noting that many previous studies examining how people relate science to religion have imposed a narrow definition of religiosity on nonreligious participants by measuring their putative religiosity. This methodological decision may be considered a shortcoming since nonreligious individuals often adhere to different belief systems (e.g., scientific, humanist, or nature-focused worldviews), which serve as replacements for religious beliefs (i.e., belief replacement hypothesis; Haimila, 2020; van Mulukom et al., 2022). That said, these secular belief systems may serve similar functions to religious beliefs (Rutjens & Preston, 2020), yet these are still substantively different from religious beliefs (van Mulukom et al., 2022). Given the extensive scope of religiosity (and nonreligious belief systems), it is imperative to recognize its diverse conceptualizations and operationalizations in order to understand the diverse landscape of findings including the religiosity construct.

To summarize, the mixed findings in previous studies examining the conflict hypothesis might suggest a more complex, non-linear association between religiosity and the endorsement of the "conflict" view. Additionally, these studies might have been muddled by different conceptualizations of religiosity. Therefore, a more specific conceptualization of religious (vs. nonreligious) experiences is necessary to discern which aspects of religiosity may be associated with endorsing the "conflict" view or anti-science attitudes. Lastly, since religious and nonreligious individuals hold different belief systems, they should not be treated as groups on opposite ends of the same continuum.

***Context-Switch.*** The so-called context-switch view represents a variant of the traditional "conflict" view. Unlike the religion-trumps-science or the science-trumps-religion views, the context-switch view allows individuals to conveniently switch their preferences when dealing with different social or instrumental goals in various social contexts. Although Barbour's taxonomy does not explicitly recognize the context-switch view, qualitative research in science education extending Barbour's taxonomy provides evidence for its existence (Yasri et al., 2013; Yasri & Mancy, 2012).

Multiple studies have shown that some participants reconciled the tension between science and religion by "wearing different hats" during religion and science classes (Shipman et al., 2002; Taber et al., 2011; Yasri & Mancy, 2012). In biology class, for instance, individuals with a context-switch view might wear their "science hat," fully devoting themselves to scientific reasoning; but the very same person may wear their "religion hat" when learning about religious teachings (Shipman et al., 2002; Taber et al., 2011; Yasri & Mancy, 2012). These findings suggest that individuals may embrace the core beliefs of the "conflict" view, yet their preferences for one over the other can shift pragmatically depending on the context (Gottlieb & Wineburg, 2012).

### ***Non-Conflict Views***

The "non-conflict" views imply that science and religion can coexist without contradicting each other (Barbour, 1990, 2000; Ecklund & Scheitle, 2018). Those who support "non-conflict" views do not experience any logical (or cognitive) dilemma from referring to both belief systems simultaneously. Scholars have argued that mentally conceptualizing science and religion as non-conflictual may be no different from being able to speak more than one language fluently or mastering different cognitive skills (Falade & Bauer, 2018; Jovchelovitch, 2008; Provencher, 2011; Wagner et al., 2000). That said, if individuals subscribe to the belief that there is no conflict between science and religion, it is interesting to explore whether they view science and religion as independent or interrelated explanations. Next, we will review several variants of "non-conflict" views and outline their differences.

***Compartment***. One way to view the relationship between science and religion is through the so-called compartment view, which posits that the two are entirely independent and cannot conflict because they operate in different domains. According to this view, science and religion have distinct goals, methods, and subject matters and should not interfere with each other (Barbour, 1966, 1998, 2000; Nord, 1999; Yasri et al., 2013). Those who uphold the compartment view reject the idea of a conflict between science and religion but do not see them as compatible (Baker, 2012). Instead, they mentally segregate their beliefs about science and religion using different "language rules." Scientific language entails explanations of natural mechanisms, while religious language expresses beliefs concerning moral principles (Barbour, 1998). The compartment view entails the "non-overlapping magisterial" concept, highlighting that authorities responsible for each are mutually exclusive (Alexander, 2007; Gould, 1997). Therefore, according to the compartment view, religious authorities are never acceptable to make scientific claims or determine scientific consensus, and vice versa.

Prior literature suggests that religious individuals are more likely to uphold the compartment view and disagree with the conflict view (Ecklund & Scheitle, 2018; Longest & Uecker, 2021; Vaidyanathan et al., 2016). Further, studies examining how students bring together religious explanations and evolution have found that the compartment view prevails as a sense-making strategy for reconciling science and religion (Shipman et al., 2002; Taber et al., 2011; Yasri & Mancy, 2012). Similarly, research involving scientists has also found that a compartment view is a popular option for reconciling the tension between their scientific occupation and religious beliefs (Khalsa et al., 2021). The compartment view is reflected in various studies and taxonomies, where it is referred to by different names such as independence (Barbour, 1966, 2000; Nord, 1999), contrast (Yasri et al., 2013; Yasri & Mancy, 2012), or modes-of-thought (Polkinghorne, 1986).

***Complementary***. Viewing science and religion as entirely independent domains (i.e., the compartment view) does not fit the beliefs held by some individuals endorsing "non-conflict" views. The complementary view reflects a belief that science and religion are autonomous belief systems that have similar (ontological and epistemological) features, which implies that they are compatible and reconcilable to a certain extent (Barbour, 2000; Haimila, 2020). Individuals who endorse the complementary view believe that scientific and religious explanations provide an accurate yet incomplete account of our everyday lives and that neither can fully explain everything (Alexander, 2007; Longest & Uecker, 2021). As such, they argue that scientific and religious explanations are necessary to provide a comprehensive understanding of the world (Barbour, 2000; Taber et al., 2011; Yasri & Mancy, 2012). People with a complementary view are more amenable in terms of how scientific and religious explanations might converge so that they are less concerned with a precise substantiation of the integration between scientific and religious explanations but rather focused on their mutual contribution to a more complete understanding of the world (Barbour, 2000; Borgerding et al., 2017).

***Consonance***. The last variant of the "non-conflict" view is the so-called consonance view, which further integrates scientific and religious explanations (Yasri et al., 2013). The consonance goes beyond the complementary view by believing that science and religion have a common origin and are, therefore, inherently interconnected as part of a unified belief system (Barbour, 1990). Therefore, people upholding a consonance view strive for explicit substantiation of the integration between science and religion (Barbour, 1990; Yasri et al., 2013). To that end, proponents of the consonance view believe that science helps redefine and enhance their faith, or the other way around, religion can help nourish their scientific understanding (Yasri & Mancy, 2012). In this sense, some individuals embracing a consonance view may consider science as a proximate explanation to the ultimate end, which corresponds to their religious beliefs (i.e., “natural theology”; Alexander, 2007; Barbour, 2000). For others, religious beliefs may need to be reinvigorated to align with modern science, as they view science as the ultimate explanation (i.e., “theology of nature”; Barbour, 1990, 2000).

### *Interim Summary*

While Barbour’s taxonomical works and empirical research have contributed significantly to our understanding of the science-religion relationship, unexplored factors underlying different beliefs regarding this interplay still remain. Importantly, people’s perceptions of science and religion as conflicting can vary depending on the issue at hand. For example, while individuals may perceive a conflict between science and religion when evaluating scientists working on evolutionary science (Elsdon-Baker et al., 2017) or when discussing the origins of human life (Leicht et al., 2021), they may not see such conflict when thinking about its closely related topics or disciplines, such as genetics or biology (Elsdon-Baker et al., 2017). To delve deeper into this matter, we will examine various psychological and situational factors influencing how people conceptualize the relationship between science and religion.

## Why Do Individuals Conceptualize the Relationship Between Science and Religion Differently?

### *Personality*

Looking at interindividual differences, personality, of course, might be key. Past studies have explored the role of broader personality traits in predicting individuals’ religiosity, science interest, need for cognition, and intelligence. Specifically, research has found that a higher level of agreeableness and conscientiousness (Saroglou, 2010, 2017), a lower level of psychoticism (Lodi-Smith & Roberts, 2007), and a higher level of honesty-humility (Aghababaei et al., 2016) predict religiosity. By contrast, openness to experience, conscientiousness, and introversion predict science interest, likely mediated by the need for cognition (Feist, 2012; Furnham & Thorne, 2013).

Individuals need to engage in effortful cognitive deliberation to relate science to religion. This process may be facilitated by certain personality traits and, thus, may explain the variety of viewpoints regarding the science-religion relationship. Discussing socially controversial issues, such as the relationship between science and religion, is challenging and requires more argumentative reasoning (Iordanou et al., 2016), particularly in a classroom setting. Previous research suggests that participants with a higher level of openness to experience and extraversion and a lower level of agreeableness are more articulate and reflective when engaging in classroom discussions regarding controversial social issues (Gronostay, 2019). Furthermore, one study has found that openness to experience is associated with perceiving a non-conflicting relationship between science and religion and with being flexible and critical when revisiting this relationship (Hanley et al., 2014).

In a similar vein, narrower personality traits related to achieving epistemic goals, such as tolerance for ambiguity (Furnham & Ribchester, 1995), need for cognitive closure (Webster & Kruglanski, 1994, 1997), intellectual humility (Davis et al., 2010), and dogmatism (Rokeach, 1954), may also predict how people relate science to religion. Individuals with high tolerance for ambiguity tend to be more critical, engaged, and amenable when discussing the science-religion relationship (Hanley et al., 2014). Further, studies show that people with a higher level of intellectual humility (Leicht et al., 2021) and lower levels of need for cognitive closure (Saroglou & Dupuis, 2006) and dogmatism (Hanley et al., 2014) were more likely to be motivated to reconcile the tension between science and religion.

The influence of narrower personality traits emanating from intergroup processes, such as right-wing authoritarianism (RWA) and social dominance orientation (SDO), is also evident. RWA and SDO both amplify religious individuals' skepticism toward science (Azevedo & Jost, 2021; Kerr & Wilson, 2021), potentially leading to an endorsement of the "conflict" view. Another evidence suggests that RWA, in combination with religious fundamentalism, leads individuals to view science and religion as being at odds with each other (Westman et al., 2000).

In sum, personality traits might help us better understand the differences in how individuals conceptualize the science-religion-relationship; yet, especially broader personality constructs likely fall short when trying to explain people's nuanced conceptualization of the relationship between science and religion. It is therefore necessary to consider more specific processes, such as cognitive factors (e.g., general cognitive ability and epistemic cognition) and motivational factors (e.g., moral beliefs and social identities).

***Cognitive Factors***

For many years, scholars have debated the role of human cognition in shaping individuals' preferences for scientific or religious explanations. While individuals may interact with both scientific and religious explanations to make sense of their experiences in this world and beyond, they often perceive them as distinct domains (Preston & Epley, 2009). In selecting the best explanation, people consider a range of factors, including simplicity, coherence, and internal consistency of an explanation, to assess its plausibility (Thagard, 1989).

Due to humans' need for coherence, it is not easy to discern that one explanation may be true and false at the same time (Swann & Brooks, 2012) or that two competing explanations can be both true or both false (Sloman, 1994). Consequently, individuals tend to be selective in their exploration of explanations, with only certain events prompting them to question "why does this happen?" and rarely regard plausible (scientific or religious) explanations emerging from these observations as equally valuable (Lombrozo & Liquin, 2023; Preston & Epley, 2005). Consequently, they may value science more than religion (or vice versa) (Preston & Epley, 2005). Thus, cognitive processes underlying scientific and religious beliefs may be akin to a hydraulic (i.e., a "trade-off") system, where selecting one type of explanation comes at the cost of undermining its counterpart (Preston & Epley, 2009; Sharp et al., 2022).

In this section, we discuss the cognitive processes involved when people mentally navigate scientific and religious explanations. We begin by examining how cognitive abilities and styles affect how individuals perceive this relationship. Next, we elucidate the mechanisms behind the formation of scientific and religious beliefs, as well as their distinct function and processing rules. In doing so, we aim to shed light on the possibility of explanatory coexistence (i.e., scientific and religious beliefs can both explain phenomena and provide answers to epistemic questions). Finally, we will synthesize pertinent literature that emphasizes the role of epistemic beliefs in explaining the diverse conceptualizations people adopt when contemplating the relationship between science and religion.

***Cognitive Abilities and Styles.*** Building upon the premise that science and religion prescribe conflicting explanations and methods of knowing, scholars have assumed that people prefer scientific over religious explanations (or vice versa) and may use their chosen preferences consistently (Shtulman & Lombrozo, 2016). Opting for scientific (vs. religious) explanations might be contingent on cognitive styles (Pennycook, 2014; Pennycook et al., 2012; Saribay et al., 2020; Shenhav et al., 2012) and ability (Razmyar & Reeve, 2013; Saribay & Yilmaz, 2017), which can, in turn, affect how people process, interpret, and engage with different kinds of information in everyday contexts (Lindeman & Lipsanen, 2016; McPhetres & Nguyen, 2018; McPhetres & Zuckerman, 2017; Pennycook et al., 2013).

Indeed, several prior studies support this notion. For example, those who perform better in analytical thinking tasks lean towards disbelieving religious explanations1 (Gervais & Norenzayan, 2012; Pennycook et al., 2016). Nonreligious participants perform better in cognitive reflection as well as cognitive flexibility tests (Zmigrod et al., 2019) and are more likely to solve base-rate problems (Pennycook et al., 2016) compared to religious individuals. In addition, a meta-analytical study ($k = 83$) concludes that religiosity correlates negatively with cognitive ability (pooled correlation: $-.20 \leq r \leq -.23$), evidencing that more intelligent individuals are less likely to be religious (Zuckerman et al., 2013, 2020).

By contrast, lower scores in analytical thinking tasks (i.e., implying an intuitive thinking style) are associated with stronger religious convictions (Lindeman & Svedholm-Häkkinen, 2016; Pennycook, 2014; Saribay & Yilmaz, 2017; Shenhav et al., 2012) and a higher susceptibility to teleological biases (i.e., explaining random natural phenomena in terms of its purposes) (Heywood & Bering, 2014). Also, those who do not perform well in analytical reasoning tasks tend to have inconsistent standards of evidence when evaluating religious and scientific information (Lobato et al., 2020; McPhetres & Zuckerman, 2017).

To summarize, previous findings support the competing nature of scientific and religious beliefs. Consequently, scholars in science education have argued that strengthening scientific beliefs may eventually dethrone non-scientific beliefs ("conceptual change" according to Posner and colleagues, 1982). Thus, keeping preferences for preconceived naïve beliefs would be considered "misattributions" (Galen, 2017). Higher cognitive abilities and certain cognitive styles (i.e., analytical reasoning) are evidently corrective to the perseverance of naïve beliefs (Fasce & Picó, 2019; Slusher & Anderson, 1989), hence the lower tendency for relying on supernatural or religious explanations.

In addition to explaining people's preferences for explanations, cognitive styles, and abilities may also be critical in shaping individuals' attitudes toward the relationship between science and religion. Specifically, individuals with higher analytical thinking may favor science over religion (Cheyne, 2009; Razmyar & Reeve, 2013) and, in turn, endorse the "conflict" view (i.e., science trumps religion; see Baker, 2012; Scheitle & Corcoran, 2021). By contrast, people with lower analytical reasoning and strong religious convictions (i.e., religious fundamentalism) may prefer religion over science and, in turn, also support the "conflict" view (i.e., religion trumps science; see J. J. Lee, 2022).

***Belief Formation.*** Despite possibly competing, past studies show that scientific and religious explanations are obtained through similar processes of belief formation. People acquire both "unobservable" scientific knowledge about the world (e.g., about the relationship between mental processes and the brain, the shape of the Earth, germs, etc.) and religious teachings (e.g., about Gods, angels, etc.) from authoritative sources and informants (e.g., parents, clerics, religious texts, science teachers, scientists, etc., see P. L. Harris et al., 2007; P. L. Harris & Corriveau, 2021; P. L. Harris & Koenig, 2006). Thus, individuals tend to determine the credibility of scientific and religious explanations by evaluating the characteristics of the informants they encounter (A. R. Landrum et al., 2015) rather than engaging in a systematic process of personal justification. More specifically, trust in experts can be based on information about their competence (Birch et al., 2008; Sobel & Kushnir, 2013) but also on the integrity and benevolence of these "experts" (Hendriks et al., 2015; A. R. Landrum et al., 2013). Extant evidence shows that this applies to both science (Hendriks et al., 2016) and religion (P. L. Harris & Koenig, 2006).

It is important to note that while testimony is equally central to scientific and religious belief formation, belief confidence differs significantly between these two domains, with individuals generally being more confident in their scientific than in their religious beliefs (Clegg et al., 2019; Hoogeveen et al., 2022; Shtulman, 2013), even among children (P. L. Harris et al., 2007; P. L. Harris & Corriveau, 2021) and religious individuals (Davoodi et al., 2019). In a series of studies in China and Iran, McLoughlin and colleagues (2023) found that parents use significantly fewer lexical cues of uncertainty when describing scientific compared to religious phenomena, and this pattern was found among both secular and religious parents in China as well as highly religious parents in Iran (McLoughlin et al., 2023). Additionally, a study of U.S. children aged five and eleven years old found that they were less likely to conclude that religious and magical stories could happen in real life than realistic and unusual (i.e., extremely unlikely events, such as winning the lottery several times in a row) stories, regardless of their age and religious background (Payir et al., 2021).

These findings, then, bring us to the next question: why is people's confidence in their scientific beliefs different, even higher, than their religious beliefs, even though both beliefs are formed through a similar formation process? Davoodi and Clegg (2022) suggest that cultural transmission through adult testimony plays a more important role in shaping supernatural (i.e., religious) compared to scientific beliefs. Indeed, young children learn about unobservable scientific phenomena from adult testimony (P. L. Harris & Corriveau, 2021; P. L. Harris & Koenig, 2006) but as they get older, children can reinforce and solidify their scientific beliefs through firsthand experience (Davoodi & Clegg, 2022). For example, a child may first learn about disease-causing germs from their science teacher, but then observe these previously unobservable germs under a microscope, thereby reinforcing their scientific beliefs. By contrast, supernatural (i.e., religious) beliefs are heavily, or perhaps solely, dependent on cultural transmission, leading to lower levels of belief confidence compared to scientific beliefs (Davoodi & Clegg, 2022).

Since religious and scientific beliefs are held to different belief confidence, Harris and Corriveau (2021) suggest that there are distinct psychological underpinnings to scientific and religious beliefs, despite their striking similarity in their belief formation process.

***Processing Rules.*** While scientific and religious beliefs are acquired through similar processes of belief formation, they entail different processing rules for believing an idea (Van Leeuwen & Lombrozo, 2023). This may explain why individuals consider science and religion more or less competing (vs. reconcilable). First, laypeople often equate scientific beliefs to factual descriptions of phenomena (i.e., factual beliefs, see Van Leeuwen, 2014). Therefore, scientific beliefs are (or rather, should be) primarily appraised based on their truth-bearing quality. Therefore, scientific claims are mostly scrutinized based on their evidence (Van Leeuwen, 2014, 2017a). For religious beliefs, this is not the case. Instead, religious beliefs are not easily overturned by contrary evidence.

Second, religious beliefs can be expanded upon and developed in ways that factual beliefs cannot. For example, people can improvise or modify religious rituals or practices based on their interpretation of religious jurisprudence (Van Leeuwen, 2014). Relatedly, religious beliefs are strongly influenced by "the special authority" (Van Leeuwen, 2014) of certain individuals or institutions, or more sharply, people may be more likely to accept a particular religious doctrine from an eminent, respected religious leader. This "special authority," according to Van Leeuwen (2014), must be perceived as having a virtuous quality, and thus, plays an anointed role for their revered characters.

By contrast, factual beliefs are evidentially fragile, and thus more susceptible to scrutiny in light of new evidence, arguments, or methods (Van Leeuwen, 2014, 2017b). Therefore, the content and value of factual beliefs depend less strongly on the "eminence" of certain individuals but more on the weight and quality of evidence justifying those beliefs (de Grefte, 2021), while religious beliefs may be less sensitive to evidence (Van Leeuwen, 2014). More sharply, Van Leeuwen (2014) argues that factual and religious beliefs are under the influence of different kinds of authority, the former being called "evidential authority," while the latter being called "special authority."

Third, factual beliefs are involuntary, which means that people cannot freely decide to believe (or disbelieve) them because factual beliefs are dictated by evidence, as we described above. For example, factual beliefs about poliovirus (e.g., that it spreads from person to person) or temperature (e.g., that it can be measured by a thermometer) remain the same everywhere and anytime (i.e., context invariant) so they are applicable to guide actions irrespective of the context (Van Leeuwen, 2014). By contrast, religious beliefs are tied to specific practices or contexts (Van Leeuwen, 2014). For example, during communion, Christians may believe that sacramental bread and wine represent the body and the blood of Jesus but may also think of the same bread and wine as ordinary consumable products outside the context of rituals.

Previous studies show that individuals may be able to start recognizing the distinctive features of factual and religious beliefs in middle childhood (Banerjee et al., 2007; Flavell et al., 1990; Heiphetz et al., 2014). For this reason, three-year-olds are unable to differentiate between "false" and "true" factual beliefs, but they already demonstrate an ability to discern their preferences and opinions from those held by others (Flavell et al., 1990), suggesting that belief segregation is not fully developed during this stage. Meanwhile, children between the ages of eight and ten exhibit the ability to distinguish between factual beliefs and personal opinions, and further, they are more inclined to conform to others' factual beliefs than to others' personal opinions

(Banerjee et al., 2007). A study further demonstrates that seven- to ten-year-old participants were able to correctly differentiate between factual beliefs, opinions, and religious beliefs (Heiphetz et al., 2014; Wainryb et al., 2004) based on their functionality: factual beliefs represent the physical world, opinions tell them more about a person, and religious beliefs offer explanations about both (Heiphetz et al., 2014). Another study shows that children within the same age range were found to utilize their scientific beliefs to explain death as the endpoint of the human lifecycle while simultaneously believing in the continuing presence of certain mental processes afterlife in accordance with their religious beliefs (Astuti & Harris, 2008; P. Harris & Giménez, 2005).

Interestingly, compared to adults, children are more likely to acknowledge that religious beliefs represent the physical world (Heiphetz et al., 2014), evidencing that mental segregation between factual and religious beliefs becomes more fine-grained later in adulthood. Adults in English-speaking countries semantically isolate factual beliefs from religious beliefs by using different language expressions; "to think" for describing factual claims and "to believe" for inferring religious beliefs (Heiphetz et al., 2021). However, it is important to note that Astuti and Harris' (2008) study in rural Madagascar shows the opposite – adults are more likely to believe in the assertion of the afterlife than children because they were more actively involved in performing the rituals for the deceased ancestor. According to this study, Vezo children already showed a clear separation between the concept of the end of the material body (i.e., scientific beliefs) and their belief in the continuation of life in the afterlife, and this separation became sharper as the children got older (Astuti & Harris, 2008). Notably, according to evidence from cross-cultural studies, semantic segregation between factual and religious beliefs has also been observed in other societies (Anggoro & Jee, 2021; Van Leeuwen et al., 2020, 2021). Two brain studies are also suggestive of this segregation, showing that religious explanations are processed similarly as metaphorical sentences, contrary to factual statements (Fondevila et al., 2016; Fondevila & Martín-Loeches, 2013; S. Harris et al., 2009).

In further support of Van Leeuwen's (2014) varieties of belief hypothesis (i.e., the different processing rules for believing scientific and religious explanations), one study shows that participants view science and religion as different in their prescriptions for explanation and mystery, with science seeking to explain phenomena, while religion tolerates and even embraces mystery (Liquin et al., 2020). A more recent study supports and expands these findings by underscoring that participants regard “scientific unknowns” as viable targets for further inquiry, while “religious unknowns” do not (Davoodi & Lombrozo, 2022b). In addition, Davoodi and Lombrozo (2022a) demonstrated in three studies that scientific explanations are more closely tied to epistemic aims (i.e., knowledge acquisition and enhancement), whereas religious beliefs serve non-epistemic aims (i.e., fulfilling social, moral, emotional, aesthetic, and/or pragmatic functions).

A study conducted by Wagner and colleagues (2000) in North India illustrates how individuals assign different values to religious and scientific beliefs by examining how North Indians make sense of mental illness. While all participants in this study expressed that they would personally take a family member with a mental illness to a psychiatrist rather than to a traditional healer, they acknowledged that this personal choice might be disapproved by other family members, who generally preferred using traditional methods. Furthermore, some participants, even those with stronger preferences for psychiatric treatments, were willing to let their family members visit traditional healers. In doing so, participants believed that traditional healers still had a place, but only in maintaining harmony among family members. Interestingly, one participant explicitly stated that there are certain types of patients that only traditional healers can cure, such as those who place great importance on religion and traditions, do not believe in modern medicine, or distrust doctors. The same participant argued that both approaches have their own merits, but determining which one is better is contingent on the context: traditional healing is appropriate in one social context and modern psychiatry is a legitimate treatment method in another. Here, participants in this study attributed non-epistemic values (i.e., kinship, social ties) to religious beliefs and epistemic values to factual (i.e., scientific) beliefs and, thus, scientific and religious beliefs could coexist.

This line of evidence supports the notion that individuals can distinguish explanations of natural phenomena from religious beliefs, ascribe different values to each and, thus, may engage with and use both religious and scientific explanations to achieve different goals, paving the way for explanatory coexistence (Busch et al., 2017; Legare et al., 2012; Legare & Visala, 2011).

***Explanatory Coexistence.*** According to the evidence we reviewed in the previous subsections, scientific and religious beliefs can coexist in people’s minds (i.e., explanatory coexistence); yet, people attribute different values (i.e., epistemic vs. non-epistemic values) to these beliefs, and use them for different purposes. While the prevalence of this phenomenon varies across different cultural contexts, religious, and educational backgrounds as well as age groups, explanatory coexistence is not unique to any single culture; rather, it is considered a universal phenomenon (Busch et al., 2017; Clegg et al., 2019; Haimila et al., 2022; Legare et al., 2012; Legare & Gelman, 2008; Legare & Visala, 2011; Shtulman & Legare, 2020).

By building upon cross-cultural data on how individuals navigate scientific and religious beliefs in these three domains, Legare and Visala (2011) propose a taxonomy of "coexistence thinking." This taxonomy consists of three strategies individuals use to relate scientific and religious explanations, which they call target dependent, synthetic, and integrative thinking (Legare et al., 2012; Legare & Visala, 2011).

First, target dependent thinking denotes an idea that individuals apply scientific and religious explanations to distinct aspects of a given phenomenon (Legare et al., 2012; Legare & Visala, 2011). Two studies investigating how individuals explain the concept of death with Ni-Vanuatuan adults (Watson-Jones et al., 2015) and Swedish children (Ahmadi et al., 2019) show that participants in both studies, regardless of their age group and cultural background, use scientific and religious explanations in parallel to conceive different aspects of death. Scientific beliefs were used to describe a matter of fact about death (e.g., "…a body that go down to the ground," or "…you're under the ground and never live again"), while religious beliefs were exclusively applied to the explanation of the afterlife (e.g., "…bad people go to hell," or "…life goes back to God").

Second, synthetic thinking reflects a strategy of partially integrating scientific and religious explanations of the same aspect of a given phenomenon (Legare et al., 2012; Legare & Visala, 2011). Individuals applying synthetic thinking loosely combine scientific and religious explanations to the same aspects of a given phenomenon, without clearly elaborating how these competing or unrelated explanations can be coherently related (Legare et al., 2012). An illustrative case of this type of reasoning is reflected in a study of how Ugandan adults explain the cause of epilepsy (N. Sanchez et al., 2021). Participants in this study simultaneously believed both biological and supernatural causal factors for epilepsy, suggesting that sufferers should seek medical treatment while also maintaining religious faith for healing (i.e., "Take your child to the hospital and believe in God that the child will get better"). Yet, participants did not provide a clear rationale for how medical treatment and a prayer to God can jointly contribute to recovery (N. Sanchez et al., 2021).

Third, integrative thinking strives to fully integrate scientific and religious explanations into a coherent causal explanation (Legare et al., 2012; Legare & Visala, 2011). Here, individuals assemble religious and scientific explanations into a single causal chain, with scientific explanations as the proximate cause and religious explanations as the ultimate cause, or vice versa (Legare et al., 2012). For example, 38% of South African adults who tried to make sense of the cause of acquired immunodeficiency syndrome (AIDS) (Legare & Gelman, 2008) combined supernatural (i.e., religious) and scientific explanations (e.g., "Because of jealousy, someone might send a spell to make someone with AIDS sleep with him," see Legare & Gelman, 2008, p. 635). Here, witchcraft serves as a distal cause of AIDS (i.e., the "why") and scientific beliefs offer an answer to the "how" AIDS is transmitted (i.e., the proximal cause).

A meta-analytic study that included 45 studies published between 1985 and 2016 identified several factors that can explain the prevalence of explanatory coexistence (Pnevmatikos & Georgiadou, 2019): age, culture, religiosity, scientific expertise, and situational factors (e.g., family upbringing and intercultural exposure). These factors contribute differently to the prevalence of explanatory coexistence. Specifically, religiosity was found to have a greater impact on the prevalence of coexistence in the domain of death, while culture was found to have a large impact on the domain of illness (Pnevmatikos & Georgiadou, 2019). Furthermore, situational factors predicted the prevalence of coexistence when it comes to explaining the origins of life. Age and scientific expertise had small to moderate effects on the prevalence of coexistence in the three domains, but it is important to note that a pooled effect size of scientific expertise was aggregated only from a small number of studies (Pnevmatikos & Georgiadou, 2019).

***Epistemic Beliefs.*** Tapping into the mechanism that undergirds scientific and religious beliefs would allow us to gauge how lay individuals relate science to religion. Executive functions (i.e., general cognitive abilities and styles or "cold cognition") may not fully explain why people have different viewpoints about the science-religion relationship. Instead, understanding how people conceptualize the epistemological dimension and underlying principles of scientific and religious explanations can provide a better understanding of how people relate science to religion. Specifically, we argue that people's epistemic beliefs can provide insights into how people conceptualize the relationship between science and religion.

Epistemic beliefs represent a "multidimensional system of beliefs" (Chinn et al., 2011) about the nature of knowledge and knowing (Conley et al., 2004; Hofer & Pintrich, 1997; Schiefer et al., 2022) and navigate individuals' engagement with diverse forms of information (Schommer-Aikins, 2004). Epistemic beliefs play a pivotal role in regulating how individuals inspect and reflect upon their own beliefs (Hofer, 2004), thereby influencing the extent to which processing rules can be applied to diverse forms of information (Chinn et al., 2011; Hofer & Pintrich, 1997). Epistemic beliefs are known to be positively associated with various aspects of learning (Chinn et al., 2011; Schiefer et al., 2022), better science achievements, academic performance, and aspiration to pursue a career in science (Cartiff et al., 2021; Greene et al., 2018; Guo et al., 2022).

Previous research has sparked a scholarly discussion about epistemic beliefs, which are beliefs about knowledge and how it is acquired, used, and evaluated (Chinn et al., 2011; Hofer & Pintrich, 1997; Urhahne & Kremer, 2023). The literature suggests that there are four key aspects to these beliefs: certainty and development, which are core beliefs about what knowledge is, and source and justification, which are central beliefs about how we form and evaluate knowledge (Buehl, 2008; Conley et al., 2004; Hofer & Pintrich, 1997; Schiefer et al., 2022). Certainty denotes the extent to which individuals perceive knowledge as tentative and acknowledge the coexistence of multiple solutions to complex problems. Development encapsulates the belief that knowledge continuously evolves in response to new methods, tools, and evidence. Source concerns the emphasis on critical scrutiny and analytical thinking in the process of knowledge generation, which disregards the notion of adherence to external sources such as authorities. Finally, justification highlights the conviction that knowledge must be suitably supported by evidence from rigorous observation or experimentation (Schiefer et al., 2022; Urhahne & Kremer, 2023).

Epistemic beliefs become more mature over the course of schooling as individuals' knowledge base grows (Kuhn et al., 2000), and its development follows four stages described by Kuhn et al. (2000): realist, absolutist, multiplist, and evaluativist. However, there is no exact timetable for the development of epistemic beliefs (Tabak & Weinstock, 2008) and individuals may not necessarily progress through all of them in a linear fashion (Kuhn et al., 2000).

When epistemic beliefs are at the most mature stage (i.e., evaluativist), individuals internalize collectively shared norms of knowing. For example, when confronted with two opposing arguments, each with some degree of truth, evaluativists may estimate which argument is more grounded in principles by applying these shared norms as guiding criteria. They compare, evaluate, and weigh different standpoints of one issue and are motivated to find common grounds and, subsequently, integrate the conflicting viewpoints in a more sophisticated manner than individuals with lower epistemic maturity (Kuhn et al., 2000).

One example of how such epistemic maturity could look has been described by Gottlieb and Wineburg (2012): Historians who participated in this study were given a think-aloud task, where they were asked to examine and comment on eight documents from various sources (e.g., scholarly articles, popular articles, children's books, and Bible verses) related to the story of Exodus. One of these documents dealt with historical evidence of the Egyptians joining the Israelites in the Exodus. One participant, a Jesuit priest and a history professor at a Catholic university, found this document particularly interesting and simultaneously elaborated upon the text from two perspectives: a theologian's and a historian's perspective. Specifically, this participant wondered whether the scripture mentioned anything about Egyptian refugees. At the same time, their historical side pointed out that even if it did not, it was very likely that the described event (i.e., the Egyptians joining in the Exodus) would have happened. Gottlieb and Wineburg (2012) argue that this participant demonstrated "a fluid mental shift" (i.e., epistemic switching) from one set of assumptions about the world to another because scientific and religious explanations were equally important to this person. Yet, when reading another document, which contained a critical history analysis highlighting the lack of archaeological evidence supporting the Biblical version of the Exodus, the same participant mentioned that they liked the scientific rigor that was applied here, but that the text was missing "the miraculous elements" of the Exodus as described in the scripture, that is, the moral layer embedded in the story (Gottlieb & Wineburg, 2012, p. 104). The example shows how individuals can successfully negotiate scientific and religious criteria when evaluating a piece of information.

### ***Motivational Factors***

While we have previously examined how individual differences in personality and cognitive factors may impact perceptions of the relationship between science and religion, it is also important to consider the role of motivational factors. In this section, we will explore several motivational factors, such as moral beliefs and social identities, that contribute to the diversity of perspectives people hold when relating science to religion. Considering these factors, we can better understand how the underlying psychological processes shape people's views of the science-religion relationship.

***Moral Beliefs.*** Contemplating the relationship between science and religion can be emotionally challenging. The role of emotion is evident in many prior studies, highlighting the suspicion that when there is an increasing divide between scientific and religious explanations, these disagreements can evoke a state of cognitive dissonance and, consequently, lead to emotional turmoil (Yasri & Mancy, 2012). A previous study has shown that contemplating the conflict between science and religion can trigger physiological responses (Bland & Morrison, 2015), indicating the presence of emotional arousal. Additionally, classroom interventions aimed at enhancing students' comprehension of scientific knowledge that contradicts literal religious beliefs (e.g., evolution) may also have emotional costs for both students and teachers (E. M. Evans, 2008). Such affective responses are also reflected in qualitative studies dealing with students' struggles learning science and religion at school (Fysh & Lucas, 1998; Shipman et al., 2002).

The compatibility of science and religion is likely a deeply moral issue for many, if not most, people. This moral dimension may explain why construing the relationship between the two can evoke moral emotions such as guilt, shame, anger, and disgust. Similar to other morally relevant issues, the more individuals believe that conceptualizing the relationship between science and religion is strongly connected to their internalized moral principles, the more likely they are to respond to views that differ from their personal opinions with stronger emotional reactions (Skitka & Wisneski, 2011). In other words, when the relationship between scientific and religious explanations becomes a moral issue, it can no longer be seen as a matter of epistemological preference.

While many scholars have examined this relationship from an epistemological standpoint, some have called for a closer examination of the moral dimensions of the science-religion interplay (Baker et al., 2020; J. H. Evans, 2011, 2013, 2018; J. H. Evans & Evans, 2008). According to these scholars, the relationship between science and religion is fundamentally a moral issue rather than simply an epistemological one. Despite these calls for greater attention to the moral dimensions of the science-religion conflict, there has been comparatively little research in this area.

Previous scholarship has characterized the "moral conflict" between science and religion in several ways. Some have focused on the competition for cultural authority between scientific and religious institutions (J. H. Evans, 2018; Scheitle et al., 2018), while others have suggested that scientific claims threaten the legitimacy of religious worldviews by implicitly conveying moral messages (J. H. Evans, 2013). Additionally, scholars have argued that scientific research involving modifying living organisms, primarily through technologies that may violate moral principles such as purity, represents a moral conflict between science and religion (J. H. Evans, 2018). For example, some scholars have conceptualized disgust as an emotional response to violations of purity norms, particularly when an individual transgresses against God's rules (Graham et al., 2013; Rozin et al., 1999). Previous research has suggested that this emotion may explain why individuals feel uneasy about certain scientific research and technologies that may be seen as violating the sanctity of God's creations, such as animal biotechnology (Thompson, 1997), genetically modified organisms (GMOs) (Scott et al., 2018), and transhumanist technologies (Laakasuo et al., 2018).

However, it is important to note that disgust may also arise in response to harmful acts, not just violations of purity (Giner-Sorolla & Chapman, 2017). In light of this, it is unclear why being a religious scientist would be seen as harmful or a violation of purity by some people (Fysh & Lucas, 1998). While the perception of harm and purity may paint a picture of why some religious individuals feel uncomfortable about certain scientific findings, it does not fully explain why religious scientists are viewed as "hypocritical" or "deluded" (see Fysh & Lucas, 1998). Thus, we suggest that a narrow, specific domain of moral principles corresponding to epistemic aims may also be at play in shaping these attitudes.

Interestingly, research suggests that rationality can be moralized itself (Russel, 2001; Ståhl et al., 2016). This moral conviction also reflects William K. Clifford's ethics of beliefs, which states that "it is wrong always, everywhere, and for anyone, to believe anything upon insufficient evidence" (Clifford, 1877, p. 168). In psychology, Ståhl and colleagues (2016) have explored whether rationality and justification are morally laden issues. They found that moralizing rationality is a dispositional attitude that varies between individuals, is relatively stable over time, and is conceptually different from the general domain of morality (e.g., utilitarian and deontological inclinations). They also found that those who moralize rationality are likely to experience negative moral emotions towards irrational behavior, think that an irrational actor deserves punishment, and engage in activism to impede the spread of irrational beliefs (Ståhl et al., 2016). Investigations into "moralizing rationality" have provided crucial insights into how epistemic moral principles can guide individuals about what to believe (or disbelieve) and how these principles are conceptually and empirically distinct from general moral domains such as purity and harm (Ståhl et al., 2016; Ståhl & Turner, 2021; Ståhl & van Prooijen, 2018). We speculate that viewing epistemological choices as a morally laden issue may uniquely explain people's viewpoints regarding the relationship between science and religion.

But what happens when the same evidence leads two people to arrive at two different conclusions? Findings show that individuals consider moral beliefs as acceptable justifications for evidence-deficient propositions because they lower the evidential threshold required to believe, especially when they consider the explanations to be morally valuable (i.e., the evidence criterion shifting hypothesis, see Cusimano & Lombrozo, 2021). For example, when parents suspect that their children are doing something bad, they may require much more evidence to decide whether their children are actually doing something bad (or not) than to decide whether their neighbors' children are doing something bad. In this way, moral beliefs ("helping kin" in our example, see Curry et al., 2019) shift the evidentiary standard by which parents judge what to believe. People tend to perceive their morally justified beliefs as legitimate and ideal, even when these beliefs lack factual evidence, and most importantly, they are aware of the influence of moral biases in their beliefs (Cusimano & Lombrozo, 2023).

***Epistemic Needs and Motives.*** Previous literature has investigated that embedding science and religion in one's self-concept can fulfill the need for explanations, control, and existential meaning (Rutjens & Preston, 2020). While the need for control and existential meaning was almost exclusively associated with religion (Inzlicht et al., 2011; Saroglou, 2014a), some evidence paints a different picture: Science can also fulfill these needs, especially for those who are nonreligious (Davoodi & Lombrozo, 2022a; Farias et al., 2013; Preston, 2011). In fact, one study shows that under conditions of heightened stress and mortality anxiety, individuals are more likely to believe in science (Farias et al., 2013). And further, nonreligious individuals have indicated stronger convictions that science provides them with a sense of meaning compared to religious individuals (Haimila, 2020).

Similarly, a stronger belief in the progress of science and technology was found to be associated with increased personal control and higher life satisfaction (Stavrova et al., 2016). A more extensive study involving nonreligious participants in ten countries revealed that pro-science beliefs (i.e., a general belief in science, scientific epistemology, expertise, and authority) were central for shaping people's worldviews and for providing them with a sense of meaning and moral guidance, even more so than other alternatives (e.g., humanism, equality, freedom, etc., see van Mulukom et al., 2022).

Religious (vs. science) identity may also be closely linked to individuals' ontological beliefs concerning what can and cannot be known and what can and cannot exist, and these beliefs are collectively shared among group members (Nelson, 2006). Therefore, we suspect that the role of epistemic beliefs in shaping the variety of viewpoints people hold about the science-religion relationship is contingent on individuals' sense of social identity. Additionally, given that individuals' moral beliefs are often crucial aspects of their identity (Strohminger & Nichols, 2014), we speculate that the effect of moral beliefs we reviewed before on shaping one's perception regarding the science-religion relationship is also contingent on the level of one's sense of belonging to a certain social group.

Social Identities and Ideology. Beliefs about science, religion, and their relationship might be used as a basis for social identity. Individuals may internalize their membership in a "religious" or "scientific" community, along with its in- and out-group boundaries and shared norms. Consequently, how people think about the science-religion-relationship might be critical to their self-concept, deriving a sense of collective self-esteem from their specific membership, which they are motivated to uphold (Crocker & Luhtanen, 1990; Leicht et al., 2021).

According to Van Leeuwen (2014, 2017a, 2017b), religious identity may affect individuals to add normative elements to plain, descriptive explanations. Further, religious identity involves emotional fervor, "powerful, sacred worldviews", which are resilient against questioning or scrutiny, and provide people with a sense of eternal group belonging (Ysseldyk et al., 2010). On the other hand, science identity comprises recognition and emotion (Avraamidou, 2020).

From a social identity perspective, individuals with a stronger sense of religious (vs. science) identity will likely perceive a conflict when considering the relationship between science and religion. Similarly, individuals are likely to align their views on the science-religion relationship with the perceived consensus within their community (Ecklund & Park, 2009; Kobayashi, 2018). For example, individuals with a stronger identification as scientists might perceive science and religion as being at odds and may specifically prefer a science-trumps-religion view. In a study by Scheitle and Corcoran (2021), graduate students were inclined to construe a conflict as an expression of solidarity with peer scientists, especially those working in scientific disciplines that are more likely at odds with religion (e.g., evolutionary science). On the contrary, individuals reporting a stronger religious identity may endorse a religion-trumps-science view (Baker, 2012; J. J. Lee, 2022) and perceive science as a threat to their social identity (Baker, 2012). These findings suggest that the mental conceptualization of the science-religion relationship may be expressed as motivated reasoning (Kunda, 1990) as it arises from the sense-making process of one's membership in a particular social group. In that case, the focus may be less on knowledge enhancement and more on maintaining a positive self- or group-image.

Scholars have pointed out that individuals' social identity is often construed by simultaneously interweaving the strands of multiple memberships in many social groups. Some social groups may be entirely encapsulated in others (e.g., all self-categorized Christians are religious). Some are completely independent (e.g., all Christians are not Muslims). Still, some may only partially overlap (e.g., some scientists are Christians). Research on social identity complexity (SIC) has scrutinized how individuals navigate and make sense of multiple social categories and suggested that individuals may perceive that these categories intersect, dominate (over another), are compartmentalized or merged, leading to a phenomenon called biculturalism (Roccas & Brewer, 2002).

According to SIC theory, when people feel that their multiple group memberships greatly overlap, they tend to have a simpler, less inclusive identity structure. For instance, someone who is both scientist and nonreligious may think of their scientist peers as consisting predominantly of nonreligious individuals, while perhaps overlooking the fact that there are also some religious scientists. Conversely, when identifications of multiple group memberships only partially overlap, social identities can become more complex, rendering a cross-categorization phenomenon (Migdal et al., 1998; Roccas & Brewer, 2002). Awareness of the possibility of cross-categorization would benefit individuals because they may be less prone to intergroup biases (Brewer, 2010; Prati et al., 2021; Roccas & Brewer, 2002). From this standpoint, some individuals may simultaneously identify as part of "scientific" and "religious" communities. These memberships can be equally integral to their self-concept, yet the categorizations based on these memberships can be perceived as only partially overlapping. If that were the case, individuals may allow more congenial viewpoints when construing the relationship between science and religion, leading to the "non-conflict" view.

In contexts where scientific and religious institutions are engaged in a power struggle for cultural authority, individuals' religious (vs. science) identities are prone to politicization (S. K. Mehta et al., 2021), potentially leading to exclusionary ideologies, such as religious fundamentalism (Altemeyer & Hunsberger, 2004; Brandt & Reyna, 2010) or scientism (i.e., a strong belief in the superiority of science over any other modes of insight; Francis et al., 2018; Haack, 2012; Ridder et al., 2018). Extensive research has indicated that religious fundamentalism (J. H. Evans, 2013, 2013; J. J. Lee, 2022; Longest & Smith, 2011; Noy & O'Brien, 2016; O'Brien & Noy, 2018) as well as scientism (Astley & Francis, 2010; Francis et al., 2018) predict perceptions of a conflict between science and religion. Moreover, these ideologies may be intertwined with other closely-related ideologies, such as conservatism (Baker et al., 2020; J. J. Lee, 2022; Longest & Smith, 2011; Stankov & Lee, 2018) and secularism (Beauchamp & Rios, 2020; Simpson & Rios, 2019; Ståhl, 2021), further fueling perceptions of conflict between science and religion.

## Under What Circumstances Do Individuals Conceptualize the Relationship Between Science and Religion Differently?

In the previous section, we discussed how individual differences, cognitive, and motivational factors can shape an individual's perception of the relationship between science and religion. It is important to acknowledge that conceptualizing the science-religion relationship is also contingent on cultural and social factors (Rutjens et al., 2018, 2022). By considering these contextual factors, which we will review now, we can gain a more comprehensive understanding of how the relationship between science and religion is perceived and interpreted by individuals within their specific cultural and social contexts.

### *Rearing Practices*

Child-rearing practices are shaped by familial and community values and involve belief transmission from parents to children (N. Quinn, 2005). During early childhood, children rely on parental testimony and consensus (Davoodi et al., 2019) to understand their world, including science and religion. As they enter school, they experience a "border-crossing" (Aikenhead, 1996), where those raised with an appreciation for science are better equipped to navigate the cultural shift to the subculture of science in schools (Aikenhead, 2001).

Building upon the premise that the perception of the science-religion relationship is a morally loaded belief, parents may likely pass down their own beliefs to their children (Davoodi et al., 2019; Rozin, 1999). Substantiating this suspicion, a study shows that Iranian parents who value both scientific and religious explanations but tend to privilege science over religion (Payir et al., 2018) and, similarly, Jewish parents in the U.S. who tend to convey a view of science and religion as complementary, are likely to share similar beliefs with their children (Goodall & Ghent, 2014).

Finally, studies have examined how scientists' upbringing influences their beliefs about the compatibility of science and religion. Scientists raised in families where religion was never important tend to view science and religion as adversaries, while those with a religious upbringing and remain religious tend to endorse a "non-conflict" view (Ecklund & Park, 2009). Interestingly, scientists with a religious upbringing who later reject religious faith (i.e., "religious dones") tend to hold stronger views of a "conflict" view than those without religious upbringing and remain nonreligious (Ecklund & Park, 2009). This suggests that parental rearing practices are not entirely detached from individuals' quest for spirituality; therefore, both can also shape people's beliefs regarding the science-religion relationship.

### *Cross-Cultural Exposure*

The role of culture in shaping how people relate science to religion has been noteworthy. For example, in several worldwide surveys we reviewed above, individuals living in North America, Western, and Southern Europe typically were more likely to support the "conflict" view (Bell et al., 2013; Johnson et al., 2020; Kostyukov, 2019). This was explained by their endorsement of secularism, which is generally skeptical of the idea of coexistence between science and religion (Beauchamp & Rios, 2020). According to studies conducted in Israel, the United States, and China, culture can also shape the development of epistemic beliefs, as cultural values, such as conceptions of knowledge, identity, and authority, can differ in meaning across cultures and significantly affect classroom interactions (Buehl, 2008; K. Chan & Elliott, 2004; Tabak & Weinstock, 2008). As a result, individuals of the same age but from different cultural backgrounds may not reach the same stage of epistemic beliefs, leading to varying views of the science-religion relationship (Tabak & Weinstock, 2008).

For example, the concept of "authority" may not be similar between societies with lower power distance that emphasizes equality and participation, and those that accept and socially enforce respect for authority (Hofstede & Bond, 1984). Consequently, individuals from cultural backgrounds that place a high value on respect for authority may be inclined to expect authoritative figures to pass on knowledge to them, while such a concept is less valued in other societies (K. Chan & Elliott, 2004).

Cross-cultural exposure allows individuals to be reflective in their personal knowledge construction (Collier, 2015); yet, only a limited number of studies have looked at how such exposure influences the science-religion relationship. A recent study by Rios and Aveyard (2019) demonstrated that Emirati Muslim students who spent several weeks per year living in Western countries reported a stronger conviction that science and religion are at odds. By contrast, longer overseas stays did not impact U.S. students' perception of the science-religion relationship (Rios & Aveyard, 2019). This finding suggests that cross-cultural exposure may not necessarily lead to a more fine-grained interpretation of science and religion, particularly when exposed to Western values such as secularism (Beauchamp & Rios, 2020). Importantly, it should be noted that the study assumed that Emirati participants held a "non-conflict" view before their overseas stays and did not compare participants' beliefs before and after exposure to Western values. Thus, further research is necessary to fully understand the effects of cross-cultural exposure on how people relate science to religion.

## Mental Conceptualization of the Science-Religion Relationship: A Flowchart

Previously, we have argued that cognitive factors, most importantly, epistemic beliefs, and motivational factors, like social identity and moral beliefs, are essential antecedents of the variety of ways people relate science to religion. To paint a clearer and more structured picture of how these factors play their roles, we have created a flowchart, visually illustrating the process (see Figure 1). It depicts how these antecedents lead to an integrative contemplation of the science-religion-relationship through "coexistence thinking" (Legare et al., 2012; Legare & Gelman, 2008).

This process, in turn, determines whether individuals adopt a “conflict” or a “non-conflict” view on the science-religion relationship.

Starting from the top of Figure 1, when encountering a specific observation prompting the need for explanations, individuals may think of scientific and/or religious explanations, which can be more or less competing. Broader personality traits (such as openness, extraversion, or agreeableness), as well as narrower traits (such as tolerance for ambiguity, need for cognitive closure, intellectual humility, or dogmatism), may facilitate (or hamper) individuals’ willingness to reconcile scientific and religious explanations. However, navigating through their competing nature, some cognitive and motivational factors are considered necessary conditions for utilizing “coexistence thinking.” These conditions are symbolized as two decision diamonds, “cognitively prepared” and “motivated to reconcile” religious and scientific explanations, as seen in the top left of Figure 1.

To adopt non-conflict views, individuals must be motivated to reconcile scientific and religious explanations (Legare & Visala, 2011), and as argued earlier, individuals may align their perception of the science-religion relationship according to their motivational states (i.e., internalized social identities and moral beliefs). Therefore, it is likely that people reconcile scientific and religious explanations because they are motivated to construct a rich and nuanced understanding of the world (i.e., knowledge enhancement motives), but it can also be that they want to paint a coherent picture consistent with their prior beliefs (i.e., belief confirmation motives). As a result, endorsing non-conflict views may reflect a thorough, deliberative rumination about the world we live in, but it may also be heuristics stemming from motivated reasoning.

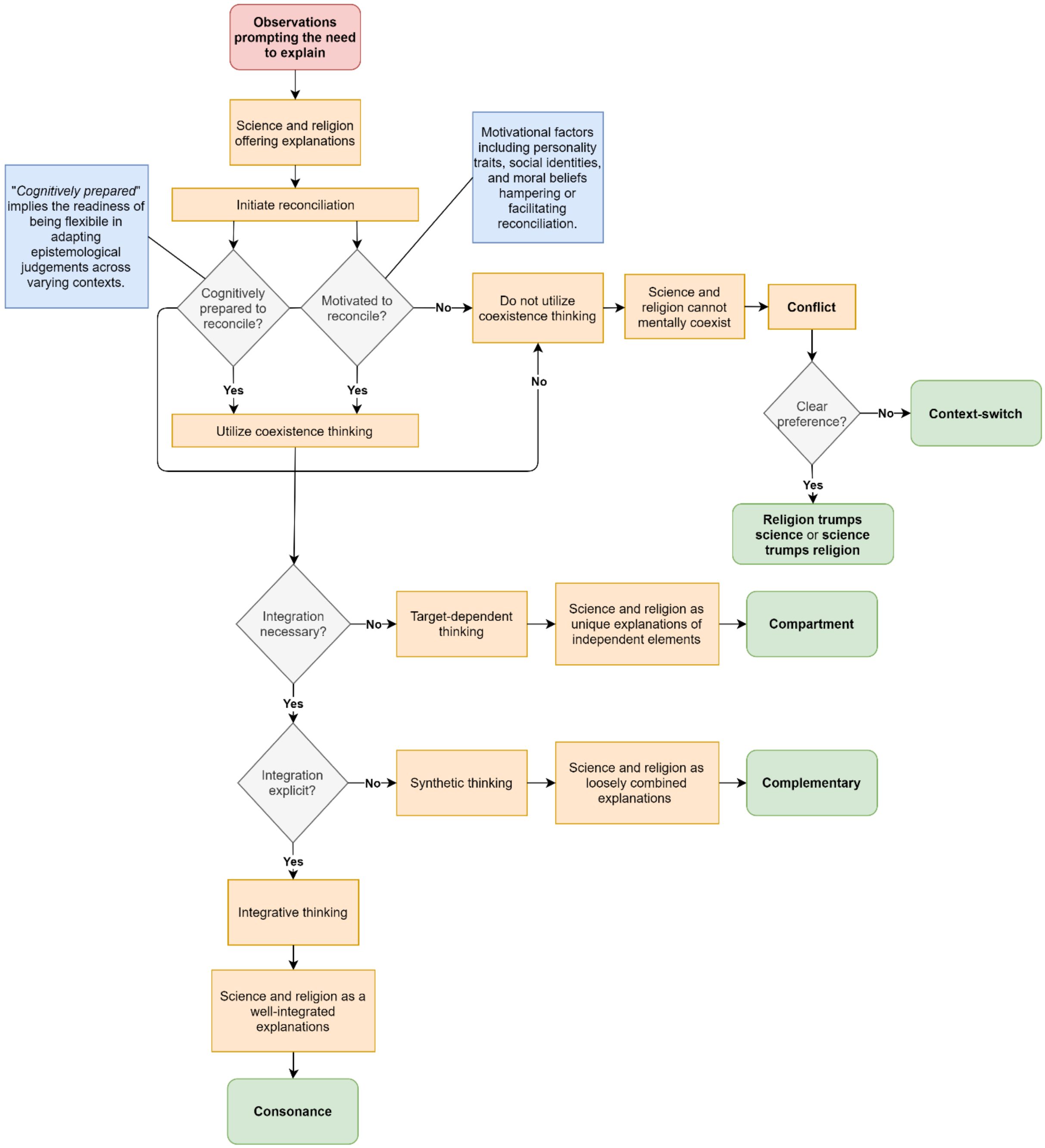


**Figure 1.** Annotated Flowchart Depicting End-to-End Process of Mentally Relating Science to Religion

The second necessary condition for utilizing "coexistence thinking" is that an individual needs to be cognitively "prepared" to do so. By "cognitively prepared," we mean that individuals can make adapted, context-sensitive epistemological judgments, which denotes the maturity of epistemic beliefs (Bromme et al., 2008; Kienhues & Bromme, 2011). This “flexibility” is particularly useful when encountering conflicting explanations and uncertain situations (Kienhues & Bromme, 2011). Individuals with more epistemic flexibility are better prepared to apply different sets of assumptions when considering scientific and religious explanations, allowing them to make epistemological judgments in a more flexible fashion (Bromme et al., 2008) and to simultaneously utilize religious and scientific explanations through coexistence thinking without (or with minimal) cognitive dissonance. While coexistence thinking reflects deliberative, effortful reasoning, it is not necessarily indicative of one’s cognitive abilities because people across different cultural backgrounds and developmental stages, regardless of their cognitive ability, are found to utilize this type of reasoning to simultaneously make sense of religious and scientific explanations (Legare & Gelman, 2008; Legare & Visala, 2011), as we previously argued in the earlier section.

Those who believe that science and religion are equally integral to their identity and moral principles may be more motivated to reconcile science and religion. If that were not the case, individuals might instead reject the idea of a coexistence between science and religion, thus espousing the “conflict” view. At the top-right of Figure 1, we show that when individuals hold the “conflict” view with a clear preference, they may endorse either the religion-trumps-science or the science-trumps-religion view. If they have no strong preferences, they may support the context-switch view.

As we previously reviewed, coexistence thinking is composed of three types of processes, which differ in their degree of integration: target-dependent, synthetic, and integrative thinking (Legare et al., 2012; Legare & Visala, 2011). The extent to which types of coexistence thinking are utilized is contingent on whether individuals think that (1) integration between scientific and religious explanations is necessary and (2) this integration is aimed to produce a fully unified causal explanation (as displayed by two decision diamonds in Figure 1). Each type of coexistence thinking prompts a unique view of the relationship between science and religion.

When individuals believe that integrating scientific and religious explanations is unnecessary, they may use target-dependent thinking (Legare et al., 2012; Legare & Visala, 2011). In that case, individuals may appeal to science and religion to explain independent elements of a given phenomenon, depending on the context or target (Legare et al., 2012). Consider the case of Ayesha, a doctor seeking to explain their patient’s death by simultaneously using her scientific and religious beliefs. She may explain to the grieving family members that their loved one has died due to a clogged aortic valve, but she may console the patient's family by saying that the patient's soul is now resting in peace in God's loving arms. By doing so, Ayesha uses scientific and religious explanations to discern different aspects of death: science addresses the cause, while religion provides explanations of the afterlife.

If integration is considered necessary but does not have to be unified and coherent, individuals may go through synthetic thinking (Legare et al., 2012; Legare & Visala, 2011), believing science and religion can be used simultaneously to explain the same aspect of a certain phenomenon, albeit without clear or explicit integration. Consider again the previous example: While Ayesha may explain the medical cause of death to the grieving family members, she may also console the patient's family by saying that death is predestined by divine power. Ayesha may further explain that this type of disease usually runs in families because the risk of having a clogged aortic valve is doubled when a first-degree family member has the disease. Perhaps, it is God's unique way of alerting surviving family members to pay more attention to their health. Here, Ayesha employs scientific and religious explanations simultaneously to make sense of the cause of death: science provides a bodily mechanism causing the patient's death, while religion suggests normative components (i.e., a reminder for family members to protect their health) as the cause of death. Nevertheless, the amalgamation between scientific and religious explanations (e.g., "Why did God choose this family to carry the risks, but not another family?") is less important to her.

Furthermore, individuals may utilize integrative thinking if they believe scientific and religious explanations can be combined to produce a unified causal explanation (Legare et al., 2012; Legare & Visala, 2011). In that case, individuals may use religious beliefs as an explanans (i.e., statements, principles, or laws providing the explanatory basis) and scientific explanations as an explanandum (i.e., events or observations to be explained), or vice versa. Suppose Ayesha, the doctor, is a Muslim who believes that the human soul would be "pulled out" by an angel at the end of their life, separating the soul from the body. During this process, Ayesha believes that the deceased's soul would be fully "aware" of their surroundings, even "feeling" the pain from the separation. One day, Ayesha reads an article about an electroencephalogram (EEG) study on near-death experiences reporting the presence of upsurge, abnormal electrical activities inside a human's brain only a moment before the dying brain completely stops working, which signals a hyper-alert state before death. The article prompts Ayesha to wonder whether this “electrical jump” inside the human brain may align with her religious beliefs: perhaps this upsurge represents a physiological response when the body is separated from the soul. Here, Ayesha explicitly integrates religious and scientific explanations as a parsimonious causal explanation by utilizing scientific explanations as corroboration of her religious beliefs.

Again, the decision diamonds in this part of the flowchart are likely differentially impacted by personality traits. For example, in the middle right of Figure 1, individuals with a higher tolerance for ambiguity may be less likely to favor scientific over religious explanations or vice versa, leading them to hold a context-switch view. Additionally, while those with higher openness to experience might display a stronger inclination to reconcile scientific and religious explanations (Hanley et al., 2014), as we elaborated on in the previous section, individuals with a higher need for cognitive closure may be more inclined to explicitly combine the nonrelated (or competing) scientific and religious explanations into a unified causal explanation (i.e., a consonance view) – a process depicted in the lower-left of Figure 1. When encountering two (possibly competing) explanations, individuals with a higher need for cognitive closure may strive for a definitive answer and, thus, are more motivated to seek a complete resolution between scientific and religious explanations (Webster & Kruglanski, 1994, 1997). Allowing two competing explanations to coexist without explicit corroboration can cause discomfort for individuals with a higher need for cognitive closure (Webster & Kruglanski, 1997) and, as a result, these individuals may employ scientific explanations to support their religious beliefs or vice versa.

It is important to note that people may value science in general, yet dismiss specific scientific explanations if they are inconsistent with their religious beliefs. On some occasions, individuals may rationalize their rejection by misconstruing certain elements of scientific explanations as “unscientific,” thus strategically masking their true reason for rejecting these beliefs (i.e., the inconsistency with religious explanations). This rationalization – which has been referred to as the “scientific impotence excuse” (Munro, 2010), which is, in turn, a special case of motivated science rejection (Lewandowsky & Oberauer, 2016; Washburn & Skitka, 2018) – is a symptom of perceptions of a “conflict” between science and religion because, at a deeper level, religious beliefs are the true reason for denying scientific explanations.

Hildering, Consoli, and van den Born (2013) provide a vivid illustration of this phenomenon. In their study, a subgroup of highly religious participants rejected Darwinian evolution because it fundamentally conflicted with their religious beliefs, but went on to argue that scientific investigations to elucidate the evolutionary process in the past could not be reproduced in the present. Therefore, they argued that evolution could not be regarded as a well-justified science. Despite this dismissive view of evolutionary science, they all believed that science in general plays an important role in society and that scientists, even those who work in evolutionary science, are sincere, honest, and trustworthy persons in general.

More importantly, it is also possible that a person may invoke different types of coexistence thinking to perceive the science-religion relationship in different domains. For example, one may invoke target-dependent thinking (e.g., “the body decays but the soul stays in the purgatory”) to explain death but invoke integrative thinking (e.g., “I disregarded physical distancing and thus, neglected the welfare of others, and now I believe God is punishing me with a coronavirus infection”) to explain the cause of illness. This can lead to different mental models for different domains or topics (Elsdon-Baker et al., 2017; Leicht et al., 2021).

At last, the detailed processes do not happen in a vacuum but are embedded in wider situational factors, including modulations by family (Payir et al., 2018), school (Tabak & Weinstock, 2008), and cultural values (Beauchamp & Rios, 2020; Vaidyanathan et al., 2016). A negative perception of secular values held by individuals, for example, may affect them holding a conflict view with a clear preference for religion (Beauchamp & Rios, 2020), while upholding secular values may render individuals inclined towards a non-conflict to embrace a compartment view (Gould, 1999).

In sum, the flowchart integrates cognitive factors by building strongly on the theory about epistemic beliefs. It also considers various motivational factors, especially their influence on the motivation to engage in coexistence thinking. Lastly, the flowchart also demonstrates how motivational factors can facilitate individuals to utilize specific types of coexistence thinking,

## Conclusion

Do people think of science and religion as longtime nemeses or cordial allies? This review shows that the mental conceptualization of the relationship between science and religion is nuanced and multifaceted, and individuals may have various viewpoints when contemplating this topic. The present article provides a comprehensive, integrative review of the literature on this topic, exploring how people mentally conceptualize this relationship and how these conceptualizations can be systematized. Additionally, we discuss how interindividual differences (such as epistemic beliefs, identity, and personality) and contextual factors (such as rearing practices and cross-cultural exposure) are related to these mental conceptualizations.

One of the central conclusions here is that the "conflict" view – perceiving science and religion as two irreconcilable and mutually exclusive epistemic authorities – is not the only viewpoint held by people. Instead, we adopt a variety of mental conceptualizations reflecting our unique experiences, beliefs, and values. Some individuals might view science and religion as "non-conflicting" ways of understanding independent domains of the world, while others see science and religion as two related domains that complementarily explain different elements of one given phenomenon. And, finally, some people may integrate scientific and religious explanations into one unified causal explanation.

Another important conclusion is that interindividual differences notably shape people's mental conceptualizations of the science-religion relationship. For example, individuals who are more flexible when making epistemological judgments tend to be amenable when relating science to religion. Epistemic beliefs are "cognitive resources" that allow this flexibility to facilitate coexistence thinking (Legare et al., 2012; Legare & Gelman, 2008), enabling people to synchronically engage with scientific and religious explanations. Furthermore, we have argued that individuals' perception of the science-religion relationship is contingent on exposure to other cultures that promote certain values, such as secularism (Beauchamp & Rios, 2020; Rios & Aveyard, 2019), and that people's perception of the science-religion relationship may be transmitted across generations (Ecklund & Park, 2009; Payir et al., 2018). Most importantly, we have argued that research programs investigating how people relate science to religion may inform us about the role of motivational factors (i.e., identity and moral beliefs) in shaping laypeople's engagement with science. It is important to note, however, that unlike cognitive science findings on how scientific and religious beliefs are formed and navigated, the existing evidence pointing to the role of personality traits and motivational factors is very limited to the Western context, raising questions about its generalizability. We therefore call for more extensive research on this topic, with a strong emphasis on cultural contexts.

Our review underscores the need for continued but better-systematized research on how lay individuals relate science to religion. The flowchart depicted in Figure 1 aims to contribute to such an endeavor. By exploring the factors that shape people's mental models of the science-religion relationship, we can not only gain a deeper understanding of how individuals make sense of the world around them, but also gain insights into how to promote more constructive dialogue and cooperation between these two domains.

## Footnote

[1] It is important to note that Gervais and Norenzayan's (2012) studies did not replicate in a direct replication attempt (C. Sanchez et al., 2017). Evidence corroborating the role of analytical thinking in causally decreasing religious beliefs is actually mixed: for example, Villanueva and colleagues (2022) found no effect of analytical thinking on religiosity. In a similar vein, a latent profile study unpacks the evidence that some subtypes of religious individuals are, in fact, analytic thinkers (Lindeman & Lipsanen, 2016).

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# 7 Manuscript 2

Stage 2 Registered Report:

## Measuring How Individuals Relate Science to Religion

Rizqy Amelia Zein[1, 2], Moritz Heene[1], & Mario Gollwitzer[1]

[1] Department of Psychology, Ludwig-Maximilians-Universität München

[2] Department of Psychology, Universitas Airlangga

Author Note

Correspondence to: Rizqy Amelia Zein, Department of Psychology, Ludwig-Maximilians-Universität München (LMU), Leopoldstraße 13, Munich, Germany 80802

Department of Psychology, Universitas Airlangga, Kampus B Unair Jalan Airlangga 4-6 Surabaya, Indonesia 60286, mail to: Amelia.Zein@psy.lmu.de or amelia.zein@psikologi.unair.ac.id

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## Abstract

When trying to make sense of what is going on in the world and their personal lives, people often refer to scientific and religious explanations. Based on pertinent literature, we introduce a novel self-report instrument that captures five types of how people subjectively conceptualize the science-religion relationship. In addition to examining the psychometric properties of the new instrument, we tested whether these five types of conceptualizations are ordered along a single continuum of conflict vs. compatibility. In doing so, we ran and compared two unidimensional item response theory (IRT) models; a generalized partial credit model (GPCM) and a generalized graded unfolding model (GGUM), both in a German (total *N* = 2,920) and in a U.S. (*N* = 1,197) sample. We examined model fit statistics to determine the best-fitting model and examined measurement precision at the scale and the item levels. Finally, we tested measurement invariance across countries (i.e., Germany and the United States), as well as the discriminant, convergent, and criterion-related validity of our new instrument. Our results suggest that public perceptions of the relationship between science and religion are best captured by an unfolding response process (i.e. GGUM) and vary systematically across cultural contexts. In addition, U.S. participants perceived higher levels of conflict than their German counterparts. This research contributes to our theoretical understanding of science-religion perceptions and provides a validated measure for future cross-cultural research.

[227 words]



*Keywords*: science, religion, unfolding model, item response theory, differential item functioning.

## Measuring How Individuals Mentally Relate Science to Religion

Science and religion are often portrayed as opposites, as irreconcilable, and as fundamentally in conflict with each other. This portrayal may at least in part be rooted in historical episodes in which science and religion have clashed (e.g., Galileo's trial, the public rejection of Darwinian evolution, etc.).

Does this conflict portrayal resonate with how people subjectively construe the relationship between science and religion in their own lives? Some research suggests that it does, as previous studies have shown. For instance, religious individuals are more likely to hold negative attitudes toward science (Jochman et al., 2018; McPhetres & Zuckerman, 2018), to trust science and scientists less (Chan, 2018; Noy & O'Brien, 2016; Simpson & Rios, 2019), and to be more susceptible to science denialism than non-religious individuals (Azevedo & Jost, 2021; Rutjens et al., 2018). In a similar vein, several studies have demonstrated that religious individuals, perhaps unsurprisingly, are more likely to believe that science is generally incompatible with their religious beliefs (Chan, 2018; Gauchat, 2008; Paz-y-Miño-C & Espinosa, 2015). Psychological functions served by both religious and scientific explanations, such as the need for explanation, control, and existential meaning, may contribute to a competition between scientific and religious beliefs, which in turn, leads to perceptions of conflict between science and religion (Rutjens & Preston, 2020).

However, the propensity to hold negative attitudes toward science appears to exist more strongly among religious fundamentalists (J. O. Baker et al., 2020; Cacciatore et al., 2018; Lee, 2022; Perry et al., 2021), and stereotypical views of scientists (i.e. scientists are more likely to be non-religious) substantially explains this association (Larson & Witham, 1999; Rutjens & Heine, 2016; Simpson & Rios, 2019). Moreover, other scholars have argued that religiosity plays a significant role in predicting negative attitudes toward science, especially on certain topics where scientific evidence directly challenges religious beliefs, such as the origins of life and the universe, space exploration, the anthropogenic climate crisis, and genetic engineering, to name a few (Drummond & Fischhoff, 2019; Leicht et al., 2021).

Empirical evidence has also supported the assertion that the propagation of the conflict view (i.e. the belief that science and religion are fundamentally opposed) may only be prevalent in culturally secular countries (Johnson et al., 2020). For example, while religiosity is an important predictor of less favorable attitudes toward science in the U.S., this pattern does not generalize to other countries (Cologna et al., 2025; McPhetres et al., 2020). In some countries (e.g., Nigeria, Qatar, Kuwait, Egypt, India, and the Philippines in McPhetres et al., 2020, and Türkiye, Bangladesh, and Malaysia in Cologna et al., 2025) the association is reversed, with higher levels of religiosity corresponding to more favorable attitudes toward science.

Indeed, several global surveys have captured a wide variation across countries in perceptions of the relationship between science and religion (Kostyukov, 2019; Wellcome Trust, 2021). When participants in the 2020 Wellcome Trust Global Monitor (Wellcome Trust, 2021) were asked "*When scientific evidence contradicts religious teachings, do you believe in science or religion?*" more than 60 percent of participants in European countries (e.g., Germany, the United Kingdom, Belgium, Italy, etc.) were proponents of science, while more than half of the participants in some other countries (e.g., Brazil, Jordan, Türkiye, and Indonesia) sided with religion. Furthermore, the proportions of participants who said they believed in science and those who sided with religion are about the same in the U.S., India, and Uzbekistan (Wellcome Trust, 2021).

In sum, findings in the literature support the notion that individuals relate scientific and religious explanations in a variety of fashions. This suggests that a binary categorization (i.e., endorsing vs. opposing the conflict view) is inadequate to capture the full range of viewpoints that people may hold when relating scientific to religious explanations.

## Moving Beyond Conflict vs. Compatibility

When relating science and religion, individuals may think of a conflict between the two – but not necessarily so. Some may consider the two as independent domains, while others may value both and use them as a complement to each other. Barbour's (1966, 1990, 2002) taxonomical work, which refers to four ways of relating science and religion (e.g., conflict, independence, dialogue, and integration), has been widely used to describe how people mentally construe the science-religion relationship. While ample evidence from qualitative studies provided support for this taxonomy (Fysh & Lucas, 1998; Hokayem & BouJaoude, 2008; Konnemann et al., 2016; Longest & Uecker, 2021; Mansour, 2011, 2015; Pearce et al., 2021; Scheitle, 2011, 2011; Shipman et al., 2002; Stones et al., 2020; Taber et al., 2011; Vaidyanathan et al., 2016; Yasri et al., 2013; Yasri & Mancy, 2012, 2016), the types of mental models found in these studies were named under various terms. For better semantic clarity, we subsequently use *compartment* for "independence," *complementary* for "dialogue," and *consonance* for "integration" (Yasri et al., 2013; Zein et al., 2024).

The first model is the *traditional conflict*, which refers to the belief that scientific and religious explanations are fundamentally at odds and impossible to reconcile. People adopting this model may have a clear preference for either science (i.e. science trumps religion) or religion (i.e. religion trumps science, see Barbour, 1966). Nevertheless, it is possible that one's belief that science and religion are at odds means that they cannot believe in science and religion at the same time, but that they can flexibly switch between the two models of explanations depending on the context. While Barbour does not include this ambivalent situation in his taxonomy, qualitative studies have provided support for its existence (Shipman et al., 2002; Taber et al., 2011; Yasri & Mancy, 2012). For example, an individual might rely on their scientific reasoning when taking a science exam but switch to their religious beliefs when attending a church service. We call this a *context-switch* model (Yasri et al., 2013; Zein et al., 2024).

The *compartment* model suggests a belief that science and religion are two independent domains and thus, do not necessarily interfere with each other. However, unlike the context-switch view, people endorsing a compartment view may be able to utilize scientific and religious explanations at the same time to approach the same problem from different perspectives or explain separate elements of a phenomenon. For example, when attending a funeral, people endorsing a compartment view may use science to explain the biological cause of death ("*this person died from multiple organ failure*…"), but they use religious beliefs to make sense of the afterlife ("…*and now they are at peace with God*"). These two elements (biological and afterlife) are construed as independent, so to them, there is no need to connect the two. Consequently, according to people who adopt the compartment model, science and religion are neither in conflict nor compatible (Gould, 1999; Zein et al., 2024).

The so-called *complementary* model suggests that scientific and religious explanations can tap different elements of human experience, with science explaining the factual aspect while religion focusing on normative content. In contrast to the compartment model, proponents of the complementary model believe that science and religion are incomplete and insufficient without each other, so they must be combined (Zein et al., 2024). For example, people who hold a complementary view may think that their failure on an exam is because they are unprepared (i.e. factual explanation), but their religious beliefs may tell them that the failure is God's punishment, teaching them a valuable lesson about the importance of self-discipline and preparation. However, how these two explanations work together (e.g., "*who is responsible for the failure? The person or God?*") is often very vague and is less important to a person with a complementary view.

The final model, known as the *consonance* model, reflects a deeper level of overlap between science and religion than the complementary view. People adopting the consonance model believe that scientific and religious explanations are perfectly compatible and may even reinforce each other. Therefore, people who adopt the consonance model combine scientific and religious explanations of a phenomenon into a single causal chain, with religious beliefs playing a role as the cause (*explanans*), and then, scientific explanations are the *explanandum* – the description of phenomena explained by the cause (e.g. "*God orchestrated evolution to refine His creations*"), or vice versa (e.g. "*The more I learn about evolution, the more I feel the presence of God*," see Zein et al., 2024).

**Measuring How Individuals Relating Science to Religion**

While qualitative investigations of the taxonomy have been extensive, to date, a quantitative test of Barbour's taxonomy is currently lacking. One of the rare examples is a study by Marin and Lindeman (2021), in which participants were asked to indicate their agreement with four statements, with one item representing each mental model (i.e., conflict, compartment, complementary, and consonance). Yasri and colleagues (2013) pursue the same strategy. The drawbacks of this approach are first, that it limits participants' ability to fully express the nuances of their beliefs about the relationship between science and religion, and second, that with only one item representing each mental model, measurement precision cannot be warranted.

Several other attempts to measure people's beliefs about the science-religion relationship assume that people construe the relationship as completely in conflict (vs. completely compatible). Based on this assumption, people's perceptions of the relationship between science and religion can be described as a continuum, ranging from "completely conflict" to "completely compatible." This, in turn, limits the range of responses available to participants to express the nuances of their beliefs (Leicht et al., 2021), thus neglecting the qualitative differences between mental models as suggested by Barbour (1990).

Some of these measures heavily emphasize the traditional conflict view but overlook the rest of the mental models. As a result, the items are worded in such a way that participants are forced to state their exclusive preference for science or religion. For example, the Wellcome Trust Global Monitor mentioned above included only one item measuring beliefs about the relationship between science and religion (i.e. "*Generally speaking, if science disagrees with the teachings of your religion, which do you believe? Science or the teachings of your religion?*"). In addition, an item measuring the same construct in the World Values Survey is worded quite similarly (i.e. "*Whenever science and religion conflict, religion is always right*").

Items with similar wording are also commonly used to gauge public acceptance of evolution in several large-scale surveys, with items measuring evolution acceptance framing evolutionary science as fundamentally opposed to belief in God (Hill et al., 2019). This strategy, in turn, results in uniform responses (i.e. ceiling and floor effect), particularly when the scale is administered to highly religious or highly secular populations. As a result, these surveys often report an inflated number of religious participants denying evolution (Elsdon-Baker, 2015).

Findings reported by Paiva et al. (2022) provide further support for the suspicion that certain wording in the existing scales runs the risk of eliciting uniform responses. In their study, they administered three different scales measuring beliefs about the science-religion relationship (Longest & Smith, 2011; Paiva et al., 2019; Taber et al., 2011) to a highly religious sample (i.e., religious education teachers). Evidence suggests that these scales suffered from a lack of internal consistency (Paiva et al., 2022), and this is most likely due to participants' uniformly negative responses to the items (e.g., "*A good scientist CANNOT believe that the universe was created approximately 6000 years ago*" or "*Religious ideas about how the universe began have been PROVED WRONG by science*"). In short, these scales may be more appropriate for measuring participants' endorsement of the traditional conflict view and do not really tap into a full range of viewpoints that people may hold when thinking about science and religion.

In various studies, Rios and colleagues used a scale with four items asking participants about their general beliefs regarding the compatibility between science and religion (e.g., "*To what* *extent do you personally believe that science and religion are incompatible versus compatible?*", "*…to be both religious and a scientist?*", "*…to value both religion and science?*", and "*…to trust both religion and science as sources of information about the world?*", see Mackey et al., 2023; Rios, 2021; Rios & Aveyard, 2019). Unlike the scales used in a study by Paiva and colleagues (2022), this scale shows sufficient internal consistency (Rios, 2021). Nevertheless, this does not eliminate the risk of eliciting uniform responses because the qualitative differences between mental models, as suggested by Barbour (1990), have yet to be taken into account. Furthermore, there is still no evidence of validity; thus, the need for a psychometrically sound measurement instrument remains.

This brings us to the most recent attempt to fill this gap in literature. Leicht and colleagues (2021) created a scale to measure individuals' perceptions of science-religion compatibility, and their strategy is based on the well-reasoned argument that individuals' perceptions of compatibility may vary depending on the issues. For example, individuals may perceive stronger conflict when thinking about certain issues (e.g., evolution) or scientific disciplines that directly contradict religious beliefs (e.g., evolutionary science, see Elsdon-Baker et al., 2017). However, individuals may perceive different levels of compatibility when thinking about other issues (Elsdon-Baker et al., 2017). To that end, Leicht and colleagues (2021) listed eight topics (e.g., the origins of human life, treatment of mental illness, natural disasters, death, etc.), and asked participants to indicate the extent to which they personally view science and religion as completely in conflict or completely compatible for each topic they included in the scale.

First, they examined the structure of the scale, and factor analysis shows that the scale consists of two factors: explanations (i.e. origins of human life, the universe, and life other than human life as well as death) and human-world interactions (i.e. treatment of mental and physical illness, the cause of illness, and explanations of the relationship between humans and the environment). In two studies, Leicht and colleagues (2021) confirmed the two-factor structure and measurement invariance between religious individuals, agnostics, and atheists. While the scale created by Leicht and colleagues (2021) has satisfactory psychometric properties, the scale is still built on the assumption that individuals differ in their *level* of compatibility perceptions, or, more sharply, that the compatibility perceptions lie on a continuum ranging from "completely conflict" to "completely compatible." Meanwhile, extant evidence from qualitative studies has instead provided more support for Barbour's (1990) taxonomy, suggesting that individuals (qualitatively) differ in their mental model *types* when relating scientific to religious explanations.

**The Present Study: Dominance vs. Unfolding Model**

Notably, Barbour's (1990) taxonomy assumes that people's mental models of science-religion compatibility differ in *qualitative* aspects, but it may well be that each of the mental models is related to a different degree of conflict-compatibility perceptions. That means, the mental models postulated by Barbour (1990) and studies extending his taxonomy (the context-switch, see Yasri et al., 2013; Yasri & Mancy, 2012) may just as well differ in *quantitative* aspects.

At the lowest end of the spectrum, endorsement of the traditional conflict model may indicate that individuals view scientific and religious explanations as completely contradictory so that they consider one explanation to be right and the other to be wrong. Furthermore, the context-switch model may support the idea that science and religion offer contradictory explanations but individuals who adopt this model do not have exclusive preferences so they can switch sides depending on the situations at hand. Therefore, the context-switch model assumes that science and religion are still in conflict, but the *level* of conflict perception is less intense than the traditional conflict model.

Moving further along the continuum, individuals who adopt a compartment model believe that science and religion are completely autonomous and thus neither in conflict nor compatible. While individuals who adopt the complementary model may agree that scientific and religious explanations are naturally different, they believe that scientific and religious explanations are compatible because they need to fill in each other's gaps. Finally, near the highly compatible end of the continuum, individuals who believe in the consonance model seek a complete assimilation of scientific and religious explanations (see Figure 1).

It is important to note, however, that although the mental models appear to be equally distant from each other, as we illustrate in Figure 1, Barbour (1990) never explicitly proposes such a strong assumption. Furthermore, while it is true that evidence supports the role of epistemological understanding (i.e. epistemic beliefs) that leads to more nuanced interpretations of the relationship between science and religion (i.e. the non-conflict views, see Borgerding et al., 2017; Stones et al., 2020; Yasri & Mancy, 2016), we do not assume that endorsing the non-conflict view requires some kind of mastery or higher intellectual abilities.

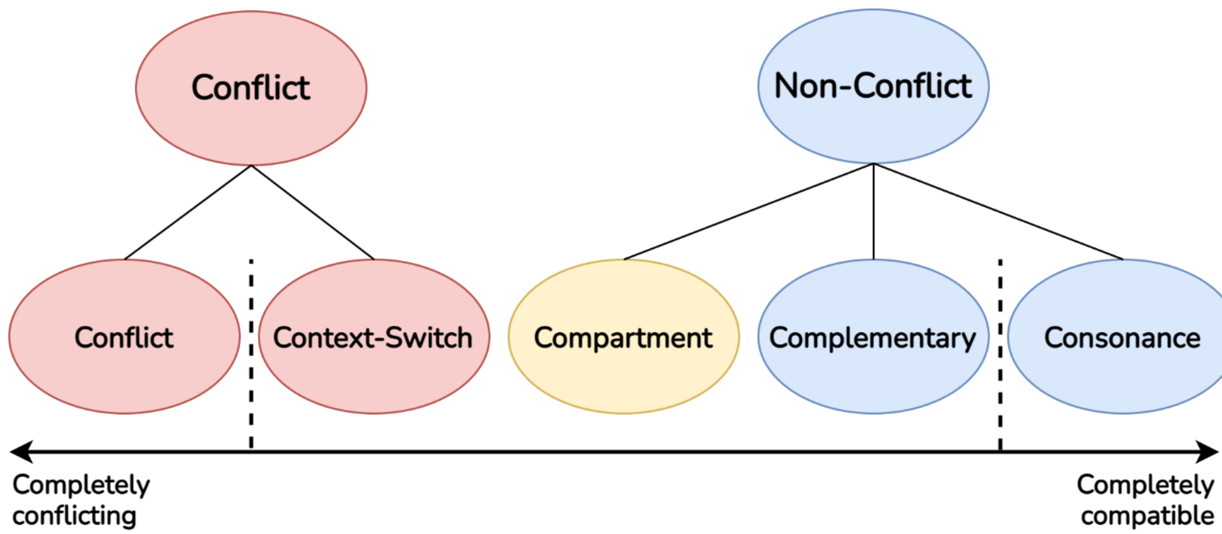



**Figure 1.** The conflict-compatibility continuum of perceptions of the relationship between science and religion

While it is theoretically worthwhile to investigate the question of whether these types of mental conceptualization are qualitatively distinct and are ordered along a continuum of conflict-compatibility, it is rather challenging to test this notion empirically. As a one way to scrutinize this question, we propose to develop a novel scale representing five types of mental conceptualization, model participants' responses using two measurement approaches: dominance (Likert-style) and unfolding models (Roberts et al., 2000), and then, compare the two models to determine the best fitting model. We propose that people's perceptions of the relationship between science and religion follow the unfolding, rather than the dominance, Likert-style model because the unfolding model can more accurately discriminate between people who are in the middle range of the continuum (i.e. context-switch, compartment, and complementary) than the dominance model.

The unfolding or ideal point model stems from the Thurstonian theory of response behavior (Dalal et al., 2010) to deal with scales that measure attitudes and preferences. The unfolding model assumes that the probability of a participant responding favorably to an item depends on whether that particular item is close to their preference (i.e. *maximum agreement*, Roberts, 2018; Roberts et al., 2000). For example, participants who hold a conflict view have the highest probability of responding favorably to items representing the conflict view, but this probability decreases when they are exposed to items representing the other views. In turn, the relationship between the true score on the latent trait dimension ($\theta$) and the probability of responding to a particular response category is non-monotonic (Roberts et al., 2000) as it follows a *proximity* instead of a dominance relationship as in traditional item response models. In the dominance model of measurement (i.e. the typical Likert-style), the probability of responding positively to items increases monotonically as participants' true score on the latent trait dimension ($\theta$) increases (Bock & Gibbons, 2021). Consequently, the dominance model may be able to accurately estimate the latent score at the lowest and highest ends of the continuum but may not be able to accurately discriminate individuals who are positioned in the middle of the continuum.

More importantly, it can be empirically investigated whether the data fit the unfolding or the dominance model better (Liu & Chalmers, 2018; Reimers et al., 2023). To this end, we developed a scale that captures the five types of mental models. After asking participants to complete these scales, we analyzed the data based on the dominance model (i.e. generalized partial credit model – GPCM, Muraki, 1992; Muraki & Muraki, 2016) as well as the unfolding model (i.e. generalized graded unfolding model – GGUM, Roberts, 2018; Roberts et al., 1998), respectively. By doing so, we were able to scrutinize whether the unfolding model fits the data better than the dominance model.

Since our proposed scale uses polytomous responses, it is important to model how trait levels are related to the probability of endorsing a specific response category (e.g., "strongly disagree") – or, more precisely, the points on the trait continuum at which participants are equally likely to endorse one response category and its next adjacent category (i.e., the "step functions" or item thresholds or *b*). Additionally, we also estimated item discriminations (*a*, i.e., the ability of an item to differentiate between latent trait levels) (Bock & Gibbons, 2021; De Ayala, 2022). While both the GPCM and the GGUM are used for polytomous item response data, they operate under different frameworks within IRT. The GPCM, an extension of the Partial Credit Model (PCM), allows for different discrimination parameters across items, thereby allowing varying sensitivity across items. By contrast, the GGUM allows the estimation of item location parameter ($\delta$), which indicates where an item is situated along the latent trait continuum (Luo, 2001; Reimers et al., 2023).

In sum, the GPCM assumes that the relationship between trait levels and the probability of endorsing a higher category monotonically increases, while the GGUM by enabling a non-monotonic relationship. In practice, the GGUM is actually “an unfolding version” of the GPCM (Roberts et al., 2000), therefore comparing the GPCM with the GGUM can maximize the comparability between the dominance and the unfolding model.

Furthermore, if the unfolding model shows a better fit than the dominance model, we expect that the degree of compatibility perceptions, which are associated with different types of mental models, can be located on a continuum as displayed in Figure 1. That means that item location parameters ($\delta$) yielding from the GGUM analysis (Roberts & Laughlin, 1996) from items representing the same type of mental model are expected to be clustered, and the order of cluster locations is consistent with our illustration in Figure 1. In doing so, we combine the theoretical assumption that individuals adopt different *types* of mental models to relate science to religion with the assumption that these types are *ordered*, ranging from “completely conflict” to “completely compatible” on a continuum. Therefore, both the GPCM and the GGUM rest on the assumption that the conflict-compatibility continuum (Figure 1) is unidimensional and bipolar.

Previous research investigating self-determination theory (SDT) has used an approach similar to that we described here. In that study, Freund and Lohbeck (2021) proposed that people differ in their motivation types (i.e., amotivation, external, introjected, integrated, identified, and intrinsic) and that these types can also be ordered along an autonomy-control continuum, with amotivation at the low end and intrinsic motivation at the high end of the continuum (Freund & Lohbeck, 2021). Furthermore, several personality scales are found to prompt unfolding, instead of dominance responding behavior, such as 16 Personality Factors (16 PF) facets (Stark et al., 2006), and conscientiousness (Carter et al., 2014); social attitudes, for instance, toward abortion (Roberts et al., 1998) and political ideology (Curini, 2010) as well as other non-cognitive constructs such as adult attachment styles (Sun et al., 2021), work satisfaction (Carter & Dalal, 2010), and religious morality (Vista, 2022).

In addition, we would like to test if our scale has sufficient validity by comparing it with other scales that measure constructs theoretically distinct from, but potentially related to our newly developed scale. To this end, we would compare our newly developed scale with the Belief in Science Scale (BISS - Dagnall et al., 2019; Farias et al., 2013). Belief in science reflects individual differences in the perception of science as a superior, and even exclusive, source of knowledge and belief system (Farias et al., 2013). Farias and colleagues (2013) assert that individuals with strong beliefs in science are skeptical of, or even reject, scientifically unsubstantiated beliefs, including religious explanations (Dagnall et al., 2019; Farias et al., 2013).

That said, belief in science focuses on individuals' perceptions of the high value of science and scientific institutions rather than on how individuals conceive of the relationship between science and religion. In other words, individuals may value science and scientific institutions exceptionally highly but still value religion to a similar degree because science and religion deal with different aspects of reality (i.e. the compartment view), or because they think that science and religion complement each other (i.e. the complementary view). Therefore, while individuals with strong beliefs in science may also hold the conflict view with a preference for the superiority of science, we hypothesized that belief in science and individuals' perceptions of the science-religion relationship are theoretically distinct.

In addition to testing discriminant validity, it is also important to compare our proposed scale with the existing one measuring the same construct. Therefore, we would also administer a scale developed by Leicht et al. (2021) and compare it to our novel scale. While the scale developed by Leicht et al. (2021) is built upon a different theoretical foundation (i.e., no assumption regarding the *types* of mental models), the scale shares a partial similarity with our newly developed scale – it assumes that the construct lies on a continuum of conflict-compatibility. Therefore, we hypothesized that the latent dimensions of Leicht et al.'s (2021) scale would be moderately correlated with the latent factor of our scale.

Individuals with higher levels of religiosity are more likely to perceive science as compatible with their religious beliefs (Leicht et al., 2021). In turn, those who place higher importance on religion may be more likely to endorse non-conflict views. Therefore, we correlated religiosity with perceptions of the relationship between science and religion, hypothesizing that the correlations would gradually increase along with the compatibility continuum. To that end, we measured the centrality of religiosity, which captures individuals' assessment of how salient or how important religion is in their lives (Huber & Huber, 2012) and correlated its score with our novel scale.

Finally, it is important to make sure that the items yield similar response patterns from two individuals with similar levels of perceptions, regardless of where these individuals come from. Therefore, we expected the items of our scale to work similarly (i.e. similar item discrimination and threshold parameters) across countries. Since our scale was developed in Germany, we compared data from a German sample (as a reference group) with data from a U.S. sample to scrutinize its measurement invariance. More precisely, we expected that participants with the same level of perceptions (e.g., similar levels of conflict belief), regardless of their country of residence (Germany vs. the United States) have the same probability of responding to the response category (e.g., equally likely to choose “strongly agree” with the item “*I strongly believe that science and religion are ultimately at odds, with no possibility of harmony*”). We chose the United States as the target group because much previous research on this topic has been conducted with U.S. samples – probably because the issue is of particular societal importance in this country (J. O. Baker, 2012; Ecklund & Park, 2009; Scheitle, 2011).

This registered report is divided into three parts: item development and initial testing (Pilot Study), item refinement and model testing (Study 1), and validity and invariance testing (Study 2). The Pilot Study and Study 1 were not preregistered, and the results of both studies were presented as pilot data in the Stage 1 manuscript, while Study 2 was preregistered (https://osf.io/xsz5c) and is the focus of this registered report.

## Pilot Study: Item Development and Initial Testing

### *Method*

To measure our primary variable of interest, in the first stage, we created an item pool (Supplementary Material 1) derived from past qualitative studies investigating mental models when relating science and religion (Fysh & Lucas, 1998; Hokayem & BouJaoude, 2008; Konnemann et al., 2016; Longest & Uecker, 2021; Mansour, 2011, 2015; Pearce et al., 2021; Scheitle, 2011, 2011; Shipman et al., 2002; Stones et al., 2020; Taber et al., 2011; Vaidyanathan et al., 2016; Yasri et al., 2013; Yasri & Mancy, 2012, 2016). This results in 45 items in total: nine items reflecting the traditional conflict model, eight items measuring the context-switch model, ten items measuring the compartment model, ten items reflecting the complementary model, and the last eight items corresponding to the consonance model. Participants were asked to indicate their agreement level to these items in four possible responses; 1/strongly disagree, 2/disagree, 3/agree, and 4/strongly agree, as recommended by Dalal et al. (2014).

Items were first developed in English and translated into German by a bilingual translator. Next, the items were back-translated to English using an AI-based translation tool (DeepL), and then four German native speakers reviewed the final German version and adjust them if necessary. In doing so, we aim to ensure that the German and the original English versions are invariant.

We circulated a study invitation to our participant pool ($n$ = 614, Female = 61.23%, Male = 36.15%, Others = 2.6%, $M_{age}$ = 39.66, $SD_{age}$ = 16.55), consisting of a German-speaking sample, from December 2023 to February 2024 while awaiting the first round of review.

We tested the unidimensionality of the scale data in all reported studies by assuming that individuals' perceptions of the relationship between science and religion is unidimensional, bipolar, and locally independent (Bock & Gibbons, 2021). To that end, we performed unrotated principal component analysis (PCA) to identify grouping patterns among the items (De Ayala & Hertzog, 1991; Tay & Drasgow, 2012). Items loading on the first two principal components (Maraun & Rossi, 2001) and yielding item-level communalities greater than 0.3 are considered optimally unidimensional for further analyses, according to evidence from simulation studies (Roberts, 2018; Roberts et al., 2000; Roberts & Laughlin, 1996).

We carried out an unrotated principal component analysis (PCA) by imposing a two-component structure (Tay & Drasgow, 2012). We anticipated the emergence of two components even though we assumed that the construct is unidimensional because the second component reflects an "extra factor" (Maraun & Rossi, 2001; van Schuur & Kiers, 1994) or "spurious dimension," (Tay & Drasgow, 2012) often found in bipolar unidimensional constructs. It may seem counterintuitive that we imposed a two-component structure on the hypothesized unidimensional, bipolar construct, but our analytic approach here aligns what is generally recommended in the literature (Tay & Drasgow, 2012; van Schuur & Kiers, 1994). When applying linear models such as PCA to nonlinear, unfolding data, we expect the presence of the second, "extra" component that represents items that do not actually belong to the absolute high and low ends of the continuum (i.e. the "conflict" and the "consonance"). This "extra" component thus typically consists of items in the middle of the continuum, capturing responses that are not strongly aligned with either end of the spectrum.

In addition to the presence of the "extra" factor, a negative or near-zero correlation between the loadings of the first and second components is also indicative of a unidimensional, bipolar construct (Tay et al., 2011; Tay & Drasgow, 2012). Taken together, the PCA plot shows a distinctive "simplex-like" pattern (Davison, 1977). This semicircular shape, with the curve folding inward at its ends, is another indicator of an unfolding response process typical of a construct such as the one measured in this study (Davison, 1977; Roberts et al., 2000; Tay & Drasgow, 2012). We performed PCA with a polychoric correlation matrix to account for ordinal data.

To determine which of the two models (i.e., the "unfolding" vs. the "dominance" model) fits the data better, we ran two IRT models and compare their fit statistics. First, we ran the GPCM (Muraki, 1992; Muraki & Muraki, 2016) reflecting the "dominance" model as well as the GGUM (Roberts, 2018; Roberts et al., 1998) reflecting the "unfolding" model. Both models were estimated using marginal maximum likelihood with the expected-maximization algorithm (MML-EM, Chalmers, 2012; Liu & Chalmers, 2018; Muraki & Muraki, 2016; Roberts et al., 2000). To determine the best fitting model, we inspected key statistics of global model fit (Log-Likelihood – LL, Akaike Information Criterion – AIC, Bayesian Information Criterion – BIC, sample-size adjusted AIC – AICc, and sample-size adjusted BIC – SABIC). Higher values of LL and lower values of AIC, BIC, AICc, and SABIC indicate a better fit to the data (Kang et al., 2009).

When fitting the model, it is possible that we would encounter model misspecification problems, and if this were the case, we would examine the local fit to locate the source and magnitude of the model misfit (Kline, 2023). In doing so, we performed Yen's $Q_3$ statistics (Yen, 1984) to compute the residual item-pair correlations after accounting for $\theta$. While Chen and Thissen (1997) suggested that a critical value of $Q_3$ statistics is around |0.2|, we decided to take a stepwise approach by prioritizing the examination of the content of item pairs with most severe local dependencies, with $Q_3$ statistics above |0.3|, as the first step before addressing other items with less severe local dependencies (Zein & Akhtar, 2025). Respecification of the model (e.g. removal of items, etc.) would consider both $Q_3$ statistics and item content.

Based on data from the pilot study, the results of which are presented in the next section, and feedback from an anonymous reviewer, we refined and shortened the scale to 27 items, with only 5-6 items representing each mental model. We further calibrated these items to better reflect an unfolding pattern by rewriting them to have varying degrees of wording strength. Each subscale contains very strongly worded items (e.g., "*To me, it is completely inconceivable that science and religion are in conflict since they clearly convey the same fundamental truths*") and the more "intermediate" or neutral items (Cao et al., 2015, e.g., "*It seems to me that science and religion can sometimes go in the same direction*").

To empirically test whether the scale items reflect different levels of wording strength as intended, we asked eight of our lab members to rate the wording strength of our revised scale (27 items) from 0 (very mildly worded) to 10 (very strongly worded). To assist the raters in their evaluations, we provided them with specific instructions that included the description and a concrete example of each mental model/subscale. Additionally, we also asked raters to place all 27 items on a continuum ranging from 0 (completely conflict) to 10 (completely compatible). In doing so, we essentially asked raters to predict item locations on the continuum of conflict – compatibility.

We also asked raters to provide general feedback on the items, and based on the feedback, we refined these items again to ensure wording strength varies meaningfully, and, most importantly, represent the prototypicality of each mental model.

***Results and Discussion***

We present the PCA plot of the first and the second principal components in Figure 2. The PCA plot shows that semicircular pattern exists in our data and that the loadings of the principal components are clustered within each subscale and ordered along the x-axis, suggesting an ordered sequence and transitions between the mental models. It is important to note, however, that we presented the scale to participants in five blocks, each consisting of only items from one subscale, and then randomized the order of items within the block. Thus, in one block, participants saw only items from the conflict subscale and may have been able to adjust their responses accordingly. In this case, although the items appeared to be neatly clustered according to their respective subscale/mental model (see Figure 1), the scale presentation may have confounded the results.

Moreover, the plot shows that the loadings of the compartment items are grouped on the left side, closer to the conflict, while items of the context-switch subscale are grouped closer to the complementary, which slightly differs from our initial hypothesis. The correlation between the first and second principal components is negative ($r$ = -.31, 95% CI [-.55, -.01], $p$ = .042), which supports our assumption that the construct is unidimensional and bipolar (Tay & Drasgow, 2012).

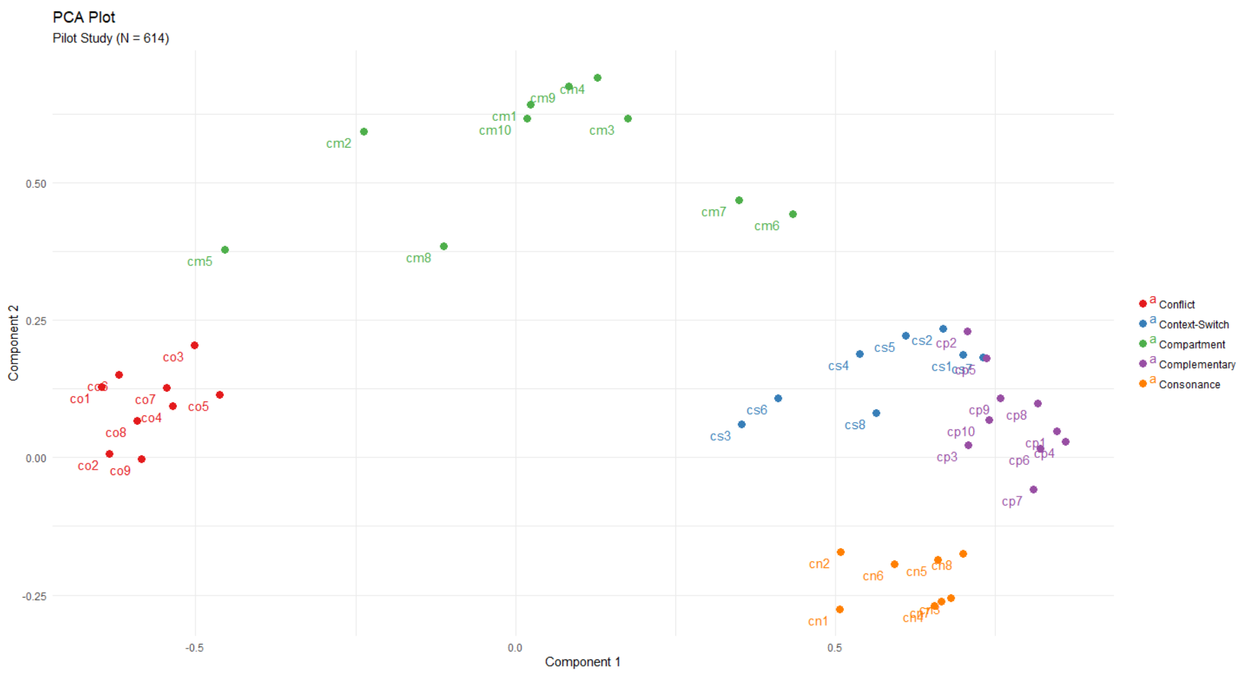



Figure 2. PCA Plot, Pilot Study ($n$ = 614)

We fit a one-dimensional GGUM and GPCM model the data, but the models initially failed to converge. We suspected that the convergence issues were caused by locally dependent items. We identified three problematic items (i.e., two conflict items and one compartment item), with item pair correlations (i.e. $Q_3$ statistics) ranging from 0.33-0.46. After closely examining the item content, we found that two "conflict" items were redundant and used absolute quantifiers as well as overly extreme phrasing (e.g. "always", "fundamentally in conflict"). In addition, one "compartment" item with a severe local dependency also overlapped with the other "compartment" items. We subsequently decided to remove these items, re-specified our models, and re-ran our analyses.

The GPCM and the GGUM models with the remaining 42 items successfully converged. The GGUM model had a good fit to the data ($M_2$(693) = 1,400.78, $p$ < .001, RMSEA = .040, 90% CI [.037, .043], *SRMSR* = .069, *CFI* = .988, *TLI* = .986), while the GPCM did not ($M_2$(735) = 8,444.155, $p$ < .001, RMSEA = .120, 90% CI [.117, .112], *SRMSR* = .165, *CFI* = .858, *TLI* = .851). Model comparison (Table 1) shows that, generally, the GGUM model fits the data better.

Table 1. Model Comparison Between Unfolding (GGUM) and Dominance (GPCM) Model, Pilot Study

| Model | Number of Parameters | LL | AIC | BIC | SABIC | HQ |
|---|---|---|---|---|---|---|
| GGUM | 210 | -26,669.52 | 53,911.72 | 54,687.24 | 54,020.53 | 54,120 |
| GPCM | 168 | -29,784.67 | 59,923.33 | 60,705.67 | 60,143.73 | 60,227.57 |

*Note.* LL = Log Likelihood; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SABIC = Sample Size Adjusted Bayesian Information Criterion; HQ = Hannah-Quinn Criterion

Based on the pilot results, we refined and shortened the scale into 27 items and asked eight raters to evaluate the wording strength of each item (0/very mildly worded to 10/very strongly worded). Intraclass correlation (ICC) analysis suggests that the average scores from all raters were consistent (ICC(2,$k$) = 0.87, 95% CI [0.78, 0.93]), and the rating variability between items was significantly greater than between raters ($F(26, 182) = 8.6$, $p < .001$), denoting sufficient interrater reliability. Descriptive statistics are reported as Supplementary Material 2.

We further asked raters to place scale items on a continuum ranging from 0 (completely conflict) to 10 (completely compatible). Average ratings from all raters are highly consistent (ICC(2,$k$) = 0.94, 95% CI [0.90, 0.97]), and the rating variability between items is significantly greater than between raters ($F(26, 182) = 18$, $p < .001$), suggesting good interrater reliability. Similar to what the PCA has shown, raters placed items reflecting a context-switch view as closer to compatibility while items reflecting a compartment view were generally closer to conflict (Supplementary Material 2).

## Study 1: Initial Model Testing

### *Method*

We tested the revised version (27 items, Supplementary Material 1) of the scale based on the results of the pilot study and after incorporating feedback from the raters. To test whether our revised scale works well as intended, we invited German-speaking PsyWeb subscribers ($n$ = 1,111, Female = 73.17%, Male = 25.11%, Others = 1.65%, $M_{age}$ = 46.12, $SD_{age}$ = 16.20), and ran a PCA with all 27 items, imposing two principal components structure. Therefore, we used the same procedure for data analysis as described in the pilot study. However, this time, we presented 27 items in three blocks, with items from all subscales intermixed. In the first and second blocks, we included two items from each subscale, for a total of ten items per block. The third block consisted of the remaining seven items. Additionally, we randomized the order of the items, so the order of scale items was presented differently for each participant. The number of response categories remained the same as described in the pilot study.

### ***Results and Discussion***

PCA shows that items were still clustered within the same subscale (Figure 3), but the items were less neatly clustered compared to data from the pilot study (Figure 2). The correlation between the first and second principal components is moderately negative ($r$ = -.51, 95% CI [-.75, -.16], $p$ = .006), further supporting the existence of a unidimensional, bipolar construct (Tay & Drasgow, 2012).

We fit a one-dimensional GGUM and GPCM model, and both models converged properly. The GGUM model fit the data well ($M_2$(243) = 1,056.22, $p$ < .001, RMSEA = .054, 90% CI [.051, .058], *SRMSR* = .075, *CFI* = .984, *TLI* = .981), while GPCM did not ($M_2$(270) = 3,217.62, $p$ < .001, RMSEA = .099, 90% CI [.096, .102], *SRMSR* = .080, *CFI* = .886, *TLI* = .875). Replicating our findings from the pilot study, the GGUM fits our data better (Table 2).

Table 2. Model Comparison Between Unfolding (GGUM) and Dominance (GPCM) Model, Study 1

| Model | Number of Parameters | LL | AIC | BIC | SABIC | HQ |
|---|---|---|---|---|---|---|
| GGUM | 135 | -30,620.44 | 61,510.89 | 62,187.65 | 61,758.85 | 61,766.79 |
| GPCM | 108 | -30,945.31 | 62,106.62 | 62,648.02 | 62,304.99 | 62,311.33 |

*Note.* LL = Log Likelihood; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SABIC = Sample Size Adjusted Bayesian Information Criterion; HQ = Hannah-Quinn Criterion

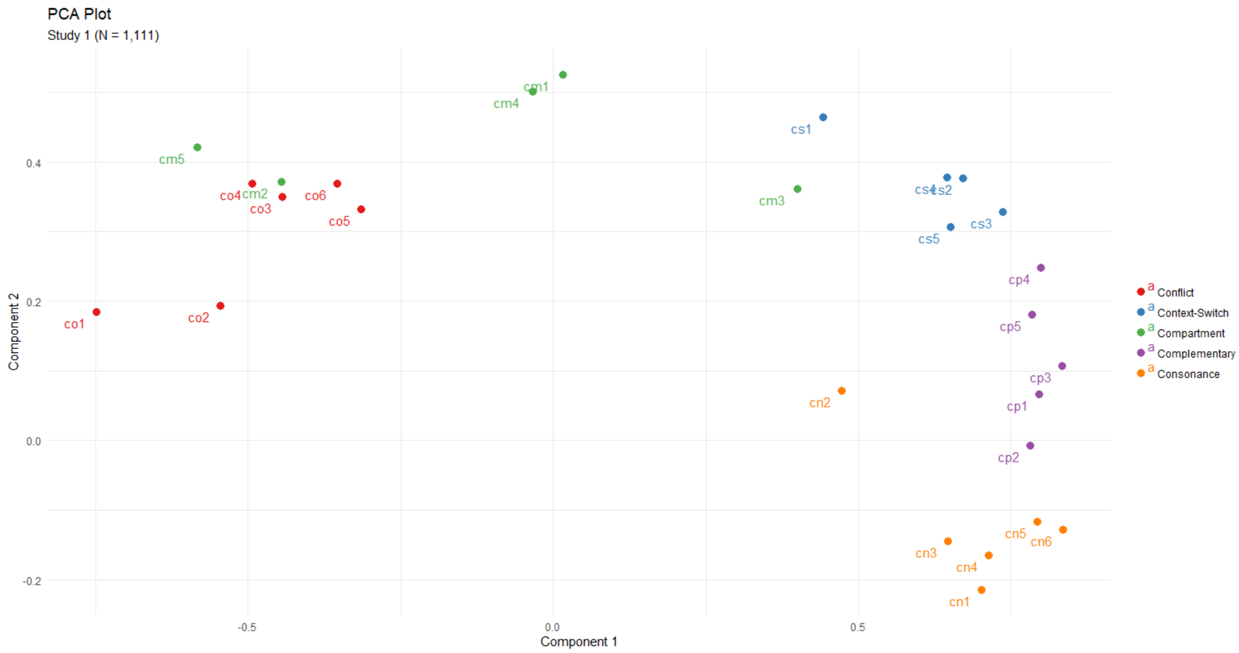



Figure 3. PCA Plot, Study 1 ($n$ = 1,111)

## Study 2: Model Testing, Criterion-Related Validity, and Measurement Invariance

### *Method*

The focus of Study 2 is to test the discriminant validity, criterion validity, and measurement invariance of the instrument. That said, we also carried out the similar procedures we described in the pilot study and in Study 1, that is, we performed dimensionality tests and model comparisons, beforehand.

### *Participants*

Since estimation of GPCM requires ~300 participants (Dai et al., 2021) and GGUM requires ~750 participants (Roberts et al., 2000) to obtain accurate and stable model and item parameters, we oversampled to compensate for data exclusion and to account for the number of estimated parameters, collecting data from 1,205 Germans and 1,214 U.S. Americans. After applying exclusion criteria, we used data from 1,195 German (female = 40.08%, male = 58.91%, others = 1.01%, $M_{age}$ = 31.04, $SD_{age}$ = 9.63) and 1,197 U.S. participants (female = 55.22%, male = 44.19%, others = 0.58%, $M_{age}$ = 40.34, $SD_{age}$ = 13.78), respectively. Recruitment criteria included being 18 years of age or older, being fluent in German (for the German sample) or English (for the US sample), and consenting to participate in our study. We recruited participants through Prolific and paid each participant $2.85 for their participation.

***Measures***

We presented demographic questions at the beginning of our survey (e.g., age, gender, educational qualification, the field of study, and religious affiliations), then organized our measurements as follows:

***Perceptions of the relationship between science and religion.*** We slightly modified the scale items by making them all self-referential since 15 items of the revised version used in Study 1 could be misinterpreted by participants as what society believes about science and religion (e.g. "*Scientific and religious explanations may work in their respective domains, but they remain separate*"), and we wanted to rule out this possibility by rewording them (e.g. "*I find that scientific and religious explanations may work in their respective domains, but they remain separate*"). The number of response categories remained the same as described in the pilot study. The version of the scale used in this study is provided Supplementary Material 1.

***Perceptions of the relationship between science and religion (Leicht et al., 2021).*** Leicht et al.'s (2021) scale consists of eight items; four items measure explanations, and the other four items reflect human-world interactions. Participants were asked to indicate the extent to which they personally view science and religion to be completely in conflict (0) to completely compatible (10) with each other. The scale was initially developed in English, so we translated the scale using the same process we described earlier in the pilot study to translate our proposed scale. Internal consistency of Leicht et al.'s (2021) scale in the German ($\omega_t$ = .90) and U.S. American ($\omega_t$ = .94) samples are satisfactory.

***Belief in Science Scale (BISS).*** Belief in science was measured by administering the Belief in Science Scale (BISS; Farias et al., 2013). BISS is a Likert-style measure consisting of 10 items (e.g. "*Science provides us with a better understanding of the universe than does religion*" or "*The scientific method is the only reliable path to knowledge*"), and participants are asked to indicate the extent to which they agree to these items in extreme-labeled responses (1/strongly disagree to 6/strongly agree). We translated the scale into German with the same process as other scales.

Internal consistency of BISS in the German ($\omega_t$ = .92) and U.S. American ($\omega_t$ = .95) samples are satisfactory.

***Religiosity.*** We measured religiosity using the Centrality of Religiosity Scale – Interreligious versions (CRSi-7), with seven items reflecting five subdimensions; intellect ("*How often do you think about religious issues?*"), ideology (e.g., "*To what extent do you believe that God or something divine exists?*"), public practice ("*How often do you take part in religious services?*"), private practice (e.g., "*How often do you pray?*"), and experience (e.g., "*How often do you experience situations in which you have the feeling that God or something divine intervenes in your life?*"). The CRSi-7 was initially developed in German and its English translations are available (Huber & Huber, 2012). As suggested by Huber and Huber (2012), we adjusted the scale according to participants' religious affiliations. For example, for Buddhist and Hindu participants, items measuring ideology need to be adjusted to accommodate their openness to polytheistic theology.

Participants reported their importance of religion in five possible responses (1/not at all, 2/not very much, 3/moderately, 4/quite a bit, 5/very much so), and their public and private practices related to religion in eight response categories (1/several times a day, 2/once a day, 3/more than once a week, 4/once a week, 5/one to three times a month, 6/a few times a year, 7/less than a few times a year, 8/never). We implemented a scoring guideline provided by Huber and Huber (2012) and used the average composite score for further analysis. Internal consistency of the generic CRSi-7 scale in the German ($\omega_t$ = .92) and U.S. American ($\omega_t$ = .96) samples are satisfactory.

*Religious and science identity.* We measured religious and science identity using a similar strategy as Leicht et al. (2021), that is, asking participants to indicate their agreement with one item, "*Religious beliefs or spirituality are important to my identity*," with five possible responses ranging from 1/not at all important to 5/very important. We adjusted the item for atheists and agnostic participants by replacing "religious beliefs or spirituality" with atheism or agnosticism, respectively. Science identity was measured using the same strategy: asking participants to indicate their agreement with one item, "*Scientific ideas and concepts are important to my identity*," with five possible responses ranging from 1/strongly disagree to 5/strongly agree.

In addition to this, we included four frequent-infrequent items (Kay & Saucier, 2023) to detect careless responding. Participants included in the data analysis should respond "strongly agree" or "agree" to frequent items (e.g., "*I breathe every day*") and "strongly disagree" or "disagree" to infrequent items (e.g., "*I have never brushed my teeth*"). Participants who failed all attention checks were excluded from the analysis. Moreover, we included a "use me" item, which asked participants whether we should use their data for data analysis at the end of the survey. We excluded participants who indicated that we should refrain from using their data.

### ***Analytical Strategy***

In addition to model parameters, in this study, we looked more closely at item-level parameters. We overviewed and compared item-level parameters (i.e., item discriminations, item thresholds, and item fit statistics) and the plots from typical IRT analyses (Item Response Functions – IRF and Item Information Functions – IIFs). To interpret item discrimination ($\alpha$), we build upon F. B. Baker and Seock-Ho (2017), who suggested that parameters exceeding 0.00, 0.35, 0.65, 1.35, and 1.70, should be interpreted as very low, low, moderate, high, and very high, respectively. It is important to note, however, that these cut-offs are somewhat arbitrary and can vary depending on the variance of the latent trait ($\theta$) in the data. Therefore, we calculated standardized discrimination parameters to account for the specific distribution of $\theta$ in our sample. Latent trait spectrum is defined with a classification system suggested by Rauthmann (2013), which is: well below average ($\theta < -2$), below average ($-2 < \theta < -1$), average ($-1 < \theta < 1$), above average ($1 < \theta < 2$), and well above average ($\theta > 2$).

If the GGUM model fits the data better, we would look at the item location parameters ($\delta$) estimated from the GGUM analysis. If mental model types are indeed ordered, as we illustrate in Figure 1, then the values of $\delta$ for items representing the same mental model should cluster together, and the $\delta$ parameters of these items should be ordered from "completely conflicting" to "completely compatible."

We estimated a multidimensional IRT model to test discriminant validity. In this process, we simultaneously specified our scale model and BISS model, and then, correlate the two constructs at the latent level. In specifying this model, we set items reflecting perceptions of the relationship between science and religion as "unfolding" (i.e., GGUM), while belief in science items as "dominance" (e.g., GPCM).

Currently, there is no consensus on the cut-off for a correlation between two constructs that indicates problems with discriminant validity. To fill this gap, Rönkkö and Cho (2022) propose a classification system, rather than a specific cut-off, in which the upper limit of the 95% confidence interval (CI) of correlations below 0.8 may indicate the absence of discriminant validity problems. Therefore, we expected that the upper bound of the 95% CI of the latent correlation between perceptions of the relationship between science and religion and belief in science to be less than 0.8 (Rönkkö & Cho, 2022).

Next, we compared our scale with the one proposed by Leicht et al. (2021. To do so, we followed the same procedure as in the discriminant validity test above. That is, we specified a multidimensional IRT model in which the items reflecting the latent dimension of the Leicht et al. (2021) scale were specified as "dominance" (i.e., GPCM) items, while the items of our scale were specified as "unfolding" (i.e., GGUM), and then, correlated them with each other at the latent level.

We then extracted the estimated person parameters ($\theta$) and its associated standard errors from the best-fitting model using an expected *a posteriori* (EAP) procedure (Chalmers, 2012; Roberts, et al., 2000; Muraki & Muraki, 2016). In doing so, we were able to correlate the perceptions of the science-religion relationship (estimated $\theta$ extracted from the best fitting IRT model) on the average score of centrality of religiosity (Huber & Huber, 2012), testing the hypothesis that higher levels of centrality of religiosity is associated with higher levels of compatibility perception (Leicht et al., 2021). Estimating the person parameters ($\theta$) also enabled us to calculate the empirical reliability of the scale (Chalmers, 2019).

Finally, we performed a Differential Item Functioning (DIF) analysis to test the measurement invariance across different countries (Germany and the United States). DIF analysis was performed following Meade and Wright's (2012) recommendation, namely a significance-based two-stage approach, which began with the selection of anchor items (i.e., invariant items). To this end, we followed a five-anchor item approach (Lopez Rivas et al., 2009; Meade & Wright, 2012).

First, we estimated an IRT model for the reference group (i.e., German sample). If the GGUM fits better to the data, we estimate the GGUM for the reference group; otherwise, we run the GPCM instead. Then, we estimated multigroup baseline IRT models (i.e., the GGUM or the GPCM) in which all item parameters (i.e., discriminations, location parameters, and threshold) are constrained to be equal across groups, but the latent mean and variance are freely estimated. This baseline model was then tested against another model with freely estimated item parameters for the item being tested for DIF. This process was iterative, so it continued until all items are tested, one item at a time, while assuming everything else was invariant (i.e., all others as anchors – AOAA, Kopf et al., 2015). For each comparison, the parameters of the tested item were obtained, and five items with a nonsignificant ($p > .05$) LRT test and the highest discrimination parameters (*a*) were selected as anchors. Next, we proceeded with the DIF analysis by imposing equality constraints on the anchor items to closely examine the focal items (i.e. the suspected DIF items). To detect the severity of DIF, we also estimated the Expected Score Standardized Difference (ESSD, Chalmers, 2012), and the interpretation of ESSD follows the interpretation of Cohen's *d* (i.e., $| d | < 0.20$ = negligible DIF, $0.20 \leq | d | < 0.50$ = small DIF, $0.50 \leq | d | < 0.80$ = moderate DIF, $| d | \geq 0.80$ = large DIF).

### ***Results and Discussion***

#### *Dimensionality*

We found evidence for a unidimensional, bipolar construct in both the German and U.S. samples, as indicated by a semicircular pattern in the PCA plot (Figure 4). Items appeared to cluster with their intended subscales, but similar to what we found in the pilot study and in Study 1, the compartment items clustered closer to the conflict items, while the context-switch items clustered closer to the complementary items. Correlations between loading factors of two principal components in the German ($r = -.57$, 95% CI [-.78, -.24], $p < .001$) and US American ($r = -.66$, 95% CI [-.83, -.38], $p < .001$) samples were also negative, consistent with our findings in the pilot study and Study 1. Two components recovered by the PCA explained 81% and 74% of the variance in the German and the U.S. sample, respectively.

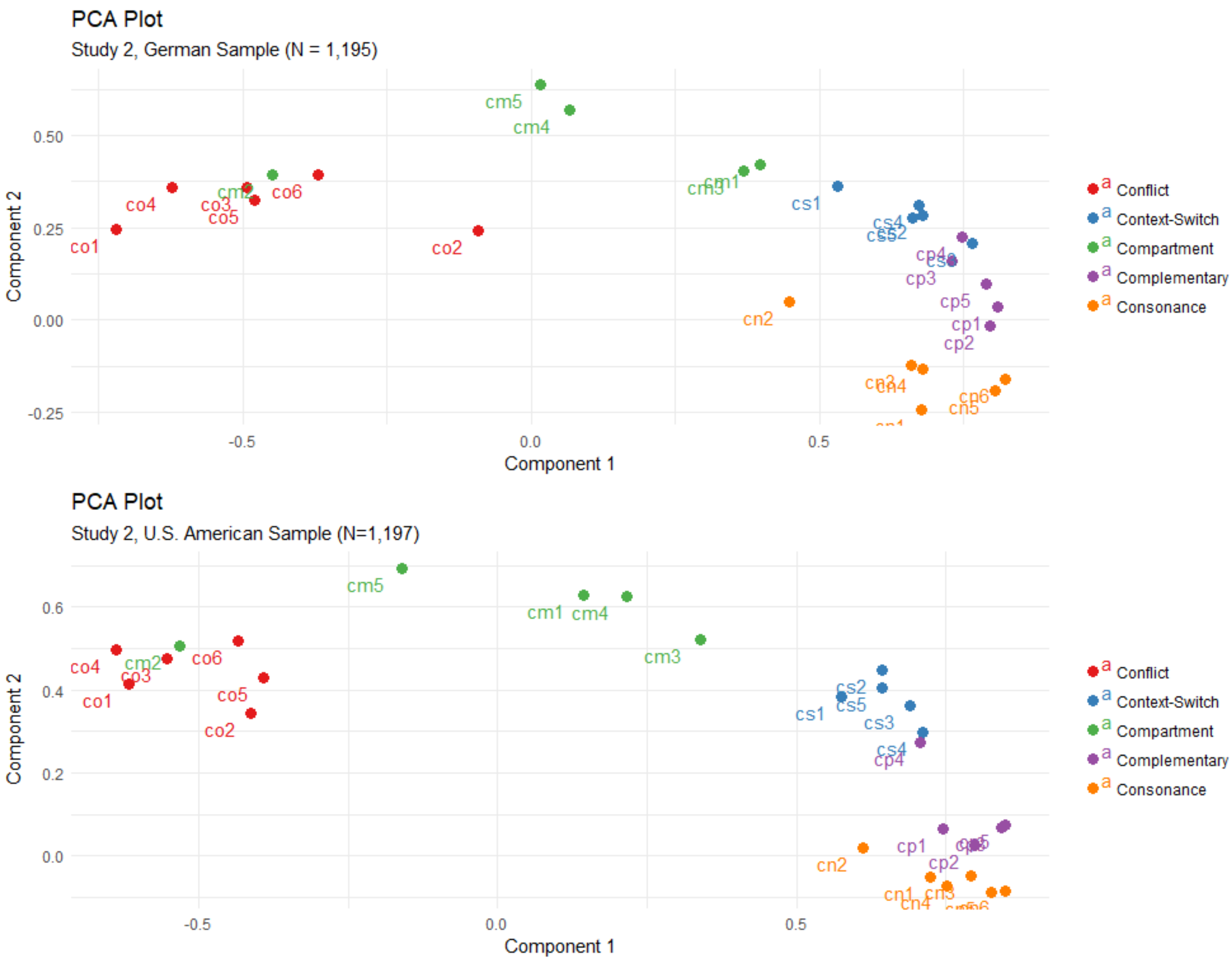



Figure 4. PCA Plot, Study 2, the German (Upper) and the U.S. American Sample (Lower), 27 items

Table 3. Final Items Included in the Analysis, 23 Items

| No. | Conceptualization Types | Scale Items |
|---|---|---|
| 1 | Conflict | I strongly believe that science and religion are ultimately at odds, with no possibility of harmony. |
| 2 | Conflict | To make decisions based on science, I need to abandon my religious beliefs completely. |
| 3 | Conflict | More often than not, I feel that science and religion offer opposing viewpoints. |
| 4 | Context-Switch | Depending on the situation, I can fully switch between relying on science or my faith. |
| 5 | Context-Switch | In certain situations, I strongly favor science, but in others, I entirely embrace my religious beliefs. |
| 6 | Context-Switch | In certain situations, I can endorse scientific viewpoints, but in others, I rather embrace religious beliefs. |
| 7 | Context-Switch | I can flexibly switch between my trust in scientific evidence and my faith. |
| 8 | Context-Switch | The importance I place on science relative to religion can vary, depending on the situations. |
| 9 | Compartment | I believe that the purposes of science and religion are so different that one cannot serve the function of the other. |
| 10 | Compartment | In my view, science and religion deal with different aspects of a phenomenon, each in its own unique way. |
| 11 | Compartment | I think science and religion use very distinctive methods to make sense of the world, and each method is valid only within its own domain. |
| 12 | Compartment | I find that scientific and religious explanations may work in their respective domains, but they remain separate. |
| 13 | Complementary | I believe that only when science and religion complement each other, can we gain a comprehensive understanding of the world. |

| No. | Conceptualization Types | Scale Items |
|---|---|---|
| 14 | Complementary | I believe that what science shows us and what we can learn from religion should be brought together in order to understand the world. |
| 15 | Complementary | It appears to me that science and religion can mutually fill in each other's gaps to form a complete picture of our world. |
| 16 | Complementary | In my opinion, science can answer certain questions that religion cannot, and vice versa, but the combination of the two makes them equally useful. |
| 17 | Complementary | In my view, bringing science and religion together can expand our understanding of the world, each from its own angle. |
| 18 | Consonance | To me, it is completely inconceivable that science and religion are in conflict since they clearly convey the same fundamental truths. |
| 19 | Consonance | To me, thinking about science is also an aspect of my spiritual life. |
| 20 | Consonance | I firmly believe that science and religion have the same root, even though they may appear different on the surface. |
| 21 | Consonance | It seems to me that science and religion can sometimes go in the same direction. |
| 22 | Consonance | When I think about the connections between science and religion, it seems like they are part of the same unity. |
| 23 | Consonance | The idea that science and religion are in harmony makes sense to me. |

*Note*. Instructions and the German version of the scale are available as Supplementary Material 1.

Table 4. Model Fit and Model Comparison Between Unfolding (GGUM) and Dominance Model (GPCM) in German ($N$ =1,195) and US American ($N$ = 1,197) Samples, 23 Items

| Model | Country | Parameters | LL | AIC | BIC | SABIC | HQ | $M_2$ | df ($p$) | RMSEA [95% CI] | SRMSR | TLI | CFI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GGUM | Germany | 115 | -28,423.35 | 57,076.70 | 57,661.58 | 57,296.29 | 57,297.06 | 575.27 | 161 (.000) | .046 [.042, .050] | .057 | .986 | .989 |
| GPCM | Germany | 92 | -28,819.70 | 57,823.39 | 58,291.29 | 57,999.07 | 57,999.68 | 2,022.30 | 184 (.000) | .091 [.087, .095] | .075 | .895 | .907 |
| GGUM | United States | 115 | -28,483.87 | 57,197.73 | 57,782.80 | 57,417.52 | 57,418.15 | 556.93 | 161 (.000) | .045 [.041, .049] | .090 | .988 | .991 |
| GPCM | United States | 92 | -29,253.16 | 58,690.32 | 59,158.38 | 58,866.15 | 58,866.66 | 4,951.74 | 184 (.000) | .147 [.143, .150] | .116 | .786 | .809 |

*Note.* Parameters = number of estimated parameters; LL = log likelihood; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SABIC = Sample Size Adjusted Bayesian Information Criterion; HQ = Hannah-Quinn Criterion; RMSEA = root mean squared error of approximation; SRMSR = standardized root mean square residual; TLI = Tucker-Lewis Index; and CFI = comparative fit index

***Model and Item Parameters***

We encountered convergence problems when fitting the GGUM models in both samples when all 27 items were included in the analysis. After examining the model residuals, using a procedure similar to that described in the pilot study, we decided to remove four items (three "conflict" items and one "compartment" item) from the models in both samples. We found substantial evidence of redundancy. In particular, the three "conflict" items formed a highly interrelated cluster within the conflict subscale, with residual correlations ranging from 0.26-0.44 in both samples. Similarly, one "compartment" item showed problematic local dependence with multiple items across subscales, particularly with a "conflict" item that was also part of the problematic item cluster we identified earlier. In terms of content, two "conflict" items in the problematic cluster were quite similar, while another "conflict" item in the same cluster was strongly correlated with the problematic "compartment" item, suggesting that this "compartment" item was inadvertently tapping into the "conflict" dimension. After removing these items, the GGUM models converged properly. The final 23 items used in the analysis are shown in Table 3. The model parameters of the models with the remaining 23 items are presented in Table 4.

As shown in Table 4, GGUM models were superior to the GPCM model in all samples, as indicated by a higher value of LL and lower values of AIC, BIC, SABIC, and HQ. The model fit indices of GGUM in the German and US samples, in general, showed a good fit (Schermelleh-Engel et al., 2003), except for a slightly higher SRMSR of the U.S. GGUM model, which supports our assumption that participants' response behavior follows an unfolding model rather than a dominance model.

We standardized the discrimination ($\alpha$) and item location parameters ($\delta$) of GGUM models and present them in Table 5. Unstandardized discrimination, item location and threshold parameter estimates, and item fit indices are available as Supplementary Material 3. As we predicted, the item location parameters of the GGUM models in two samples show evidence of ordering, starting with the conflict, which is on the highest spectrum of $\theta$, followed by the compartment, the context-switch, the complementary and the consonance. However, the differences between the complementary and the context-switch in the German sample and between the complementary and the consonance in the U.S. sample are fine-grained, as one context-switch item (in the German sample) and one complementary item (in the U.S. sample) are located between two context-switch items and two consonance items, respectively. In addition, items reflecting the compartment view, aligning with the PCA plot we presented earlier (Figure 4), are located closer to the conflict view, not closer to the compatibility as we previously expected.

Table 5. GGUM Standardized Discrimination Parameter and Standardized Parameter Location Estimates in German and US American Sample, 23 Items

| German Sample (*N* = 1,197) | | | | US American Sample (N = 1,195) | | | |
|---|---|---|---|---|---|---|---|
| ***α*** | ***δ*** | **No.** | **Subscale** | **Subscale** | **No.** | ***δ*** | ***α*** |
| .84 | 1.57 | 5 | Conflict | Conflict | 3 | 3.65 | .85 |
| .69 | 1.56 | 6 | Conflict | Conflict | 5 | 3.26 | .68 |
| .83 | 1.33 | 3 | Conflict | Conflict | 6 | 2.81 | .93 |
| .97 | .01 | 5 | Compartment | Compartment | 5 | .64 | .66 |
| .63 | -.17 | 4 | Compartment | Compartment | 1 | -.00 | .72 |
| .99 | -.68 | 1 | Compartment | Compartment | 4 | -.15 | .84 |
| .80 | -.77 | 3 | Compartment | Compartment | 3 | -.40 | .90 |
| 1.03 | -.90 | 1 | Context-Switch | Context-Switch | 2 | -.54 | 2.64 |
| 1.75 | -.99 | 4 | Context-Switch | Context-Switch | 1 | -.56 | 1.63 |
| 1.79 | -.99 | 5 | Context-Switch | Context-Switch | 5 | -.57 | 2.28 |
| 2.00 | -1.01 | 2 | Context-Switch | Context-Switch | 3 | -.59 | 2.61 |
| 2.42 | -1.07 | | Complementary | Context-Switch | 4 | -.70 | 2.35 |
| 2.82 | -1.12 | 3 | Context-Switch | Complementary | 4 | -.73 | 2.19 |
| 2.02 | -1.24 | 3 | Complementary | Complementary | 3 | -.96 | 3.93 |
| 2.53 | -1.34 | 5 | Complementary | Complementary | 1 | -.99 | 2.26 |
| 2.68 | -1.35 | 1 | Complementary | Consonance | 2 | -1.00 | 1.25 |
| 2.44 | -1.43 | 2 | Complementary | Complementary | 5 | -1.00 | 3.99 |
| .59 | -1.47 | 2 | Consonance | Complementary | 2 | -1.05 | 2.80 |
| 2.94 | -1.58 | 6 | Consonance | Consonance | 3 | -1.09 | 2.98 |
| 2.97 | -1.64 | 5 | Consonance | Consonance | 5 | -1.12 | 3.96 |
| 1.22 | -1.65 | 3 | Consonance | Consonance | 1 | -1.13 | 2.30 |
| 1.70 | -1.71 | 1 | Consonance | Consonance | 4 | -1.13 | 2.08 |
| 1.45 | -1.73 | 4 | Consonance | Consonance | 6 | -1.14 | 3.93 |

*Note.* α = discrimination parameter estimates, δ = location parameter estimates. Bold items mean that the items are in the same location in the German and U.S. American samples.

Figure 5 shows the Scale Characteristics Curves (SCC) for the respective sample, depicting the expected scores (T($\theta$)) as a function of the latent trait. For both samples, expected scores rise with increasing levels of $\theta$, peaking between -2 and 0, and then declining. The peak for the U.S. sample occurs earlier along the trait continuum compared to the German sample, indicating that the measure is more sensitive to these trait levels in the U.S. sample. The bell-shaped SCC is indeed consistent with typical unfolding models, such as GGUM. In unfolding models, the SCC typically shows a pattern where expected scores increase with the latent trait to a peak and then decline as the trait continues to increase. This reflects the idea that participants closest to an item's location on the latent trait continuum are more likely to agree with it, while those further away in either direction may disagree. Item response function (IRF) plots for each item are available as Supplementary Material 3.

Figure 6 presents the Scale Information Curves (SIC) from the GGUM for the German and U.S. American samples. These curves show how precisely the scale measures the $\theta$ at different levels. SICs show multiple peaks, which are typical to unfolding models. For the German sample, the information peaks at -2, then decreases before reaching peaks again between -0.5 and 0.25. In comparison, the U.S. sample shows greater overall information, with peaks at -2 and ~0.75, indicating higher measurement precision at these levels. Item information function (IIF) curves for each item are available as Supplementary Material 3.

We extracted the estimated $\theta$ using the EAP procedure, then we used the estimated $\theta$ of both samples to calculate the empirical reliability of the scale. The measure was sufficiently reliable in both the German sample ($\rho_{emp}$ = .924) and the US American sample ($\rho_{emp}$ = .923), indicating good overall measurement precision at the scale level.

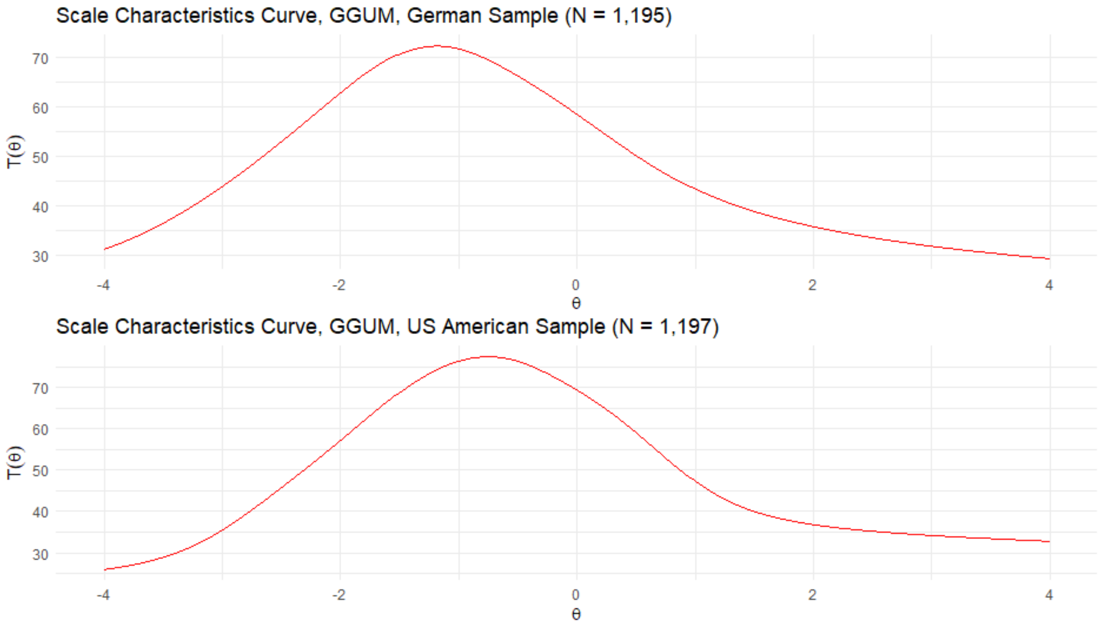
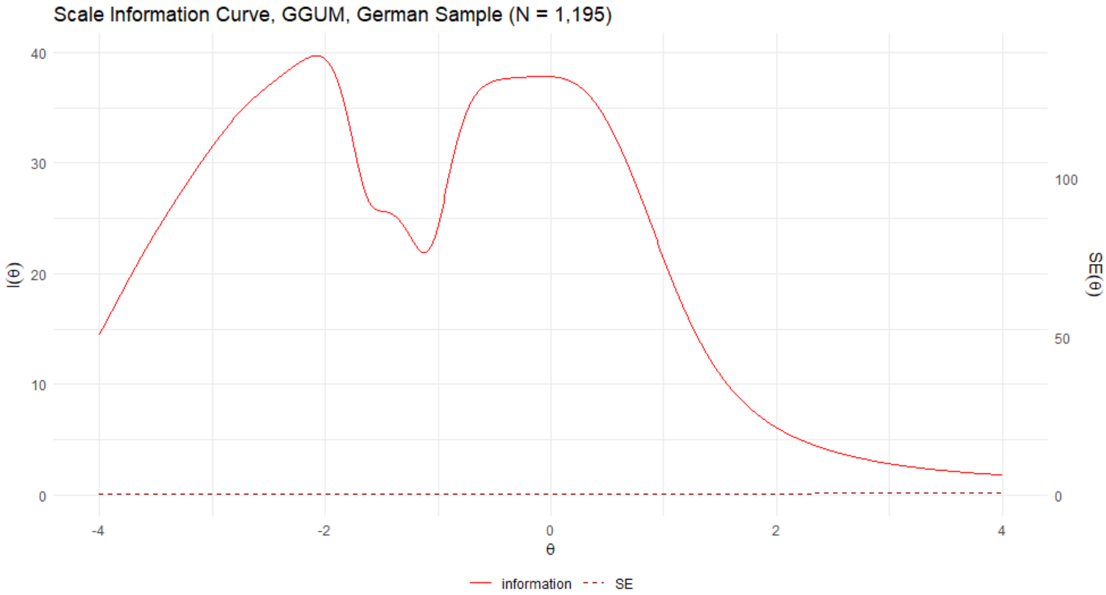



Figure 5. Scale Characteristics Curve of the German and the US American Sample



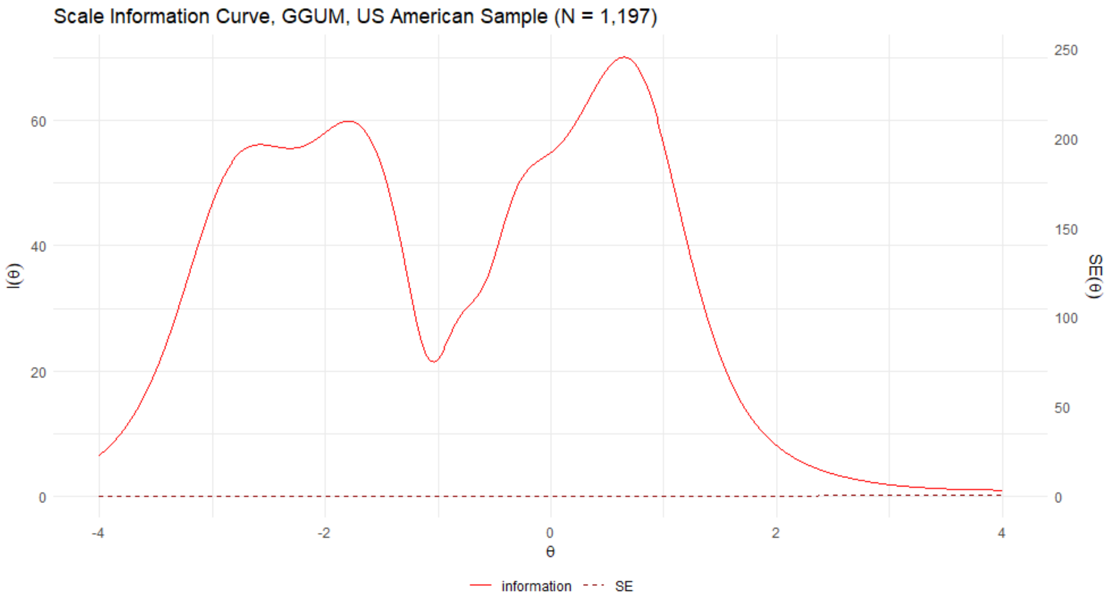




Figure 6. Scale Information Curve of the German (Upper) and the U.S. American Sample (Lower)

***Discriminant and Convergent Validity***

We fit multidimensional IRT models with mixed item types to test discriminant validity, in which we correlated the perception of the science-religion relationship with belief in science at the latent level. Correlations between our scale's *θ* with belief in science were moderate to high both in the German (ρ = .68, 95% CI [.66, .71], $ρ^2$ = .46) and the U.S. sample (ρ = -.50, 95% CI [-.54, -.45], $ρ^2$ = .25), but the upper values of the 95% confidence interval are still below the pre-registered 0.8 threshold (Rönkkö & Cho, 2022), denoting that our scale and BISS measure different constructs. Both correlations indicate that higher perceptions of conflict between science and religion is associated with higher belief in science, but the correlation is slightly weaker in the U.S. sample. It is important to note that the negative sign of the correlation coefficients in the U.S. sample is merely an artifact, as the software automatically placed items reflecting the conflict view at the lower end of the θ spectrum, rather than at the higher end of the θ spectrum as in the German sample. Model fit indices are available as Supplementary Material 4.

We calculated the mean score of Leicht et al.'s (2021) scale and examined its density. The distribution density for the German sample was positively skewed and showed low variability (*M* = 3.88, *SD* = 1.97), with most participants indicating a low compatibility of all eight domains listed in the scale. In contrast, the U.S. sample exhibited greater variability in distribution density (*M* = 5.16, *SD* = 2.56).

To assess the relationship between the scales, we applied the same procedure as testing discriminant validity to estimate the correlation between the *θ* of our scale and the Leicht's, et al. (2021) scale, which measures a similar construct with some conceptual overlap. The correlations were high in both the German (ρ = -.76, 95% CI [-.78, -.73], $ρ^2$ = .57) and in the U.S. sample (ρ = .74, 95% CI [.72, .77], $ρ^2$ = .54). The negative correlation in the German sample is an artifact of the scoring orientation and does not reflect any substantive conclusion.

Importantly, the correlation between the latent scores of the two scales, while high, was not so strong as to suggest redundancy (Carlson & Herdman, 2012; Cheung et al., 2024). This suggests that our novel scale can serve as a complementary tool, particularly in cases where Leicht et al.'s (2021) scale produces data with low variability, such as in the German sample. Model fit indices are available as Supplementary Material 4.

### ***Criterion-Related Validity***

We correlated the estimated θ with the composite score of religiosity, religious identity, atheist identity, agnostic identity, scientific identity and religious upbringing and present the results in Table 6 for the German sample and Table 7 for the U.S. sample. The Spearman correlation coefficients between the estimated $\theta$, religiosity (German: $r$ = -.70, 95% CI [-.73, -.67], $p$ < .001, United States: $r$ = -.55, 95% CI [-.59, -.51] , $p$ < .001) and religious identity (German: $r$ = -.60, 95% CI [-.63, -.56] , $p$ < .001, United States: $r$ = -.53, 95% CI [-.57, -.49] , $p$ < .001) are the strongest in both countries, meaning that religious people with a strong religious identity are less likely to perceive a greater conflict between science and religion.

Atheist identity (German: $r$ = .29, 95% CI [.23, .34], $p$ < .001, United States: $r$ = .18, 95% CI [.13, .24], $p$ < .001) is correlated with the estimated $\theta$, meaning that participants with a more pronounced atheist identity may perceive a greater conflict between science and religion. Furthermore, while science identity is positively correlated with the estimated $\theta$ in the German sample ($r$ = .20, 95% CI [.15, .26], $p$ < .001), it is nonsignificant in the U.S. sample ($r$ = .03, 95% CI [-.03, .09], $p$ = .263). That indicates Germans with stronger science identity might tend to perceive more conflict between science and religion. It is, however, important to note that while Spearman correlation can indicate a linear or non-linear relationship between two variables, it cannot detect a potential non-monotonic relationship (e.g. quadratic or curvilinear) between religiosity and perceptions of the relationship between science and religion, which may be theoretically possible (Lee, 2022).

Table 6. Zero-Order Correlations, German Sample ($N$ = 1,195)

| No. | Parameter | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Estimated θ GGUM | | | | | | | | |
| 2 | Religiosity | 2.13 | 0.77 | -.70*** | | | | | |
| 3 | Religious Identity | 1.39 | 1.51 | -.60*** | .62*** | | | | |
| 4 | Atheist Identity | 1.58 | 1.46 | .29*** | -.27*** | -.15*** | | | |
| 5 | Agnostic Identity | 1.45 | 1.40 | -.06 | .11*** | .14*** | .39*** | | |
| 6 | Science Identity | 3.70 | 1.25 | .20*** | -.12** | -.09** | .32*** | .21*** | |
| 7 | Religious Upbringing | 2.42 | 1.30 | -.32*** | .41*** | .39*** | -.13*** | .05 | -.00 |

*Note*. ***$p$ < .001, **$p$ < .01, *$p$ < .05

Table 7. Zero-Order Correlations, U.S. American Sample (*N* = 1,197)

| No. | Parameter | *M* | *SD* | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Estimated θ GGUM | | | | | | | | |
| 2 | Religiosity | 3.05 | 1.11 | -.55*** | | | | | |
| 3 | Religious Identity | 2.75 | 1.86 | -.53*** | .69*** | | | | |
| 4 | Atheist Identity | 0.86 | 1.28 | .18*** | -.17*** | -.18*** | | | |
| 5 | Agnostic Identity | 1.09 | 1.39 | .05 | -.07 | -.12*** | .62*** | | |
| 6 | Science Identity | 3.05 | 1.49 | .03 | -.12*** | -.07 | .25*** | .30*** | |
| 7 | Religious Upbringing | 3.48 | 1.32 | -.26*** | .43*** | .53*** | -.11** | -.06 | .06 |

*Note*. **p* < .001, ***p* < .01, **p* < .05

***DIF Analysis***

After fitting an unconstrained baseline model, the LRT test showed that three items (two context-switch and one consonance) were invariant, and thus selected as anchors due to their non-significant DIF. We then fit a more constrained model by specifying these anchor items as invariant, while allowing all other items suspected of exhibiting DIF to be freely estimated. Full LRT results of the unconstrained model are available in Supplementary Material 5.

We calculated the magnitude of DIF at both the item and scale levels. Item-level ESSD are presented in Table 8, and the full results, including item-level DIF effect sizes and plots showing differences in expected scores at the item and scale levels, are available in Supplementary Material 5.

Our analysis shows that all items reflecting the conflict and compartment views exhibit a large degree of DIF. This means that, relative to German participants, U.S. participants with similar underlying trait levels (*θ*) are more likely to perceive science and religion as being in conflict. Additionally, U.S. participants, compared to Germans, may more readily view science and religion as compartmentalized enterprises. This reflects cultural narratives or societal attitudes toward science and religion that differ between the two countries.

When the ESSD of all items is aggregated, the overall cumulative bias is moderate (ETSSD = 0.419). This implicates that while some items show a large degree of bias, these DIF effects tend to cancel each other out, resulting in a moderate overall impact on scale scores between groups. However, our DIF analysis provides clear evidence of systematic differences in how Germans and U.S. Americans perceive and respond to the items. Therefore, comparisons between the two countries should be made with caution.

Table 8. Expected Score Standardized Differences (ESSD) of the Focal Items Suspected of DIF

| Subscale | No. | ESSD | Interpretation |
|---|---|---|---|
| Conflict | 3 | 2.89 | Large |
| Conflict | 5 | 2.99 | Large |
| Conflict | 6 | 3.47 | Large |
| Context-Switch | 1 | .87 | Large |
| Context-Switch | 3 | .28 | Small |
| Context-Switch | 4 | .497 | Small to Moderate |
| Compartment | 1 | 1.90 | Large |
| Compartment | 3 | .87 | Large |
| Compartment | 4 | 2.10 | Large |
| Compartment | 5 | 2.11 | Large |
| Complementary | 1 | -.23 | Small |
| Complementary | 2 | -.39 | Small |
| Complementary | 3 | -.00 | Negligible |
| Complementary | 4 | .36 | Small |
| Complementary | 5 | -.18 | Negligible |
| Consonance | 1 | -.86 | Large |
| Consonance | 2 | .25 | Small |
| Consonance | 3 | -.37 | Small |
| Consonance | 4 | -.56 | Moderate |
| Consonance | 5 | -.61 | Moderate |

## General Discussion

We set out to develop a measure that captures how individuals mentally relate science to religion. Building upon Barbour's (1990) influential taxonomy and subsequent qualitative research, we created a scale that measures five distinct mental models people use when thinking about the relationship between science and religion: traditional conflict, context-switch, compartment, complementary, and consonance views (see Zein et al., 2024). The primary aim of this scale is to test the central premise of Barbour's taxonomy that individuals differ in their perceptions of the relationship between science and religion.

While Barbour's typology plays an influential role in guiding interested scholars in various fields, such as philosophy of science (e.g., Damper, 2022a, 2022b), science education (e.g., Woolley et al., 2023; Yasri & Mancy, 2012), psychology of religion and cognitive science of religion (e.g., Legare & Visala, 2011; Marin & Lindeman, 2021), and sociology of religion (e.g., Baker, 2012; Evans, 2011), the taxonomy has yet to be empirically tested in a quantitative framework. In this sense, designing a scale that reflects Barbour's taxonomical work can serve a twofold function. First, it allowed us to provide a severe test of Barbour's taxonomy, particularly with respect to the claim that people differ in their views of the relationship between science and religion, and that this difference comes in five types. Second, the scale can be a useful tool for future research projects that may unpack many relevant questions, as the following examples show.

Scholars argue that individuals dynamically engage with scientific and religious explanations throughout their lives (Davoodi et al., 2019; Ecklund & Park, 2009). At school age, individuals begin to refine their scientific reasoning skills. During this time, they are expected to gradually separate their scientific beliefs from their religious beliefs, with the former eventually replacing the latter (i.e., "conceptual change," see Posner et al., 1982). Consequently, how individuals perceive the relationship between science and religion may also change over time. Similarly, major life events, such as living abroad and interacting with people from different cultural and religious backgrounds, may also contribute to changes in individuals' perceptions of the relationship between science and religion (Rios & Aveyard, 2019; Rios & Roth, 2020). In this sense, our scale serves as a useful tool for investigating these questions much more systematically and rigorously than previous research did.

Another related question is how individuals relate to scientific and religious explanations in times of major societal crises, such as pandemics (Ayub et al., 2023; Jackson et al., 2020), anthropogenic climate crises (Arbuckle, 2017; Jenkins et al., 2018), or armed conflicts (Shai, 2022; Tarusarira, 2014). In these times of crisis, individuals are confronted with existential threats, and both science and religion offer to meet these existential needs (Rutjens & Preston, 2020). Therefore, it is possible that individuals who do not perceive a strong conflict between science and religion can flexibly use scientific and religious explanations during an existential crisis. A cross-cultural study of 54 countries shows that perceived compatibility between science and religion predicts well-being, particularly among people living in regions (e.g., Southeast Asia, South Asia, and North Africa) and among adherents of certain faith groups (e.g., Hinduism, Buddhism, and Islam) that traditionally view the relationship in a less conflictual light than people in North America and Western Europe (Price & Johnson, 2024).

Relatedly, discerning how individuals relate to scientific and religious explanations is critical for optimizing science communication strategies (Elsdon-Baker & Lightman, 2020) when discussing controversial topics related to the role of science and religion in society, such as evolution, genetic engineering, space exploration, vaccines, and many others (Drummond & Fischhoff, 2019; Lobato & Zimmerman, 2019). Again, our scale may be useful in this context. It is important to note, however, that our current study focused on rigorously testing the core tenet of Barbour's taxonomy, which we believe is a critical first step before answering any of the substantive questions sketched here. Our investigation yielded several key findings with important theoretical and methodological implications. First and foremost, our analyses consistently demonstrated that an unfolding model (GGUM) provided a superior fit to the data compared to a dominance model (GPCM) across multiple samples. This finding suggests that when people respond to questions about the relationship between science and religion, they are most likely to agree with statements that closely match their personal views. Instead of increasingly agreeing as statements reflect greater compatibility between science and religion, people are drawn to the specific statement that feels most aligned with their personal preferences. This insight has important implications for how we conceptualize and measure individuals' views about science and religion, suggesting that these views are more nuanced than a linear, cumulative progression from conflict to compatibility.

Our analyses revealed that items reflecting the compartment view consistently clustered closer to the conflict end of the spectrum, while context-switch items grouped closer to the complementary view. This pattern, which emerged across multiple samples and analyses, challenges our initial conceptualization that the context-switch is closer to the conflict, while a compartment view is closer to compatibility. The proximity of compartment to conflict suggests that viewing science and religion as entirely separate domains may be psychologically closer to viewing them as conflicting than we initially theorized.

When examining discriminant validity, the findings indicate that our scale measures a different construct than the BISS, as the latent correlations showed that the scales had more unique than shared variances (Germany: $\rho^2 = .46$; the United States: $\rho^2 = .25$). Therefore, even though our results indicate that higher levels of belief in science are associated with higher levels of conflict perception, the two constructs (i.e., belief in science and perceptions of the relationship between science and religion) are conceptually and empirically distinct.

To test convergent validity, we correlated the latent factor of our scale with Leicht et al.'s (2021), and found that they were highly correlated, but the shared variances were slightly higher than 50% (Germany: $\rho^2 = .57$; the United States: $\rho^2 = .54$). These correlations indicate substantial agreement between the two scales in measuring science-religion perceptions, yet leave sufficient unshared variance to suggest that each scale captures distinct aspects of how people mentally relate science to religion (Carlson & Herdman, 2012; Cheung et al., 2024).

Our contribution to the literature is that our scale is grounded in Barbour's (1990) taxonomy and its chosen measurement approach. Whereas Leicht et al.'s (2021) scale conceptualizes science-religion perceptions as varying along a conflict-compatibility continuum, our scale also captures qualitatively different mental models that people use to relate science and religion. The superior fit of the unfolding model (GGUM) compared to the dominance model (GPCM) across multiple samples provides strong empirical support for our measurement approach. It suggests that people's views on science and religion are better characterized by an unfolding response process, in which individuals agree most strongly with items that best match their position on the conflict-compatibility continuum, rather than simply agreeing more with items as their level of perceived compatibility increases. In addition, we have shown that our scale is able to accurately differentiate the perceptions of individuals who are situated in the middle range of the continuum, which is often difficult to do when applying the dominance model of measurement. We also provide evidence of the measurement precision of our novel scale, both at the item level and at the overall scale level.

Methodologically, our research demonstrates the importance of using appropriate measurement models when assessing complex psychological constructs. The superior fit of the unfolding model suggests that future research on science-religion relationships may need to consider using similar approaches rather than traditional dominance models. This insight may extend beyond science-religion relationships to other domains where attitudes, beliefs, or personality constructs are being measured (Stark et al., 2006).

Perhaps most notably, our DIF analysis revealed substantial cross-cultural differences in how German and American participants responded to items, particularly those reflecting conflict and compartment views. U.S. participants with similar underlying trait levels were more likely than German participants to perceive science and religion as being in conflict or as compartmentalized domains. These differences likely reflect distinct cultural narratives and societal attitudes toward science and religion in these countries, which corresponds to the fact that the relationship between science and religion is more strongly politicized in the United States (Perry et al., 2021) than it is in Germany (Evers, 2015). The moderate overall scale-level DIF (ETSSD = 0.419) suggests that while country-level comparisons should be made cautiously, the scale can still provide meaningful measurements within their respective cultural context.

These findings have practical implications for the field of science communication and science education. Our findings show that people differ in their mental models when relating science and religion, suggesting the value of personalized science communication strategies. For example, when discussing the climate crisis, science communicators may need to recognize that their audience have different ways of making sense of the relationship between scientific and religious explanations. Someone with a complementary view might be more receptive to messages that show how religious environmentalism aligns with and complements scientific evidence about the importance of taking climate action. Meanwhile, those with a compartment view might respond better to a clear separation between scientific evidence and religious explanations in discussions of the climate crisis. Our findings on cross-cultural differences also highlight the importance of taking cultural context into account (Bell et al., 2013; Johnson et al., 2020; Kostyukov, 2019). For example, science communication strategies that work in highly secular Germany may need to be adapted for more religiously diverse countries such as the United States. By understanding these different mental models, science communicators can better frame scientific information in ways that acknowledge and align with, rather than against, their audiences' pre-existing mental conceptualization when addressing the science-religion debates.

Several limitations of our study suggest directions for future research. While we tested our scale in German and American samples, future work may need to examine its properties in other cultural contexts, particularly in non-Western countries, such as regions of Asia and Africa, or among particular faith groups (e.g., Hinduism, Buddhism, Judaism and Islam), where the relationship between science and religion may be traditionally conceived in a less conflictual manner than in Western Europe and North America (Dodick et al., 2010; Falade, 2019; McPhetres et al., 2020; Payir et al., 2018; Price & Johnson, 2024; Vaidyanathan et al., 2016). People in these regions or belonging to these faith groups may perceive less conflict because they hold non-dualistic worldviews, suggesting that natural and supernatural realities are not seen as fundamentally separate or opposed (Brooke & Numbers, 2011). Moreover, many Asian and African societies have not experienced the same historical tensions between religious and scientific institutions as Western Christian countries (Fuller, 2020). This particular research program need not aim to develop a culturally unbiased measure, as such a goal may not be possible. However, it may be worthwhile to estimate the extent of differences in perceptions of the relationship between science and religion across different cultures.

One limitation of our scale is its focus on general, broader perceptions of science-religion relationships rather than domain-specific perceptions. While this broader approach allows us to capture the Barbour's (1990) mental models we initially theorized, evidence suggests that individuals' perceptions of science-religion compatibility can vary substantially across different scientific domains (Drummond & Fischhoff, 2019; Elsdon-Baker et al., 2017). Leicht et al.'s (2021) scale includes items about specific issues, such as the origin of the universe, physical and mental health, recognizing that conflict perceptions may be more pronounced in areas that directly challenge religious beliefs (e.g., the origin of the universe) compared to domains with less theological implications (e.g., physical health). Our scale's general approach provides insights into the general conceptualization that people use but may not capture how these models are differentially applied across scientific disciplines and domains. Future research can extend our unfolding measurement approach to specific scientific disciplines or topics, examining whether the five mental models manifest differently when applied to evolutionary biology versus climate science, or whether individuals employ different models for different topics or domains (e.g., genetic engineering, mental health, climate crisis, etc.). Such extensions could help bridge the gap between general frameworks and domain-specific science-religion perceptions, while maintaining the advantages of the unfolding approach.

Additionally, longitudinal research can help us understand how individuals' mental models of science-religion relationships develop and change over time, particularly in response to education, important life events (e.g., death and grieving), or societal challenges (e.g., natural disaster, pandemic, etc.). Future studies can also explore how these mental models relate to actual behavior, such as engagement with scientific information in different settings (e.g., health-related or environment-related scientific information, etc.).

Overall, our findings suggest that the relationship between science and religion is more nuanced than often portrayed in public discourse, with individuals having fine-tuned mental models to navigate between scientific and religious explanations. As we face global challenges that can benefit from scientific knowledge and religious wisdom, understanding how people separate or integrate these domains becomes more relevant. This work not only contributes to our theoretical understanding of how people relate to science and religion but also provides practical tools for studying these relationships across cultural contexts. As we move forward, this understanding may help bridge divides and foster more productive dialogue between scientific and religious institutions, ultimately contributing to a more inclusive public discourse about the role of both science and religion in addressing societal challenges.

## Ethics and Data Availability Statements

We ensure that data from our study is managed and stored in accordance with the European Union's General Data Protection Regulation (GDPR). Our research was conducted in accordance with the Declaration of Helsinki and the research ethics guidelines of the German Psychological Society. Pilot data, study materials, analysis codes, an anonymized dataset, and a codebook are made publicly available on a non-profit repository (https://osf.io/uqyr3/?view_only=3dcbfc45d4d04cf9a8606bd782482c99).

## Disclosure

To improve the presentation of this manuscript, we made use of a neural machine translation service (DeepL) for correcting spelling, punctuation, grammar mistakes in the manuscript and for back translating the scales from German to English. We also used generative artificial intelligence chatbots (Perplexity, ChatGPT 4o, and Claude 3.5 Sonnet) to search and identify scientific sources, to rewrite scale items, to debug R codes, and to generate alt-texts for the figures. To perform the analyses, we used these following R (v4.4.2, R Core Team, 2024) packages: *mirt* (Chalmers, 2012), *ggmirt* (Masur, 2022/2023), *psych* (Revelle, 2022), *easystats* (Lüdecke et al., 2022), and *tidyverse* (Wickham et al., 2019)

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## 8 Manuscript 3

# More Than Dilution: Religiosity and Conflict Perceptions Predict Perceived Utility of Religious, but not Scientific Explanations

Rizqy Amelia Zein[1,2] and Mario Gollwitzer[1]

[1] Department of Psychology, Ludwig-Maximilians-Universität München

[2] Department of Psychology, Universitas Airlangga

**Author Note**

Correspondence to: Rizqy Amelia Zein, Department of Psychology, Ludwig-Maximilians-Universität München (LMU), Leopoldstraße 13, Munich, Germany 80802 or Department of Psychology, Universitas Airlangga, Kampus B Unair Jalan Airlangga 4-6 Surabaya, Indonesia 60286, e-mail to: Amelia.Zein@psy.lmu.de or amelia.zein@psikologi.unair.ac.id

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Supplementary materials for this manuscript are available at https://osf.io/356z4/

## Abstract

People often turn to scientific and/or religious explanations to satisfy their need to explain and make sense of what happens in the world. Previous research has suggested that having access to multiple (scientific and religious) explanations may reduce the perceived utility of each single one of those explanations (the "dilution effect"). In the present study, 719 participants received different numbers of scientific and religious explanations for three incidents. We also measured participants' religiosity and their perceptions of the relationship between science and religion. Contrary to the dilution effect hypothesis, our data showed that receiving multiple explanations did not reduce the perceived utility of a single explanation. Our analyses further revealed that the utility of religious explanations depended on participants' religiosity and their perception of the science-religion relationship, but the utility of scientific explanations did not depend on any of these factors. Based on this result, we suggest that scientific and religious explanations are processed differently.

*Keywords:* science, religion, goal system theory, dilution effect, explanatory coexistence, motivated reasoning.

[155 words]

## More Than Dilution: Religiosity and Conflict Perceptions Predict Perceived Utility of Religious, but not Scientific Explanations

When faced with a large-scale societal crisis, such as a natural disaster, pandemic, or armed conflict, people turn to scientific and religious explanations to fulfill their epistemic and existential needs (Rutjens & Preston, 2020). Yet science and religion are often perceived as fundamentally irreconcilable – a narrative that can be traced back to the history of tensions between the Catholic Church and some prominent medieval scientists and philosophers, such as Nicolaus Copernicus and Giordano Bruno.

On the one hand, findings from previous research are indeed consistent with the conflict notion, highlighting that, in particular, religious people tend to believe that science and religion are incompatible (Chan, 2018; Paz-y-Miño-C & Espinosa, 2015), hold unfavorable attitudes toward science (Jochman et al., 2018; McPhetres et al., 2020), and trust science and accept scientific evidence less than non-religious people (Allum et al., 2014; Gauchat, 2015; D. R. Johnson et al., 2015; Miller et al., 2022; Noy & O'Brien, 2016; O'Brien & Noy, 2018). In this sense, religious beliefs act as a "perceptual filter" (Allum et al., 2014; Brossard et al., 2009; Scheufele et al., 2009) that individuals use to make sense of complex scientific information. Here, religious beliefs are responsible for determining what information is retained or discarded (Allum et al., 2014), leading to religious individuals to selectively distrust scientific evidence, especially that which directly contradicts their religious beliefs (Elsdon-Baker et al., 2017; Leicht et al., 2021).

That being said, other findings show that religious people are more likely to believe that science and religion are compatible with each other (Leicht et al., 2021; Longest & Smith, 2011; Zein et al., 2025), and that religious people can simultaneously express their trust and commitment to scientific findings and their religious beliefs (Cologna et al., 2025; Ecklund & Park, 2009; Ecklund & Scheitle, 2018; D. R. Johnson et al., 2015; Vaidyanathan et al., 2016). Some religious people hold the view that science and religion are two tightly compartmentalized enterprises (Vaidyanathan et al., 2016), while some of them believe that being scientifically knowledgeable is a part of their religious duty (Mansour, 2011; Vaidyanathan et al., 2016), leading them to show higher levels of trust in science than their non-religious counterparts (Cologna et al., 2025).

The inconsistency in the literature not only applies to empirical findings regarding the relationship between religiosity and the perceived value of scientific explanations; it also applies to the potential reasons underlying the difference in science-related attitudes between religious and non-religious people. For instance, some authors have argued that religious individuals are less inclined to critically engage with information and rely more on intuition than non-religious individuals (Pennycook, 2014; Pennycook et al., 2012, 2013; Zuckerman et al., 2013, 2020) and, thus, have a lower level of scientific literacy than the non-religious individuals (Sherkat, 2011).

However, other scholars have argued that people across different cultures use scientific and religious explanations simultaneously and even integrate the two in order to make sense of the world (Busch et al., 2017; Gelman, 2011; Legare et al., 2012; Legare & Visala, 2011; Shtulman & Legare, 2020). This phenomenon, namely explanatory coexistence, reveals that people draw on multiple explanatory frameworks rather than relying exclusively on either scientific or religious explanations (Legare et al., 2012). For instance, people may use scientific explanations to understand the natural mechanistic "how" of an event, while relying on religious explanations to make sense of the non-epistemic elements of an event – the "why" question (Davoodi & Lombrozo, 2022). The prevalence of explanatory coexistence across different cultures contradicts the notion that scientific and religious explanations are inherently incompatible.

The conflicting narrative in the literature raises a follow-up question: if it is true that religious individuals can simultaneously engage with scientific and religious explanations and believe that science is compatible with their religious belief, as shown by the literature on explanatory coexistence, then why do some studies show that they trust science less than their non-religious counterparts?

**The Dilution Effect or Motivated Reasoning?**

To scrutinize this question, Jackson et al. (2024) formulated and tested the "instrumentality hypothesis," which argues that lower trust in science among religious (vs. non-religious) individuals is a byproduct of having two equifinal means (i.e., science and religion) available for reaching an epistemic goal, which may reduce the perceived utility of either science or religion, respectively, for reaching that goal. Consequently, religious people may perceive science and religion as two substitutable means, leading them to assign equal but moderate perceived utility to both scientific and religious explanations. By contrast, non-religious people tend to see science as the only means to achieve their epistemic goal, prompting them to value scientific explanation highly.

This hypothesis derives from goal systems theory (Kruglanski, 2023), which argues that when people have more than one means to attain a goal, then the perceived utility of each of those means is diluted, leading to a reduced perceived utility to any of those means. In line with this reasoning, Bélanger et al. (2015) showed that participants whose goal was to increase their popularity (which has been experimentally activated) and who were presented with two equifinal means to achieve this goal (i.e., “hanging out with other people” and “helping other people”) rated the utility of each of these means as lower compared to participants who were presented with only one of these means. This phenomenon has been referred to as the “dilution effect” (Bélanger et al., 2015, 2016; Etkin & Ratner, 2012; Kruglanski et al., 2015; Zhang et al., 2007).

Applying the dilution effect to the question how religious individuals perceive the epistemic value of religious and scientific explanations, respectively, Jackson et al. (2024) proposed that religious individuals are equally committed to scientific and religious explanations – that is, science and religion are equifinal means to epistemic goals in goal systems terms – which may explain why the perceived utility of one specific explanation is lower compared to non-religious individuals, who are solely committed to scientific explanations.

To test this hypothesis, Jackson et al. (2024) conducted four studies. In the first study, they presented participants with several vignettes of anomalous phenomena and then asked them whether science or religion definitely could (1) or could not at all (7) explain each of those phenomena. In another study (Study 4), they exposed participants with science-based COVID-19 prevention strategies (e.g. washing hands, social distancing, etc.) and religion-based strategies (e.g. prayer, virtual religious gathering), and then asked them to rate the instrumentality of each of those strategies. Across these studies, when the utility ratings of religious and non-religious participants were compared, religious participants rated science much lower and prioritized religion more than non-religious participants, but they rated science and religion as having about the same utility. It is important to note, however, that Jackson et al. (2024) did not directly manipulate the presentation of multiple means in any of their studies, as was done in the original study of the dilution effect (Bélanger et al., 2015), but rather assumed that religious individuals rely on both scientific and religious explanations, while non-religious individuals rely solely on scientific explanations.

Consequently, it remains unclear whether the results of the studies by Jackson et al. (2024) provide clear support for the dilution effect, as the findings could also be interpreted differently as a case of classical motivated reasoning (Kunda, 1990). In this sense, Jackson et al.’s (2024) findings may simply show that religious individuals value scientific explanations less because they are motivated to defend their religious beliefs. Similarly, non-religious individuals may strongly prefer scientific explanations because they fit well with their pre-existing secular worldview. In this context, religiosity (or lack thereof) plays its role as “a perceptual filter” (Brossard et al., 2009), deciding which parts of explanations are retained or ignored by individuals. It is worthwhile to consider that this phenomenon does not pertain exclusively to religious beliefs, as previous findings demonstrate that moral beliefs (Bender et al., 2016) and social identity concerns (Nauroth et al., 2014, 2017) can also distort people’s perceptions of scientific explanations just as religious beliefs do here.

Given that the debate between science and religion is an emotionally and morally laden issue (Evans, 2008; Yasri & Mancy, 2012), it is possible that people already have a strong preference on this topic. Under these circumstances, when evaluating new information, people seek to preserve their prior beliefs and thus prefer new information that is consistent with these beliefs (Epley & Gilovich, 2016; Taber & Lodge, 2006). In doing so, people apply different standards of evidence to reach their desired conclusion (Epley & Gilovich, 2016). Therefore, it is less surprising that religious individuals appear to value scientific and religious explanations almost equally, with a slight preference for religious explanations, as shown by Jackon et al. (2024), because religious individuals apply different evidentiary standards to religious and scientific explanations, with religious explanations having a lower threshold for rejection than scientific explanations (Lobato et al., 2020).

**Purpose of the Present Study**

Without directly manipulating the number of means, it is difficult to determine whether the results shown by Jackson et al. (2024) can be considered clear evidence for a dilution effect or rather for a motivated reasoning account. In our own research, we aimed to disentangle these two accounts by conducting a study that directly tested the dilution effect. Specifically, we presented participants with three incidents (i.e., flooding, war, and climate change) and then provided them with scientific and religious explanations for why these events occurred. The number of these explanations was systematically varied across three conditions: one, two, or four explanations. In the one-explanation condition, participants saw either one scientific *or* one religious explanation. In the two-explanation condition, participants were always presented with one scientific *and* one religious explanation. In the four-explanation condition, participants evaluated two scientific *and* two religious explanations. Each participant encountered all three incidents (flooding, war, and climate change) exactly once, with each incident paired with a different number of explanations. The order of both incidents and number of explanations was counterbalanced using a Latin square design to minimize order effects.

The three incidents we used here were selected because they naturally evoke a quest for causal explanations (how did this happen?) and meaning-making questions (why did this happen?) that can be addressed from both scientific and religious perspectives. These incidents also fall under an existential theme (death and destruction, see Polt, 1999; Sullivan et al., 2012), which may lead to the use of explanatory coexistence (Legare et al., 2012; Legare & Visala, 2011). In this sense, individuals may appeal to both scientific and religious explanations to make sense of these incidents (Legare & Visala, 2011).

To scrutinize the "dilution effect" hypothesis, we tested whether (a) the more explanations participants are exposed to, the less each of these explanations is judged to be useful in explaining the event – regardless of whether the explanation is scientific or religious. This hypothesis pertains to the general dilution effect as demonstrated by Bélanger et al. (2015). In addition, we tested (b) whether, when presented with both scientific and religious explanations (vs. scientific or religious only), religious (vs. non-religious) individuals show stronger dilution effects. This hypothesis follows from Jackson et al.'s (2024) claim that religious individuals have two viable means to understand crises (science and religion), while non-religious individuals effectively have only one (science).

Finally, we tested (c) whether people's mental representation of the relationship between science and religion moderate the dilution effect. More specifically, we reasoned that, when presented with both scientific and religious explanations (vs. scientific or religious only), individuals who agree that science and religion are not inherently in conflict with each other show stronger dilution effects than individuals who endorse a conflict view. The rationale here is that people with non-conflict views are more likely to accept both scientific and religious explanations as instrumental means (Zein et al., 2024), making them more susceptible to the dilution effect. In contrast, those with conflict views typically accept only one type of explanation as instrumental (either scientific or religious) and thus should show weaker dilution effects since they effectively have only one available means.

The three hypotheses specified in the previous paragraph assume the existence of a dilution effect when it comes to assessing the epistemic value (i.e., perceived utility) of religious and scientific explanations. Notably, our design also allows us to test whether what Jackson et al. (2024) interpreted as a dilution effect may simply represent a motivated reasoning effect. A simple motivated reasoning account would predict that it is not the number of explanations that people are confronted with that matters, but rather the type of explanation: Religious individuals (and people who hold non-conflict beliefs regarding science and religion) should consider both religious and scientific explanations as equally valuable for explaining the three incidents, while non-religious individuals (and people who hold conflict beliefs regarding science and religion) should consider religious explanations as less valuable – irrespective of the number of explanations they had been confronted with.

## Method

The dataset, codebook, study materials, and the results of *a priori* power simulation to estimate sample size are available on the Open Science Framework (OSF, https://osf.io/356z4/?view_only=1d8b56a4ba834a65bae638f436272237). The experimental design, hypotheses, and analysis plan were pre-registered prior to data collection (https://osf.io/ctru2/?view_only=da1e6c455cd741dab75220151a1be638).

### *Design*

The experiment was a within-subjects design examining three incidents (flooding, war, and climate change). For each incident, participants received different numbers of explanations (and then rated their utility, respectively) under three conditions: (1) a single explanation (either scientific or religious, explanations randomly chosen), (2) two explanations (always one scientific and one religious, explanations randomly chosen), or (3) four explanations (always two scientific and two religious). For the one and two explanations conditions, each explanation was drawn from an incident-specific pool containing a total of four possible explanations (two scientific and two religious). For the four explanations condition, all explanations in the pool were used. To control for order effects, we used a Latin square design to counterbalance both the sequence of incidents and the number of explanations, resulting in nine possible presentation orders. Each participant encountered all three incidents exactly once, with incidents separated by filler tasks to minimize carryover effects. These filler tasks required participants to observe and evaluate two paintings. Descriptions of the incidents and all scientific and religious explanations explaining these incidents are available as Appendix 1.

### *Participants*

To estimate sample size, we determined the smallest effect size of interest (SESOI) of the main effect (i.e., the number of explanations). Based on Bélanger et al.'s (2015) reported effects of 0.67-0.78 points on a 7-point scale, and accounting for potential effect size inflation in published literature (Open Science Collaboration, 2015), we set our SESOI to approximately half this magnitude. Specifically, we modeled effect sizes of 0.25 above the grand mean for 1-explanation, -0.10 for 2-explanation, and -0.15 for 4-explanation, creating a maximum difference of 0.40 points between conditions. Using the *mixedpower* package (Kumle et al., 2021), we simulated ($N_{simulation}$ = 1,000) power for detecting these effects in a linear mixed model with crossed random intercepts for participants and explanations, while random slopes were fixed to zero, accounting for our within-subjects design with a Latin square. To detect the predetermined SESOI of the main effect (i.e. the number of explanations) with ~90% power using our planned experimental design, we needed to recruit at least 600 participants.

To ensure data quality, we preregistered two exclusion criteria: an attention check criterion (i.e., implausible responses to items such as "I have never brushed my teeth"; see Kay & Saucier, 2023) and a "use me" item, which asked participants whether we should use their data for data analysis at the end of the experiment. Based on these two criteria, 15 cases were discarded from the dataset.

To recruit participants, we advertised our study invitation to a participant pool curated by our own lab, a university-wide mailing list, and social media platforms (e.g., Facebook, Instagram, and Reddit). Participants had to be at least 18 years old and to have a good knowledge of German. We recruited 734 participants, and 719 remained after excluding cases according to the criteria specified above. Ages ranged between 18 and 83 ($M$ = 34.04, $SD$ = 15.93 years) and women were slightly overrepresented (67.73% female, 30.73% male, 1.52% other). Students who participated in the experiment through the SONA system received course credit as compensation, while non-student participants were offered to participate in a raffle to win four 50€ shopping vouchers.

***Measures***

***Perceived Utility of Explanations.*** To measure our dependent variable, that is, the perceived utility of explanations, we asked participants to rate each explanation by responding to a seven-point Likert (1/strongly disagree, 7/strongly agree) consisting of four items (i.e., "*I consider this explanation useful*," "*I find this explanation valuable*," "*This explanation helps me to better understand the background of the event*," and "*This explanation can be beneficial for the future*"). The internal consistency of this four-item scale was high across all twelve explanations ($\omega_t$ = .92 – .94).

***Religiosity.*** The Centrality of Religiosity Scale – Interreligious versions (CRSi-7) was used to measure religiosity, with seven items reflecting five subdimensions; intellect ("*How often do you think about religious issues?*"), ideology (e.g., "*To what extent do you believe that God or something divine exists?*"), public practice ("*How often do you take part in religious services?*"), private practice (e.g., "*How often do you pray?*"), and experience (e.g., "*How often do you experience situations in which you have the feeling that God or something divine intervenes in your life?*"). As suggested by Huber and Huber (2012), we adjusted the scale according to the religious affiliation of the participants. For example, for Buddhist and Hindu participants, the wording of the items measuring ideology were modified to better reflect their belief in polytheistic theology.

Participants reported their importance of religion in five possible options (1/not at all, 2/not very much, 3/moderately, 4/quite a bit, 5/very much so), and their public and private practices related to religion in eight possible options (1/several times a day, 2/once a day, 3/more than once a week, 4/once a week, 5/one to three times a month, 6/a few times a year, 7/less than a few times a year, 8/never). We implemented a scoring guideline provided by Huber and Huber (2012) to calculate a composite score. Huber and Huber (2012) suggest that individuals with a composite score of 2 or below indicate no or marginal presence of religiosity and should therefore be categorized as "non-religious," while those with a score of 3 or above should be categorized as "religious." Internal consistency of the generic CRSi-7 scale was satisfactory ($\omega_t$ = .92).

***Perceptions of the Relationship Between Science and Religion.*** To measure participants' perceptions of the relationship between science and religion, we used a scale developed by Zein, Heene, and Gollwitzer (2025), consisting of 27 items with four possible response categories (1/strongly disagree, 2/disagree, 3/agree, 4/strongly agree). The scale is based on the extension of Barbour's (2002) taxonomy, in which items reflect five types of the science-religion relationship: *conflict* (i.e., believing that science and religion are fundamentally incompatible), *compartment* (i.e., believing that science and religion are two mutually exclusive enterprises), *context-switch* (i.e., believing that one can flexibly switch between science and religion depending on the situation), *complementary* (i.e., believing that science and religion are incomplete without each other), and *consonance* (i.e., believing that science and religion are perfectly compatible and can reinforce each other).

It is important to note that while the scale assumes that people differ qualitatively as reflected in these types, it also operates on the premise that these types of conceptualization are ordered on a unidimensional, bipolar continuum ranging from conflict to compatibility, with the conflict view being at the "most conflict" end, compartment in the middle, and context-switch, complementary, and consonance closer to the "most compatible" end of the continuum.

Because the scale elicits unfolding or ideal point responses (Zein et al., 2025), we fitted a generalized graded unfolding model (GGUM – see Roberts et al., 2000) to the data, using the expectation maximization (EM) algorithm to estimate model and item parameters (Chalmers, 2012). When fitting the model, we encountered a convergence issue due to multicollinearity between items. After removing two items (one “conflict” and one “context-switch” item), the model converged properly and showed a good model fit ($M_2(180) = 491.85$, $p < .001$, RMSEA = .049, 95% CI of RMSEA [.043, .054], SRMSR = .070, TLI = .980, CFI = .984).

To categorize participants as holding conflict or non-conflict beliefs, we applied the following procedure: First, we computed predicted person parameters, i.e., factor scores ($\theta$), by applying the expected a-posteriori (EAP) method (Thissen et al., 1995), and then, standardized them. Second, we computed and standardized the item location parameter ($\delta$), which indicates the location of items on the latent trait continuum (Roberts et al., 2000). We determined the classification cutoff based on the location parameter ($\delta$) of “compartment” items, which are situated in the middle of the continuum, acting as a boundary category between conflict and non-conflict beliefs as shown in the previous research (Zein, et al. 2025). Specifically, we used the mean of location parameter ($\delta$) of compartment items as the cutoff point, as these items reflect a transition between conflict and compatibility, where science and religion are seen as separate but non-conflicting domains. Using this cutoff, we classified participants with $\theta$ scores above the cutoff as having a “non-conflict” view and those below the cutoff as having a “conflict” view.

To estimate measurement precision, we calculated the empirical reliability of the scale (Chalmers, 2019) using the predicted $\theta$ scores, and the analysis showed that the scale had good measurement precision overall ($\rho_{emp} = .94$).

***Data Analytic Procedure***

To test the main effect of number of explanations, we fitted a linear mixed effects (lme) model. Our manipulated independent variable, number of explanations (1 vs. 2 vs. 4), was effect-coded such that the first contrast variable captures the difference between the 1-explanation condition and the grand mean, while the second contrast variable captures the difference between the 2-explanations condition and the grand mean. The dependent variable was the mean of perceived utility rating. To account for the dependency structure in the data, we included crossed random intercepts for participants (who rated multiple explanations) and explanations (which were rated by multiple participants) for all analysis we reported. Random slopes were fixed to zero in these models. Post-hoc comparisons were conducted using Bonferroni-corrected pairwise comparisons of estimated marginal means.

Because we stated in the preregistration document that we would compare the results to a model with a different coding scheme to ensure that our analysis is robust, we fitted another lme model with the 1-explanation condition as the reference category (i.e., dummy coding). We present the results as robustness checks in Appendix 2.

To test the second hypothesis, we planned to fit a linear mixed effects model with a three-way interaction term between number of explanations (1-explanation vs. grand mean and 2-explanation vs. grand mean), type of explanation (scientific vs. religious), and religiosity (religious vs. non-religious) as fixed effects. Religiosity was coded using effect contrasts (religious = 0.5, non-religious = -0.5). For the third hypothesis, we tested three-way interaction effects between the two contrast variables, explanation type (scientific vs. religious), and conflict beliefs (conflict vs. non-conflict), coded using effect contrasts (conflict = 0.5, non-conflict = -0.5).

To illustrate the differences between groups, we report model-predicted means, which have been adjusted for random effects of the model (Lüdecke, 2018). We also provided a robustness check by fitting lme models testing H2 and H3, where religiosity and conflict beliefs were continuous variables, not dichotomized as in our preregistration, as Supplementary Material 1.

## Results

### ***Descriptive Statistics***

Descriptive statistics of the measured variables and correlations between them are presented in Table 1. As shown in Table 1, scientific explanations were perceived to be more useful in general than religious explanations and there was no correlation between how participants rated scientific and religious explanations. Perceived utility of religious explanations was moderately correlated with religiosity and perceptions of the relationship between science and religion, denoting that religious participants and non-conflict believers rated religious explanations more favorably. Conversely, no correlations were found between perceived utility of scientific explanations with religiosity or conflict perceptions.

**Table 1.** Zero-Order Correlations Between Measured Variables

| No | Variables | *M* | *SD* | 1 | 2 | 3 |
|---|---|---|---|---|---|---|
| 1 | Perceived Utility of Scientific Explanations | 5.49 | 1.08 | | | |
| 2 | Perceived Utility of Religious Explanations | 2.25 | 1.18 | .02 | | |
| 3 | Religiosity | 2.27 | .74 | -.06 | .46** | |

| No | Variables | *M* | *SD* | 1 | 2 | 3 |
|---|---|---|---|---|---|---|
| 4 | Perceptions of the Science-Religion Relationship | -0.01 | .95 | -.07 | .40** | .57** |

Note: *N* = 719. ** *p* < .001

### *The Main Dilution Effect*

Looking at the mean values, utility ratings did not differ between the one explanation (*M* = 3.89), the two explanations (*M* = 3.85), and the four explanations condition (*M* = 3.85). Our planned contrasts showed that neither the first contrast comparing one explanation to the grand mean (*b* = 0.03, *SE* = 0.03, 95% CI [-0.04, 0.09], *t*(5022) = 0.89, *p* = .372), nor the second contrast comparing two explanations to the grand mean (*b* = -0.02, *SE* = 0.03, 95% CI [-0.07, 0.04], *t*(5022) = -0.58, *p* = .560) was statistically significant, even though the power to detect the SESOI was sufficiently high.

The model explained a substantial proportion of the total variance ($R^2$ conditional = .734), with most of this variance being attributed to individual differences between participants (*SD* = 0.62) and specific explanations (*SD* = 1.93) rather than the fixed effect of number of explanations ($R^2$ marginal < .001). The random effects indicate that while participants showed moderate variation in their overall utility rating, the explanations themselves differed much more substantially in how they were rated. Our results imply that while there was considerable variation in how participants rated explanations overall and how different explanations were rated in general, the number of explanations presented did not systematically predict perceived utility. Our findings ultimately provided no support to the hypothesized dilution effect, suggesting that the perceived utility of explanations remains relatively stable regardless of how many explanations are presented simultaneously. Our robustness checks (see Supplementary Material 1) showed that this conclusion is robust, demonstrating that the perceived utility of explanations remained stable regardless of how many explanations participants had encountered, even when the number of explanations was made a continuous rather than a categorical variable, or when a different coding scheme was used.

### *Models with Interaction Effects*

***Perceived Utility Ratings and Religiosity.*** The second hypothesis, predicting differential effects of explanation type based on religiosity, was tested using a linear mixed effects model with three-way interaction effects between the two contrast variables, explanation type (scientific vs. religious), and religiosity (religious vs. non-religious). Estimated model parameters are displayed in Table 2, while the simple simple effects for the number by the type of explanation for religious and non-religious participants, respectively, are presented in Table 3.

Table 2. Estimated Model Parameters

| **Parameter** | ***b*** | ***SE*** | **95% CI** | ***t*** | ***p*** |
|---|---|---|---|---|---|
| Intercept | 4.05 | 0.57 | [2.94, 5.17] | 7.10 | <.001 |
| Explanation type | 0.61 | 0.09 | [0.45, 0.78] | 7.22 | <.001 |
| Religiosity | 0.59 | 0.08 | [0.44, 0.75] | 7.46 | <.001 |
| Contrast 1 | 0.15 | 0.04 | [ 0.06, 0.23] | 3.42 | <.001 |
| Contrast 2 | -0.12 | 0.04 | [-0.20, -0.05] | -3.38 | <.001 |
| Explanation type × Religiosity | 1.34 | 0.11 | [1.13, 1.56] | 12.27 | <.001 |
| Explanation type × Contrast 1 | 0.08 | 0.09 | [-0.10, 0.26] | 0.85 | .395 |
| Explanation type × Contrast 2 | 0.03 | 0.08 | [-0.13, 0.18] | 0.36 | .716 |
| Religiosity × Contrast 1 | 0.30 | 0.09 | [0.12, 0.47] | 3.39 | <.001 |
| Religiosity × Contrast 2 | -0.24 | 0.07 | [-0.39, -0.10] | -3.29 | <.001 |
| Explanation type × Religiosity × Contrast 1 | 0.31 | 0.18 | [-0.04, 0.67] | 1.72 | .086 |
| Explanation type × Religiosity × Contrast 2 | -0.32 | 0.15 | [-0.61, -0.02] | -2.10 | .036 |

*Note.* Explanation type: -0.5 for scientific and 0.5 for religious explanation. Religiosity: -0.5 for non-religious and 0.5 for religious participants. Contrast 1: one explanation vs. grand mean. Contrast 2: two explanations vs. grand mean.

Table 3. Simple Simple Effects for the Number of Explanation by the Type for Religious and Non-Religious Participants

| **Contrast** | ***b*** | ***SE*** | ***df*** | ***t*** | ***p*** |
|---|---|---|---|---|---|
| **Non-Religious Participants** | | | | | |
| Religious explanation alone | -0.07 | 0.07 | 4539 | -0.91 | 1.00 |
| One religious explanation in two explanation condition | 0.06 | 0.05 | 4443 | 1.29 | 1.00 |
| Two religious explanations in four explanation condition | -0.08 | 0.05 | 4354 | -1.52 | .773 |
| Scientific explanation alone | 0.07 | 0.07 | 4543 | 0.95 | 1.00 |
| One scientific explanation in two explanation condition | -0.07 | 0.06 | 4477 | -1.20 | 1.00 |
| Two scientific explanations in four explanation condition | 0.09 | 0.05 | 4336 | 1.70 | .544 |
| | | | | | |
| **Religious Participants** | | | | | |
| Religious explanation alone | 1.06 | 0.15 | 4588 | 7.01 | <.001 |
| One religious explanation in two explanation condition | 0.33 | 0.09 | 4412 | 3.51 | .002 |

| Contrast | *b* | *SE* | *df* | *t* | *p* |
|---|---|---|---|---|---|
| Two religious explanations in four explanation condition | 0.54 | 0.09 | 4319 | 6.06 | <.001 |
| Scientific explanation alone | -0.46 | 0.14 | 4571 | -3.36 | .004 |
| One scientific explanation in two explanation condition | -0.82 | 0.12 | 4440 | -6.90 | <.001 |
| Two scientific explanations in four explanation condition | -0.64 | 0.09 | 4308 | -7.36 | <.001 |

*Note*. *P* values were corrected for multiple testing using the Bonferroni correction.

As can be seen from Table 2, the three-way interaction effect was significant only for the second contrast variable, while a two-way interaction between religiosity and explanation type as well as both main effects of religiosity and explanation type were significant. Breaking down this interaction, as presented in Table 3, shows that religious participants consistently rated religious explanations as more useful than scientific ones across all explanation conditions (1, 2, and 4 explanations), with particularly strong effects in the 1-explanation condition and 4-explanation condition. They also rated scientific explanations as less useful in all conditions. Additionally, the opposite signs for the significant main effects of two contrast variables indicate that the 1-explanation condition produced higher overall ratings compared to the grand mean, while the 2-explanation condition produced lower ratings, suggesting that providing two explanations decreased perceived utility ratings, regardless of explanation type.

Within-group comparisons show that among religious participants, religious explanations were rated as most useful when presented alone ($M$ = 5.41), but the utility ratings of religious explanations decreased particularly when presented in pairs with one scientific explanation ($M$ = 4.68, Cohen's $d$ = 0.64, $p$ < .001). A significant three-way interaction of the second contrast variable, as well as the pairwise comparisons above, suggest that religious participants gave the lowest utility ratings to religious explanations when scientific and religious explanations were directly juxtaposed (1-to-1), but then it reversed when multiple explanations of each type were presented, as in the 4-explanation condition. In contrast, their ratings of scientific explanations remained relatively stable across conditions ($M$ = 3.89, 3.53, and 3.71, respectively).

Meanwhile, non-religious participants showed no clear preference pattern, with ratings for both religious ($M$ = 3.69-3.82) and scientific ($M$ = 3.69-3.84) explanations remaining relatively stable across conditions. We visualize the model-predicted means in Figure 1. We also fit lme models for religious and non-religious participants separately, the results of which are available as Supplementary Material 2.

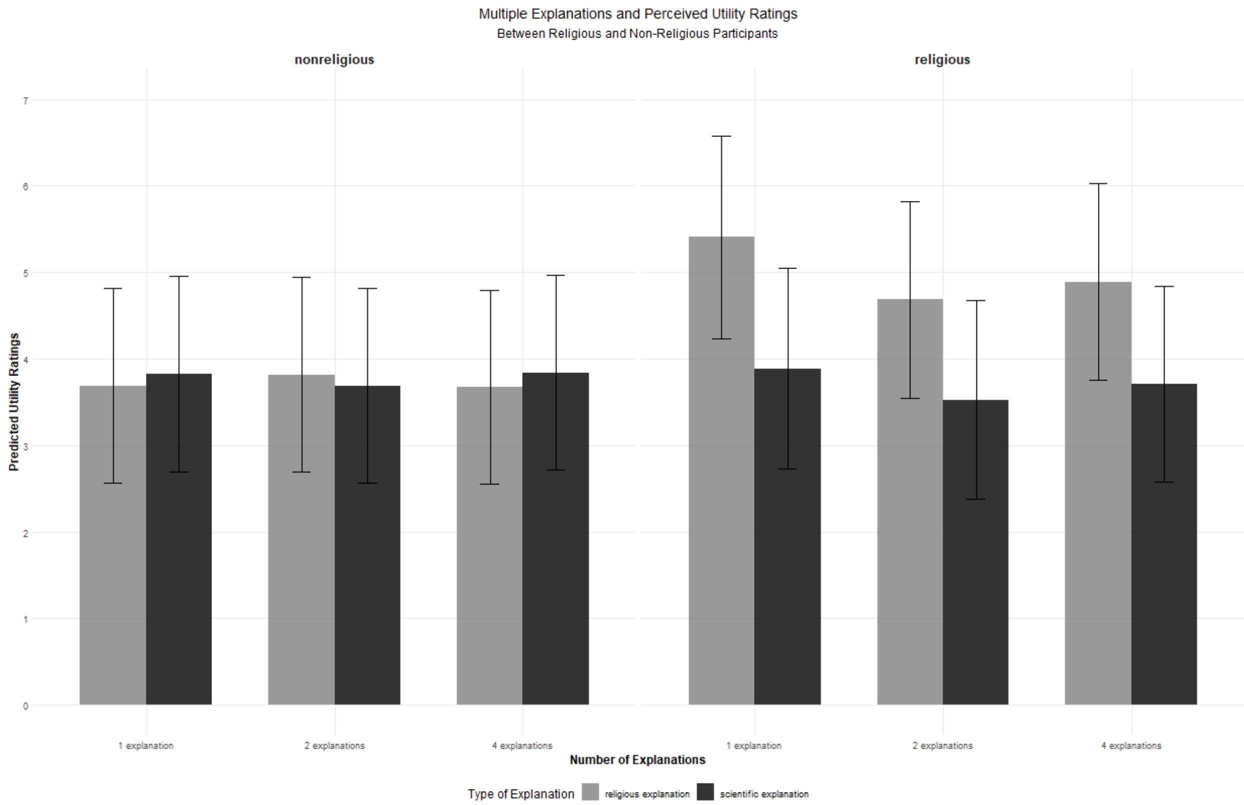


Figure 1. Religious and non-religious participants' evaluations of scientific and religious explanations across number of explanation conditions

Between-group comparisons indicated that, regardless of the number of explanations presented, religious participants rated religious explanations to be more useful than non-religious participants did ($p < .001$, Cohen's $d = 1.02$). Nevertheless, there was no significant difference in how religious ($M = 3.68$) and non-religious participants ($M = 3.78$) rated scientific explanations ($p = .663$, Cohen's $d = 0.09$). The model explained 75.5% of the total variance ($R^2$ conditional = .755), with fixed effects accounting for 2% of the variance ($R^2$ marginal = .020). Random effects of explanations ($SD = 1.97$) were more prominent in explaining the variance of utility ratings than participants ($SD = 0.59$).

***Perceived Utility and Conflict Beliefs.*** The third hypothesis, examining how conflict beliefs about science and religion moderate the dilution effect, was tested using a lme model with three-way interaction effects between the two contrast variables, explanation type (scientific vs. religious), and conflict beliefs (conflict vs. non-conflict). Estimated model parameters are displayed in Table 4 and the simple simple effects for the number by the type of explanation of conflict and non-conflict believers, respectively, are presented in Table 5.

Table 4. Estimated Model Parameters

| **Parameter** | ***B*** | ***SE*** | **95% CI** | ***t*** | ***p*** |
|---|---|---|---|---|---|
| Intercept | 3.72 | 0.57 | [2.60, 4.84] | 6.50 | <.001 |
| Explanation type | -0.05 | 0.08 | [-0.21, 0.12] | -0.55 | .583 |
| Conflict Beliefs | -0.47 | 0.07 | [-0.61, -0.32] | -6.35 | <.001 |
| Contrast 1 | -0.01 | 0.04 | [-0.09, 0.07] | -0.29 | .770 |
| Contrast 2 | -0.01 | 0.03 | [-0.08, 0.05] | -0.39 | .694 |
| Explanation type × Conflict Beliefs | -0.78 | 0.10 | [-0.98, -0.58] | -7.78 | <.001 |
| Explanation type × Contrast 1 | -0.008 | 0.08 | [-0.17, 0.16] | -0.09 | .927 |
| Explanation type × Contrast 2 | 0.14 | 0.07 | [ 0.00, 0.28] | 2.02 | .044 |
| Conflict Beliefs × Contrast 1 | -0.20 | 0.08 | [-0.35, -0.04] | -2.48 | .013 |
| Conflict Beliefs × Contrast 2 | 0.10 | 0.07 | [-0.03, 0.23] | 1.47 | .142 |
| Explanation type × Conflict Beliefs × Contrast 1 | 0.07 | 0.17 | [-0.25, 0.40] | 0.44 | .663 |
| Explanation type × Conflict Beliefs × Contrast 2 | 0.03 | 0.14 | [-0.24, 0.30] | 0.24 | .809 |

*Note.* Explanation type: -0.5 for scientific and 0.5 for religious explanation. Conflict beliefs: -0.5 for non-conflict and 0.5 for conflict believers. Contrast 1: one explanation vs. grand mean. Contrast 2: two explanations vs. grand mean.

As can be seen from Table 4, both three-way interaction effects were not significant, indicating that conflict beliefs did not moderate the dilution effect as we had hypothesized. Meanwhile, the fixed effect of conflict beliefs and a two-way interaction between explanation type and conflict beliefs were significant. This indicates that participants with conflict beliefs generally provided lower utility ratings across explanations compared to those with non-conflict beliefs. Additionally, participants with higher conflict beliefs tended to rate scientific explanations as more useful than religious explanations.

The two-way interaction between explanation type and the second contrast variable (two explanations vs. grand mean) was significant ($b = 0.14$, $p = .044$). This indicates that in the two-explanation condition, where scientific and religious explanations were directly juxtaposed (1-to-1), the gap between how participants rated scientific versus religious explanations was wider than the average gap across all conditions. Rather than producing a dilution effect where both types of explanations would decrease in perceived utility, presenting one scientific and one religious explanation side-by-side appeared to drive participants to rate these explanations more differently.

A significant two-way interaction between conflict beliefs and the first contrast (one explanation vs. the grand mean; $b = -0.20$, $p = .013$) indicates that participants with conflict beliefs rated single explanations less favorably compared to multiple explanations, while participants with non-conflict beliefs showed the opposite pattern, rating single explanations more favorably. This suggests that those who see science and religion as conflict may prefer having multiple explanations available, whereas those who see science and religion as compatible may find single explanations more useful.

Table 5. Simple Simple Effects for the Number of Explanation by the Type for Conflict and Non-Conflict Believers

| **Contrast** | ***b*** | ***SE*** | ***df*** | ***t*** | ***p*** |
|---|---|---|---|---|---|
| **Conflict Believers** | | | | | |
| Religious explanation alone | -0.31 | 0.12 | 4567 | -2.47 | .080 |
| One religious explanation in two explanation condition | -0.10 | 0.09 | 4395 | -1.16 | 1.00 |
| Two religious explanations in four explanation condition | -0.24 | 0.08 | 4320 | -2.93 | .020 |
| Scientific explanation alone | 0.09 | 0.13 | 4585 | 0.70 | 1.00 |
| One scientific explanation in two explanation condition | 0.17 | 0.10 | 4421 | 1.67 | .572 |
| Two scientific explanations in four explanation condition | 0.39 | 0.08 | 4313 | 4.86 | <.001 |
| | | | | | |
| **Non-Conflict Believers** | | | | | |
| Religious explanation alone | 0.24 | 0.08 | 4542 | 3.09 | .011 |
| One religious explanation in two explanation condition | 0.17 | 0.05 | 4444 | 3.60 | .001 |
| Two religious explanations in four explanation condition | 0.11 | 0.06 | 4357 | 1.92 | .330 |
| Scientific explanation alone | -0.06 | 0.07 | 4537 | -0.85 | 1.00 |
| One scientific explanation in two explanation condition | -0.29 | 0.06 | 4477 | -5.05 | <.001 |
| Two scientific explanations in four explanation condition | -0.16 | 0.05 | 4335 | -2.97 | .017 |

*Note*. *P* values were corrected for multiple testing using the Bonferroni correction.

Table 5 shows distinct patterns between conflict and non-conflict believers. Conflict believers consistently evaluated religious explanations less favorably than non-conflict believers, with significant negative effects in both the 1-explanation and 4-explanation conditions. They only rated scientific explanations significantly above the grand mean in the 4-explanation condition. By contrast, non-conflict believers evaluated religious explanations more favorably than conflict believers in the 1-explanation and 2-explanation conditions. In addition, non-conflict believers rated scientific explanations less favorably than conflict believers in the 2-explanation and 4-explanation conditions, but not in the 1-explanation condition.

These patterns suggest that conflict believers' preference for scientific over religious explanations was most pronounced when presented with multiple explanations, while they consistently devalued religious explanations regardless of how many explanations were presented. Non-conflict believers, however, showed their strongest preference for religious explanations when presented as a single or with fewer explanations, and only devalued scientific explanations when multiple explanations were offered simultaneously.

Most notably, between-group comparison shows that while conflict beliefs strongly influenced how participants evaluated religious explanations, with conflict believers rating religious explanations ($M$ = 3.31) significantly lower than non-conflict believers ($M$ = 4.12, $p$ < .001, Cohen's $d$ = -0.75), there was no significant difference in how conflict believers ($M$ = 3.75) and non-conflict believers ($M$ = 3.75, $p$ = .835, Cohen's $d$ = -0.07) rated scientific explanations. Model-predicted means can be seen in Figure 2. We also fit separate lme models for conflict and non-conflict believers, which results can be seen as Supplementary Material 2.

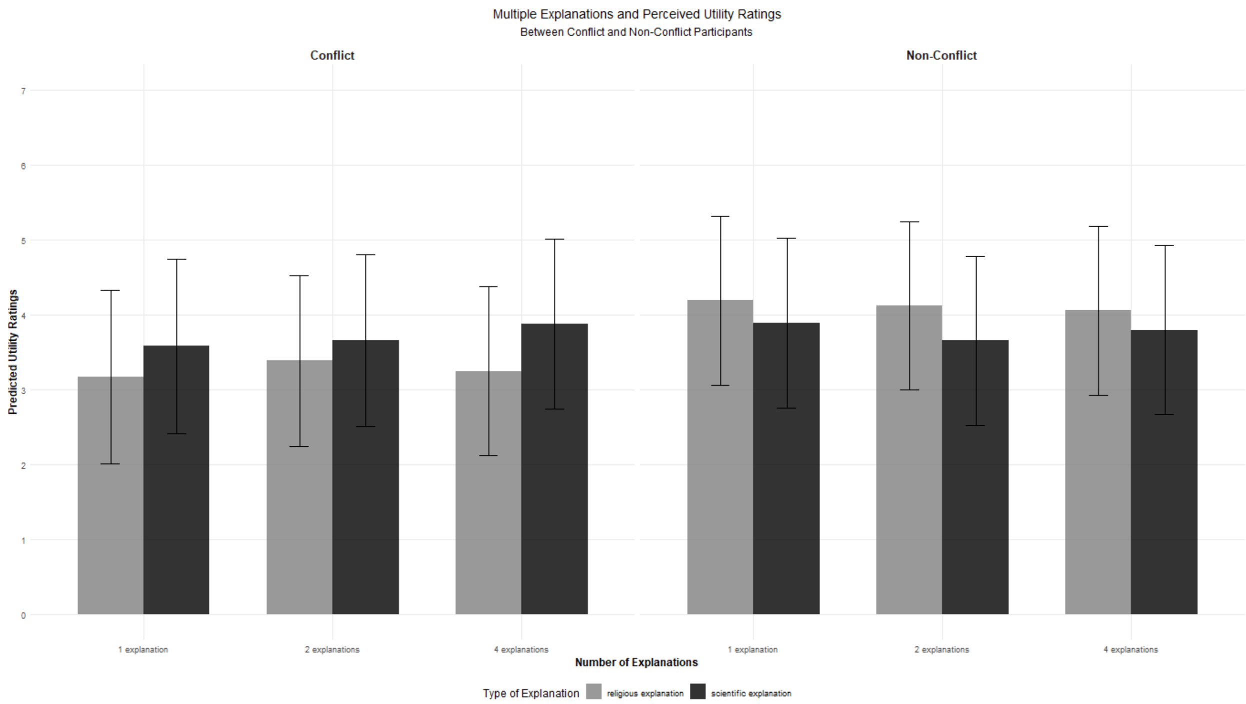


Figure 2. Conflict and non-conflict believers' evaluations of scientific and religious explanations across number of explanation conditions

The model explained 75.1% of the total variance ($R^2$ conditional = .751), with fixed effects accounting for 1.2% of the variance ($R^2$ marginal = .012). Random effects of explanations (*SD* = 1.98) contributed more to the variance in utility ratings than the differences between participants (*SD* = 0.61).

## Discussion

We set out to test the instrumentality hypothesis (Jackson et al., 2024), which proposes that religious individuals who view both scientific and religious explanations as means to achieve epistemic goals may perceive less utility in each of these means than non-religious individuals who rely primarily on scientific explanations. The hypothesis is grounded in research on the dilution effect, which suggests that the more means one has to achieve a particular goal, the less useful each of those means are perceived to be (Bélanger et al., 2015, 2016; Roberson et al., 2020). Thus, it is reasonable to assume that when one engages with both scientific and religious explanations simultaneously, the less useful one views each of them. While Jackson et al. (2024) provided preliminary evidence for the instrumentality hypothesis, experimental evidence directly testing how the number of equifinal explanatory means affects their respective utility remains lacking.

We attempted to fill this gap by conducting an experiment that directly tested the effect of the number of equifinal means on the perceived utility of explanations, independent of whether they were scientific or religious in nature. We planned a stepwise analysis: first testing for the general dilution effect, and, if found, examining how the number of explanations differentially affects the perceived utility of scientific versus religious explanations, particularly among religious versus non-religious individuals and those with conflict versus non-conflict beliefs.

Our analysis provided no support for the general dilution effect. More specifically, the perceived utility of explanations – be they scientific or religious – did not depend on the number of explanations participants encountered. Individual differences in how people evaluated these explanations (as shown by conditional $R^2$), rather than their quantity, accounted for the vast majority of variance in utility ratings. This finding suggests that in the particular incidents we focused on in this study, the presence of multiple explanations does not undermine their perceived utility.

While we found no support for the general dilution effect, our analyses suggest that participants' pre-existing beliefs about the relationship between science and religion might have played a more prominent role in shaping how they evaluated different types of explanations rather than the mere presence of multiple explanations. What emerged in our study was an asymmetry in how these beliefs influenced the evaluation of scientific versus religious explanations. Participants who view science and religion as incompatible (conflict believers) showed a preference for scientific explanations over religious ones. In contrast, those who see science and religion as non-conflicting found both types of explanations to be equally useful. While the differences in conflict/non-conflict perceptions predicted how people evaluated religious explanations, it had virtually no impact on how people evaluated scientific explanations.

This asymmetry effect emerged as well when we examined the role of religiosity. Religious participants showed a clear preference for religious explanations, while non-religious participants gave religious explanations lower utility ratings than religious participants. Yet again, both groups did not differ in how they evaluated scientific explanations, suggesting that religiosity primarily shapes participants' evaluation to religious rather than scientific explanations. We found no evidence for the dilution effect among religious participants; if anything, we observed the presence of the dilution effect only when a scientific explanation was paired 1:1 with a religious explanation. In sum, our findings suggest that participants, regardless of their religiosity or their conflict/non-conflict beliefs, rated scientific explanations as similarly valuable.

These patterns suggest that, instead of a general dilution effect, we observed what appears to be motivated reasoning, where people's pre-existing beliefs about the relationship between science and religion shape their evaluation of different types of explanations, but in a more specific manner. Both non-conflict beliefs and religiosity may act as "gatekeepers" specifically for preserving the utility of religious explanations, whereas scientific explanations appear to be evaluated primarily for their "truth-bearing qualities" (Van Leeuwen, 2014), leading to an involuntary reception of scientific explanations (Van Leeuwen, 2014; Van Leeuwen & Lombrozo, 2023), regardless of one's religiosity or views about the relationship between science and religion. This asymmetric pattern suggests a distinct cognitive processing of scientific versus religious explanation (Van Leeuwen & Lombrozo, 2023), that is, scientific explanations enjoy a kind of universal acceptance, while religious explanations are strongly contingent on identity (i.e. religiosity) and subjective preferences (i.e. perceptions of the relationship between science and religion).

Our findings may align with Van Leeuwen's (2014) notion that factual beliefs and religious credence have different properties, so they are acquired, evaluated, and applied differently. Van Leeuwen (2014) argues that factual beliefs are independent of practical settings and contexts, so they are used consistently across situations. In turn, factual beliefs are formed involuntarily in response to evidence and are automatically integrated into practical reasoning about the world (e.g., people cannot freely choose whether a rock is a living thing or not). In contrast, religious credence is context-dependent, activated primarily in specific settings or when considering particular types of questions, and is more closely tied to identity and normative values. Therefore, people believe in religious credence freely by choice according to their subjective preferences (Van Leeuwen, 2014; Van Leeuwen & Lombrozo, 2023). Another distinction is that factual beliefs are evaluated primarily by the quality of supporting evidence, meaning that factual beliefs can be revised or falsified in light of new evidence. Meanwhile, religious credence is evaluated mainly on the basis of its normative content (Van Leeuwen, 2014, 2017).

In our study, we prompted participants with "why" the incidents happened, which might elicit biased responses toward religious explanations, as religious explanations are often favored for answering "why" (Davoodi & Lombrozo, 2022; Jackson et al., 2024). Nonetheless, we found that scientific explanations – which typically prompts people to think about natural causes for an event – maintained stable perceived utility across groups. If asking "why" could prompt biased responses toward religious explanations, we would expect to see lower or more variable ratings of scientific explanations. Instead, scientific explanations were evaluated consistently regardless of participants' religiosity or conflict beliefs. This pattern aligns with Van Leeuwen's (2014) theory that factual beliefs are processed involuntarily and consistently across contexts, while religious credence is more context-dependent and influenced by identity. The fact that scientific explanations maintained their perceived utility even in response to "why" questions that could theoretically favor religious explanations may fit within this theoretical framework.

Van Leeuwen's (2014) distinction is helpful in explaining why we observed scientific explanations being evaluated similarly across groups – they may be processed more like factual beliefs, leading to consistent evaluation regardless of one's religiosity or views about science-religion relationship. Meanwhile, religious explanations, which are more characteristic of religious beliefs, are more susceptible to the influence of individual differences in religiosity and beliefs about the relationship between science and religion. However, it is important to note that we are not prepared to claim that our findings support Van Leeuwen's (2014) theory, as our study was not originally designed or planned to specifically test it. That said, we feel that Van Leeuwen's notion that religious belief belongs to a "special class" of belief is helpful in making sense of our unexpected findings.

Our study has several limitations that can potentially be improved in the future research program. First, our experimental design focused on three specific types of events; flooding, war, and climate change, which represent large-scale societal crises with complex causal mechanisms. It is possible that the dilution effect might emerge differently for more everyday phenomena or events with simpler causal structures. For instance, when someone recovers from a chronic illness, there may be scientific explanations (e.g. the effectiveness of medical intervention, the body's immunity response, etc.) as well as religious explanations (e.g. divine intervention, the power of prayer, etc.) for why and how such recovery occurs. This type of experiences may be particularly suitable for testing the dilution effect because it has a more direct and clear causal mechanism than the large-scale societal crises we used in this study, while still naturally evokes both scientific and religious interpretations of the causes of this event.

Regarding limitations, it is important to note that our sample consisted primarily of German participants and given that people's perceptions of the relationship between science and religion can vary significantly across cultural contexts (C. Johnson et al., 2020; Payir et al., 2021; Price & Johnson, 2024), our findings may not extend to populations with different cultural backgrounds. In Germany, science and scientists are widely viewed as trustworthy (Wissenschaft im Dialog, 2024), which may partly explain why participants valued scientific explanations similarly, regardless of their religiosity or perceptions of the relationship between science and religion. Previous findings show that Germans perceive a lower level of conflict between science and religion than U.S. Americans (Zein et al., 2025).

Future research could address these limitations in several ways. Studies could examine whether the asymmetric pattern we observed holds across different types of phenomena, ranging from personal experiences to natural incidents to social phenomena. Another direction would be to examine how different types of religious explanations – ranging from literal interpretations of the scriptures to more metaphorical, allegorical, or purely normative explanations – might be evaluated differently when presented alongside scientific explanations. Finally, future research could more directly test Van Leeuwen's (2014) theoretical conjecture, such as examining whether scientific explanations demonstrate the properties Van Leeuwen (2014) attributes to factual beliefs (being evaluated based on evidence), while religious explanations show properties he attributes to religious credence (being evaluated based on identity and context).

**Ethics and Data Availability Statements**

Data derived from our study is managed and stored in accordance with the European Union's General Data Protection Regulation (GDPR). Our research was conducted in accordance with the Declaration of Helsinki and the research ethics guidelines of the German Psychological Society. Study materials, analysis codes, an anonymized dataset, and a codebook are made publicly available on a not-for-profit repository (https://osf.io/356z4/?view_only=1d8b56a4ba834a65bae638f436272237).

## Disclosure

We used a neural machine translation service (DeepL) for improving the presentation of the manuscript (e.g., correcting spelling, punctuation, and grammatical mistakes). We used a large language model chatbot (Claude AI – Sonnet 3.5 and 3.7) to debug R code, generate alt-texts, and perform a consistency check between R outputs and results reported in the manuscript. To run the analyses, we used the following R (R Core Team, 2024), packages: *lme4* (Bates et al., 2015), *emmeans* (Lenth, 2025), *psych* (Revelle, 2022), *mirt* (Chalmers, 2012), *easystats* (Lüdecke et al., 2022), and *ggeffects* (Lüdecke, 2018).

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**Appendix 1**

Below are the descriptions of the incidents as well as explanations used as stimuli in the study.

**Bavarian Floods**

You may have heard on the news that in July 2024, there were severe floods affecting several areas of Bavaria, Germany. “Why did the floods happen?” you may ask. Below is one/two/four plausible explanation(s) of what caused the floods. Please read it carefully.

1. Prior wet seasons had already saturated the soil in southern Germany. When the cyclone brought heavy rains, the saturated soil could not absorb the excess water, resulting in increased surface runoff and severe flooding.

2. Through the floods, God put our faith to the test and reminded us of our vulnerability. The floods illustrated to us the transience of life and how important it is to keep reminding ourselves of this transience and our vulnerability.
3. Due to climate change, the air is also warming up at higher altitudes. And warm air can store more water vapor than cooler air. So, since warm air is more saturated with water, it can also release more water: the warmer it is, the more intense and prolonged the rain will be.
4. God sent the flood as a form of divine punishment in response to the collective sins of humanity, reminding us that our moral failures have consequences. The flood calls us to repentance and shows humanity that it must mend its ways.

**War**

Throughout history, human civilization has faced enormous collective adversity, including violent war. Millions of people have died, been displaced, and others have been indirectly affected by the devastating effects of violent war. “Why are there so many violent wars in the world?” you may ask. Below are one/two/four plausible explanation(s) for the causes of violent war. Please read them carefully.

1. From peace and conflict research, we know that wars are often about expanding or consolidating power, while the official justification is often the elimination of injustice.
2. God allows wars to happen and does not intervene even when many people are killed in them. Ultimately, people must learn to appreciate peace and kindness and actively strive for them.
3. Research on intergroup relations shows that collective memories of past conflicts, injustices, or humiliations can fuel war. When societies or groups focus on these historical grievances, they may seek revenge or retribution, perpetuating cycles of violence.
4. Although God teaches peace and reconciliation, He also allows wars as a means of restoring justice. People must be punished for some wrongdoings and are therefore allowed to punish each other. Therefore, war is something that is ultimately willed by God.

**Climate Crisis**

In recent years, our planet has experienced global weather instability and dramatic temperature increases. This has led to more frequent natural disasters, rising sea levels, and widespread disruption of our ecosystems. “Why is there a climate crisis?” you may ask. Below are one/two/four plausible explanation(s) for the causes of the climate crisis. Please read them carefully.

1. The climate crisis is happening because the burning of fossil fuels is releasing high levels of greenhouse gases that are causing global temperatures to rise.
2. The climate crisis occurs because human beings have become too greedy by overexploiting natural resources, placing material wealth over and above the lessons taught by God, which emphasize modesty in consumption.
3. The climate crisis is caused by human overexploitation of natural resources, such as overfishing, mining, and water extraction, which disrupts the balance of our ecosystems.
4. God gives humans the responsibility to be stewards of the earth by protecting and preserving the environment. Climate crisis occurs because we have ignored our responsibility as caretakers of God's creation, and in turn, damaged the natural order of our ecosystem.

**Appendix 2**

As stated in our preregistration document, we would compare the results of the main hypothesis test with an alternative scenario using a different coding scheme. Therefore, we fit a lme model by coding the number of explanations with a dummy coding scheme. In this case, we set 1-explanation condition as the reference level. The linear mixed effects model again included the number of explanations as a predictor with random intercepts for participant and explanation. Results confirmed our previous findings, showing no significant differences between the reference category (1 explanation) and either 2 explanations ($b$ = -0.05, $SE$ = 0.06, $t$(5022) = -0.82, $p$ = .415, 95% CI [-0.15, 0.06]) or 4 explanations ($b$ = -0.04, $SE$ = 0.05, $t$(5022) = -0.85, $p$ = .397, 95% CI [-0.14, 0.06]). The total variance explained by the model remained the same as in our main analysis at 73.4% (conditional $R^2$ = .734), with fixed effects accounting for almost none of this variance (marginal $R^2$ < .0001). These results are consistent with both our main analysis, confirming that the perceived utility of explanations remains relatively stable regardless of how many explanations participants encounter, even when different coding schemes are used.

## 9 Final Discussion

People construe the science-religion relationship differently (Barbour, 1998) and often fine-tune their perceptions based on specific social situations (Yasri & Mancy, 2012) or the topic at hand (Elsdon-Baker, 2015; Leicht et al., 2021). Nevertheless, how these individual differences are set in motion, what properties they have, and what psychological outcomes they predict are less well understood. The three pillars of the present research program – theoretical integration, measurement practice, and mechanistic testing – were designed to provide tentative answers to these questions.

In the first project, I mediated between the theoretical literature in the philosophy and sociology of religion and the empirical work in the learning sciences, as well as in social, cognitive, developmental, and cross-cultural psychology. This project was undertaken because, although different subdisciplines have extensively studied the same phenomenon (i.e., individual differences in perceiving the relationship between the two domains), the evidence they have produced is largely disorganized and fragmented. This makes it challenging for interested scholars to discern what is known from what remains unknown. Different research communities often have specific concerns about different parts of the theory, so integrating these multidisciplinary pieces may add value to theory development (Smaldino, 2020a). In doing so, the first project attempted to connect these dots by presenting an overview of the theory and evidence that illustrates the psychological process underlying mental model formation. It thus argues that when people are cognitively flexible and motivated to reconcile scientific and religious explanations, they are more likely to adopt non-conflict mental models.

Furthermore, the literature on modern psychometrics and experimental social psychology is remarkably helpful in achieving the goals of the second and third projects. Specifically, modern psychometrics provides early evidence for construct validation by specifying, operationalizing, and testing the measurement assumptions (Franco et al., 2022; Grahek et al., 2021; Sijtsma, 2012). I began by specifying mental models as a latent psychological attribute taking the form of a unidimensional bipolar construct in which the five qualitative mental models are 'anchors' ordered in a specific way, representing a range from 'complete conflict' to 'complete compatibility.' The psychological process underlying participants' responses was also considered – that people respond to the scale items as part of an unfolding process of response behavior (Carter et al., 2010; Drasgow et al., 2010; Roberts et al., 1998). The findings in Manuscript 2 show that all these assumptions hold: the latent construct is indeed unidimensional and bipolar, although the order of the mental models is slightly different than initially theorized. Contrary to the hypothesis presented in Manuscript 1, the Context-Switch model is psychologically closer to the Compatibility view and lies between the Compartment and Complementary views.

The third pillar tapped into the mechanics of how information is evaluated. People evaluate the value of scientific and religious explanations based on their mental models and religiosity rather than on the number of available explanations. As predicted by motivated reasoning theory (Ditto & Lopez, 1992; Kunda, 1990), people view the world through the lens of their social identity (Nauroth et al., 2017) or their preexisting beliefs (Ditto & Lopez, 1992), leading to processing information in a manner that aligns with these motivational elements. However, the results of the third project revealed that only religious explanations were affected by motivated reasoning, while perceptions of the utility of scientific explanations remained largely intact. Participants rated the utility of scientific explanations similarly, regardless of their religiosity or perceptions of the relationship between science and religion. To make sense of this finding, I drew on Van Leeuwen's (2014) hypothesis that religious credence and factual beliefs are processed differently.

Collectively, these three pillars represent an interdisciplinary integration of theory and evidence for understanding how people relate to science and religion. In what follows, I discuss some of the lessons learned along the way, particularly regarding the conceptualization and operationalization of Barbour's taxonomy, how it manifests itself in different cultural contexts. I also discuss how the mental models differentially affect the way people evaluate scientific and religious explanations.

## 9.1 Mental Models Revisited

Scholars across disciplines have called for more nuanced conceptualizations of the science-religion relationship (Barbour, 1998; J. H. Evans, 2011; Jones et al., 2019; Rutjens & Preston, 2020). Yet, the non-conflict models are more than an opposition to conflict narratives – they have qualitative differences with subtle boundaries separating them. The present research program builds on Barbour's taxonomy to clarify these distinctions.

The first pillar of the research program captures in detail how these non-conflict mental models differ from one another: 1) the *Context-Switch* emerges from underlying conflict beliefs, but people pragmatically customize their reliance on either science or religion to a very specific social context rather than relying on exclusively on either domain (K. S. Taber et al., 2011; Yasri & Mancy, 2012); 2) the *Compartment* model holds that science and religion occupy strictly separate domains of inquiry, rendering claims of compatibility or conflict meaningless because they address fundamentally different questions (Gould, 1999, 2000); 3) the *Complementary* model acknowledges the distinctiveness of the two domains while recognizing their potential to work together to provide a more complete understanding of phenomena (Basel et al., 2014; Falade & Bauer, 2018); and 4) the *Consonance* model seeks a deeper integration between science and religion, suggesting that one domain can potentially reinforce or be subsumed by the other in a harmonious relationship (Barbour, 1998; Vaidyanathan et al., 2016). Although some of these assumptions outlined in Manuscript 1 are ultimately challenged by the evidence presented in Manuscript 2 and 3, which I discuss in the next section, they at least provide some granular answers to the question, "If it is not conflict, then what else?"

### *9.1.1 Cognitive and Motivational Elements of Mental Models*

Manuscript 1 did not stop at the descriptive level, but rather offered some propositions about how the mental models are set in motion. According to the process flowchart proposed in Manuscript 1, individuals must meet two conditions to hold non-conflict beliefs: they must be *cognitively prepared* to flexibly contextualize their epistemological judgments (i.e., evaluate claims from different sources and decide which are valid, reliable, or trustworthy) and possess *motivational elements* (e.g., identity, moral beliefs, and personality) to reconcile competing explanations. Otherwise, individuals are more likely to adopt conflict beliefs.

The cognitive component builds on research linking cognitive flexibility to religious and scientific reasoning, though with an important distinction. While cognitive flexibility has been linked to religious disbelief in certain situations (Zmigrod et al., 2019), here in the flowchart it enables individuals to contextualize their epistemological judgments (Kienhues & Bromme, 2011), thereby facilitating non-conflict mental models. This process does *not* necessarily require deliberative effort or conscious reasoning, as the flowchart makes no assumptions about the speed and depth of cognitive processes. In cultural contexts where scientific and religious explanations are traditionally viewed as non-conflicting, adopting non-conflicting beliefs can occur spontaneously and with minimal cognitive effort.

Cultural norms and religious traditions that favor integration can predispose individuals to non-conflict models. In Eastern traditions with nondualism beliefs (i.e., philosophical and spiritual traditions outlining the absence of separation between physical and supernatural existence, see Jinpa, 2010; C. Johnson et al., 2020; Khalsa et al., 2021; Wallace, 2003), or in religious communities where scientific inquiry is viewed as a sacred duty (e.g., Orthodox and Reform Judaism, Sunni Islam, etc. see Dodick et al., 2010; Mansour, 2011; Vaidyanathan et al., 2016), the motivational elements supporting integration are religiously driven. These cultural contexts contrast sharply with more polarized Western Christian culture, where developing non-conflict beliefs may require greater individual cognitive effort and stronger personal motivation to overcome prevalent conflict narratives (Scheitle & Corcoran, 2021). Moreover, individuals raised in families or communities that explicitly construe that science and religion are in harmony benefit from early socialization that makes non-conflict beliefs feel intuitive rather than requiring conscious deliberation (Davoodi et al., 2019; Payir et al., 2021).

Thus, while the flowchart may operate universally, the mechanisms through which individuals satisfy its conditions, and the effort required to do so can vary considerably based on their cultural and social contexts.

### *9.1.2 Explanatory Coexistence and Non-Conflict Mental Models*

When the cognitive and motivational conditions are met, as outlined in Manuscript 1, individuals engage in explanatory coexistence, which serves as the cognitive basis for non-conflict mental models. This process reconciles potentially competing explanations through three frameworks with deepening levels of integration: *goal-dependent*, *synthetic*, and *integrative* thinking (Legare et al., 2012; Legare & Visala, 2011). Each of these frameworks corresponds to at least one type of mental model. The prevalence of explanatory coexistence challenges the secularization/conceptual change hypothesis, which posits that science will eventually replace religion at both the institutional (Inglehart & Norris, 2007) and individual levels (Posner et al., 1982).

Scientific and religious beliefs are *similar* in how they are acquired (e.g., testimony, deference to authority, see Harris et al., 2006; Harris & Koenig, 2006; Ma et al., 2024; Shtulman, 2013), encoded and organized in the mind (Boyer, 2003; Kapogiannis et al., 2009), and satisfy similar psychological needs (e.g., the need to explain, to control, and to find existential meaning, see Rutjens & Preston, 2020). It is then conceivable that scholars who support the conceptual change hypothesis (Posner et al., 1982) suspect that the science and religion are fundamentally competing, and predict that religious beliefs will eventually cease to exist in the face of scientific evidence. This replacement predicted by the conceptual change hypothesis begins when young children enter the school system (Cobern, 1996; Duit et al., 2008), and accelerating rapidly when individuals transition to higher education (Scheitle & Corcoran, 2021; Shipman et al., 2002). Yet, there is ample evidence of the pervasiveness of religious beliefs among adults (Fondevila & Martín-Loeches, 2013), who are more likely to engage with both science and religion than with only scientific or religious explanations alone (Aizenkot, 2022; Georgiadou & and Pnevmatikos, 2019; Haimila et al., 2024; Legare & Gelman, 2008). This tendency persists even when scientific understanding is present and salient (J. Evans et al., 2025; Gelman, 2011; Haimila et al., 2024).

Why do religious beliefs persist despite progress in scientific understanding? Three explanations have been proposed (Shtulman & Lombrozo, 2016). *First,* the coexistence of science and religion may signal an incomplete substitution, implying that religious beliefs persist because the learning process is unfinished. However, this idea fails to explain why some scientists, despite being experts in their fields, still hold religious beliefs to some extent (Ecklund et al., 2016; Khalsa et al., 2021).

*Second*, religious beliefs may be in and of themselves heuristics or cognitive biases (White et al., 2021), which helps explain the consistently observed correlations between analytical and reflective thinking and greater religious disbelief (Byrd et al., 2025; Gervais et al., 2018; Ghasemi et al., 2025; Stagnaro & Pennycook, 2025). However, religious beliefs systems may contain structural and functional properties that are remarkably similar to scientific theories, including their broad explanatory domains and internally consistent explanations (Shtulman & Lombrozo, 2016). Thus, religious belief systems are more complex than simply a collection of cognitive biases.

The *third* and most compelling explanation is differential utility: Religious beliefs persist because they serve different functions than scientific explanations. Scientific explanations excel at addressing mechanistic questions about natural processes, while religious explanations are better suited to answering questions about meaning, purpose, and moral choice (Davoodi & Lombrozo, 2022). The functional differentiation here helps to explain why individuals, even those with high levels of scientific literacy, may hold both types of explanations simultaneously and use them flexibly, depending on the epistemic or non-epistemic goals they are pursuing. Due to differential utility, scientific and religious explanation might be processed differently as highlighted in Manuscript 3, which is discussed later. Some endeavors to computationally model the explanatory coexistence account have found that it is more likely to be the general rule rather than the exception in how people formulate explanations of 'existential-themed' phenomena (Friedman & Goldwater, 2022, 2019). This suggests that explanatory coexistence (and by extension, non-conflict mental models) may be an adaptive cognitive strategy rather than a sign of improper reasoning.

### *9.1.3 Mental Models as Anchors in a Bipolar Continuum*

The second pillar of this dissertation examines the operationalization of Barbour's (1998) taxonomy, which offers a solution to the continuum vs. typology problem. Rather than treating

Barbour's mental models as purely discrete types, Manuscript 2 proposes that these perceptions indicate both a *difference in kind* and a *difference in degree*. Specifically, the qualitative descriptions of mental models serve as anchors or gradations along the underlying continuum of conflict to compatibility while maintaining its order (Tay & Jebb, 2018).

This type of approach is particularly useful when the boundaries between mental models are fluid and when the research goal extends beyond categorizing people (Barbour, 1998, 2002). This measurement strategy aims to place individuals accurately along the conflict-compatibility continuum, paying special attention to capturing nuanced positions in the middle range (Carter et al., 2010; Davison, 1977). Operationalizing Barbour's taxonomy in this manner makes the prototypical descriptions of mental models testable within a measurement model.

Furthermore, Manuscript 2 provides compelling evidence that the Context-Switch is psychologically closer to non-conflict views than was originally theorized, which is also supported by the scale data in Manuscript 3. Across multiple samples in Manuscript 2 (pilot study, Study 1, and Study 2 with both German and U.S. participants) and Manuscript 3, context-switch items consistently clustered closer to complementary items than to conflict items. More specifically, component loadings (PCA) and item location parameters (δ) of all GGUM models for context-switch items reported in Manuscript 2 and 3 were situated between compartment and complementary items. This remained true even after modifying the scale items to be self-referential in both German and U.S. American samples. This empirical finding required us to revise the initial theoretical assumptions laid out in Manuscript 1. Originally, Manuscript 1 positioned Context-Switch closer to Conflict based on the assumption that switching implied underlying tension but without any specific preferences.

While context switchers do not explicitly integrate these systems in the way that complementary or consonance believers do, they pragmatically make use of both domains by selectively applying each domain in appropriate social situations. This suggests that the Context-Switch may be better understood as a pragmatic manifestation of non-conflict beliefs, rather than as a form of conflict belief without specific preferences. The Context-Switch model may be comparable to *code-switching* in linguistics (Myers-Scotton, 1993), where multilingual individuals switch between two or more languages or language varieties depending on their social context. Just as a bilingual speaker may use German at home with their family but English in professional settings, context-switchers may seamlessly navigate between science and religion based on social cues and situational demands (Falade & Bauer, 2018; Yasri & Mancy, 2012). In both cases (i.e., code-switching and the Context-Switch), the switching here is pragmatic, socially adaptive, and context-sensitive rather than reflecting conflict, inconsistency, or confusion.

Manuscript 2 also demonstrates the subtle distinctions between the Compartment, Context-Switch, and Complementary views, all of which are located in the middle part of the continuum. The Compartment model represents a more static separation, viewing the two domains as entirely independent that do not interfere with each other. Individuals who subscribe to this view maintain a clear and firm boundary between the two domains and acknowledge that they have distinct subject matters, methods, and goals. For instance, when facing death, those who hold compartment views might use science to explain the biological processes of death and use religion exclusively to understand the afterlife, with no conceptual overlap between these explanations. Empirical findings in Manuscript 2 place the Compartment views closer to Conflict along the continuum because this strict separation implicitly maintains that science and religion should not explain for the same aspects of phenomena – a position that, while not overtly antagonistic, still preserves a clear separation between the two domains. The proximity between Conflict and Compartment aligns with Hill et al.'s (2019) finding that people who believe in conflict are more likely to agree with statements that convey the separation of science and religion than people who do not believe in conflict.

By contrast, the Context-Switch model represents a more flexible and pragmatic engagement with both domains, as explained above. Unlike the static boundary maintained by the Compartment view, context-switchers move fluidly between domains based on contextual cues. Target-dependent thinking is a variant of explanatory coexistence (Legare et al., 2012; Legare & Visala, 2011) that underlies the formation of the compartment model, as characterized by the process flowchart in Manuscript 1. If target-dependent thinking drives people to use scientific and religious explanations to make sense of different aspects of a phenomenon, then context-switchers apply it to selectively alternate between scientific and religious explanations in very specific social situations.

Based on the empirical findings of Manuscript 2 and 3, I have adjusted the Context-Switch model in the process flowchart (Figure 1). This adjustment more accurately reflects the proximity of the Context-Switch model to non-conflict views than to conflict views. The flowchart's key modification is the addition of a decision diamond that distinguishes the two forms in which people apply target-dependent thinking. Separating elements of a phenomenon leads to the Compartment model, while recognizing different social cues leads to the Context-Switch model. This refinement clarifies that, although both models involve some form of separation between science and religion, they use different criteria to do so. The Compartment model separates science and religion based on different elements of a phenomenon (e.g., using science to explain the biological aspects of death and religion to explain the afterlife). In contrast, context-switchers selectively apply science or religion based on social or situational contexts (e.g., using science in academic settings versus religion in worship settings). Figure 1 also more accurately illustrates the continuum of complete conflict to complete compatibility supported by empirical evidence in Manuscript 2 and 3. The Context-Switch model is appropriately positioned between the Compartment and the Complementary model.

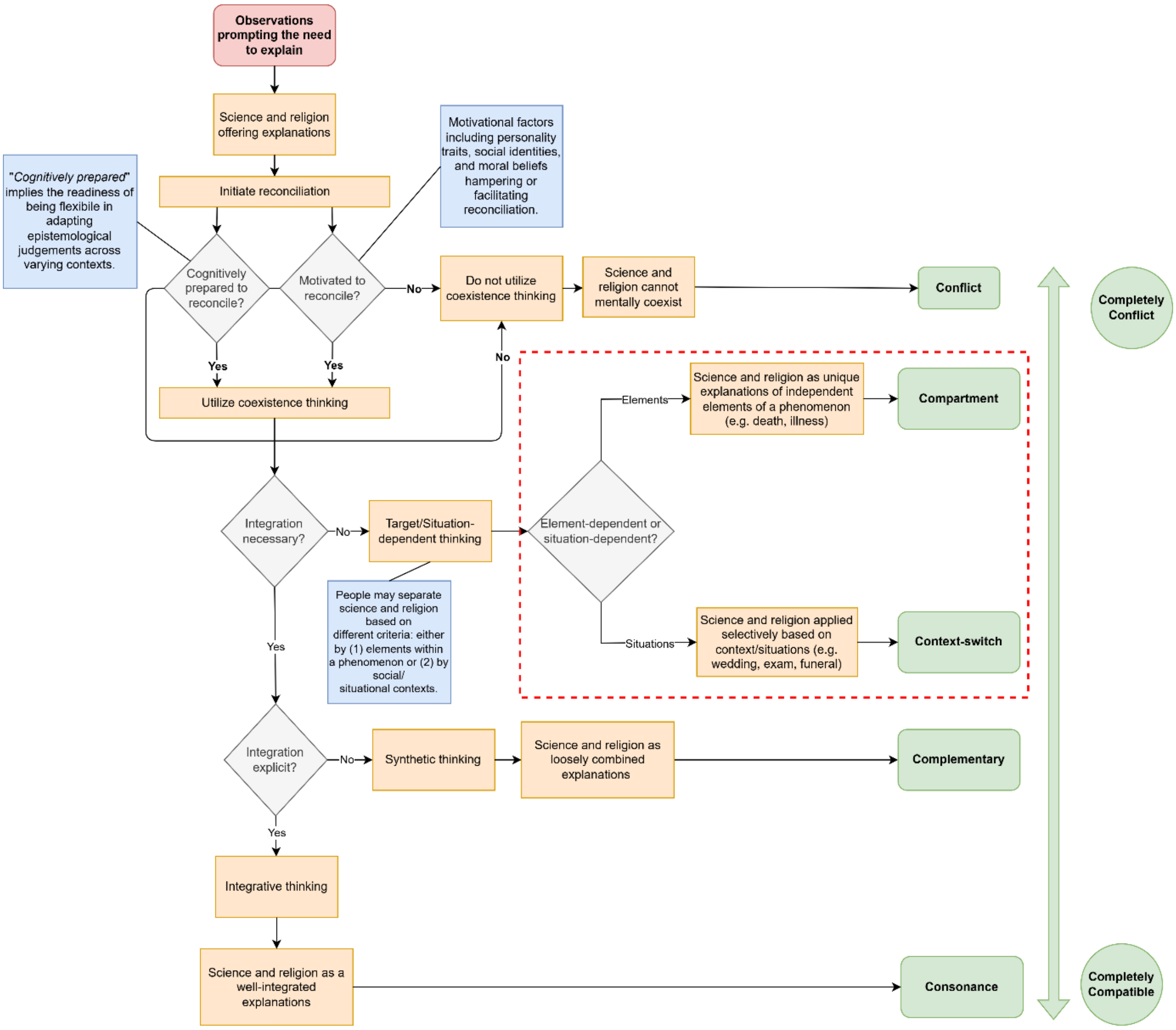


Figure 1. Annotated flowchart depicting the end-to-end process of mentally relating science to religion, with changes in the light of findings in Manuscript 2 in the dotted red box.

Additionally, Barbour (1998, 2002) claims that the differences between Dialogue (Complementary) and Integration (Consonance) are arbitrary, a claim supported by the data presented in Manuscript 2. The item location parameters (δ) reflecting the Complementary and Consonance models are close together, particularly in the U.S. sample but less so in the German sample. This close proximity of the Complementary and Consonance views on the continuum suggests that U.S. participants may not differentiate strongly between these views. Rather, they may view them as variations on the general theme of compatibility. However, this is not really the case in the German sample, where the boundaries between the two models are somewhat clearer. Thus, it still seems useful to retain both models as they might be relevant in some cultural contexts.

So far, I have mainly focused on the nature and operationalization of mental models at the conceptual level. The next section moves to examining how these mental models predict how people evaluate the utility of specific explanations. The shift from “what mental models are” to “what mental models do” reveals asymmetries in how people process different types of explanations.

## 9.2 Asymmetrical Motivated Reasoning

Ample evidence demonstrates the ubiquity of selective scrutiny, myside bias, and biased assimilation in how individuals interpret scientific evidence and explanations (Bayes & Druckman, 2021; Bender et al., 2016; Celniker & Ditto, 2024; Ditto et al., 2019; Hart & Nisbet, 2012; Nauroth et al., 2017; Nisbet et al., 2015; Rosman et al., 2021). Consistent with these findings in motivated reasoning research, Jackson et al. (2024) found that religious individuals highly value religious explanations, while rating scientific explanations as less useful than nonreligious individuals do. However, Jackson et al. (2024) interpreted these findings through goal system theory, which explains religious people moderate and equal reliance on science and religion is a byproduct of considering them as equifinal means. I tested the dilution effect hypothesis directly, examining whether the number of available explanations affects how people value the utility of explanations. However, I found a lack of evidence in support of it. While this null finding could reflect a genuine absence of the dilution effect in this context, several design limitations suggest caution when drawing strong conclusions about the dilution effect in general. I discuss these limitations in more detail later.

Based on motivated reasoning theory (Kunda, 1990), one would expect religious individuals to evaluate explanations consistent with their pre-existing religious beliefs more favorably while being more critical of conflicting scientific explanations. Alternatively, general perceptions of science-religion conflict might drive these differential utility evaluations, with people higher in conflict perceptions preferring one type of explanation over the other.

The final project of this dissertation tested this account by examining how religiosity and general perceptions of science-religion conflict influence people's evaluations of specific scientific and religious explanations. The findings revealed an unexpected asymmetrical pattern: although religiosity strongly predicted how individuals evaluated religious explanations, they had virtually no effect on evaluations of scientific explanations. This asymmetry was consistent across different conditions (one, two, or four explanations), suggesting a pattern that differs from traditional motivated reasoning predictions. Moreover, while perceptions of conflict between science and religion on specific, controversial issues do not always translate into general perceptions of conflict between science and religion (Elsdon-Baker, 2015; Hill et al., 2019; Leicht et al., 2021), these perceptions nonetheless systematically affected how people evaluate specific explanations – but only for religious explanations. This suggests that although people may distinguish between the general relationship of science and religion and conflict on very specific issues, their broader perceptions of the relationship systematically shape how they evaluate specific explanations in practice, albeit asymmetrically.

This asymmetry leads to an overarching theme that runs throughout this dissertation: scientific and religious explanations serve different functional roles (Davoodi & Lombrozo, 2022), then are processed based on different rules (Van Leeuwen, 2014; Van Leeuwen & Lombrozo, 2023), and therefore may coexist without causing cognitive dissonance (Legare & Gelman, 2008). Scientific explanations primarily serve epistemic goals through evidence-based evaluation, while religious explanations serve non-epistemic goals, such as existential meaning, identity, and moral guidance, through value or identity-based evaluation (Van Leeuwen, 2014). This functional differentiation explains both why religious beliefs persist alongside scientific understanding and why explanatory coexistence is so widespread across cultures (Davoodi & Clegg, 2022). Rather than signaling confusion, the coexistence of scientific and religious explanations reflects adaptation – people use different tools simply for different purposes.

### *9.2.1 Psychological Differentiation Between Scientific and Religious Beliefs*

As discussed earlier in Manuscripts 1 and 3, Van Leeuwen's (2014) distinction between factual beliefs and religious credence is a promising framework for understanding this asymmetry, though future research designed specifically to test this theory would be needed to confirm this interpretation. If scientific explanations are processed as factual beliefs – involuntarily formed and consistently evaluated regardless of personal beliefs, while religious explanations function as credence –filtered through identity and values, then the asymmetrical pattern we observed follows naturally from this framework.

This notion aligns with extant empirical evidence. For example, neuroimaging studies have shown that religious statements activate brain regions associated with processing metaphorical language, while factual statements activate networks associated with literal comprehension (Fondevila et al., 2016). Additionally, some studies have shown that religious individuals scrutinize scientific explanations much more rigorously than religious ones (Lobato et al., 2020; McPhetres & Zuckerman, 2017). In the third project, participants may have evaluated scientific explanations primarily for their epistemic value, which varies relatively little across religiosity and conflict beliefs, while evaluating religious explanations for their non-epistemic value, which varies greatly depending on religiosity and beliefs about conflict. Since scientific and religious explanation serve different functional roles, they can coexist as predicted by explanatory coexistence literature (Busch et al., 2017; Legare & Gelman, 2008).

Another plausible interpretation of these findings is that scientific explanations have become so culturally normative in Germany (Wissenschaft im Dialog, 2024), where the study in Manuscript 3 was conducted, that even religious individuals may feel socially pressured to acknowledge their validity, regardless of their personal beliefs. However, this interpretation seems less plausible since participants completed the study anonymously online, which should minimize social desirability bias. To reduce the demand effect, the experimental stimuli (i.e., the explanations evaluated by participants) were not labeled as either scientific or religious and were presented in random order.

The asymmetrical pattern observed in the final project suggests that religious individuals, particularly those with non-conflict beliefs, may wish to keep religious explanations useful without devaluing scientific explanations. While previous studies have consistently shown that individuals interpret scientific findings based on their pre-existing beliefs (Altenmüller et al., 2021, 2023; Bender et al., 2016) and social identities (Nauroth et al., 2017), perceptions of the science-religion relationship and religiosity did not seem to predict how participants rated the utility of well-established scientific explanations. A similar pattern, where religiosity does not predict people's evaluation of scientific arguments, has also been observed in previous studies, even for highly contested issues such as evolution (Alassiri, 2020; Funk, 2019; Oliveira et al., 2022; Stahi-Hitin & Yarden, 2022).

### 9.3 Cultural Embedding of the Perceptions of the Science-Religion Relationship

A DIF analysis in the German and American samples presented in Manuscript 2 revealed a systematic cultural bias in the measure. This provides further support for the claim that people's perceptions of the relationships are deeply embedded in their cultural/social contexts (C.

Johnson et al., 2020; Rios & Aveyard, 2019; Rios & Roth, 2020). Although Germany and the United States are both considered to be representative of Western Christian countries, the analysis revealed that participants in the United States perceived a greater conflict between science and religion. The magnitude of response differences between the two samples were large for some individual items, especially for conflict and compartment items. Aggregating the DIF effect sizes of individual items resulted in moderate DIF at the scale level.

At least two plausible sociopolitical explanations are available for why participants from the two countries responded quite differently to the scale items. *First*, the different historical relationships between church and state have led to contrasting institutional arrangements in the two countries (Stolz et al., 2020). Although Germany has similar constitutional secularization, its system permits the integration of religious education in public schools, which enables science and religion to occupy separate domains within the same educational system (Evers, 2015). By contrast, the constitutional separation of church and state in the United States has driven a situation in which religious and scientific institutions developing in parallel with greater independence. This positions them as competitors for cultural authority rather than as separate or complementary systems (Gauchat, 2011). Coupled with higher levels of personal religiosity in the United States (Tamir et al., 2020), the relationship between science and religion becomes more salient and personally relevant to the U.S. participants. This makes it a fertile ground for intense perceptions of conflict (Perry et al., 2021). This contrasts with the culture of nonreligion in Germany, where more people leave the church each year (Pelegrín, 2025; Stolz et al., 2020).

*Second*, political polarization in the United States has transformed the science vs. religion debate into an ideological battleground, creating a broader tension between the two domains. Issues such as evolution, climate change, stem cell research, and reproductive rights and technologies have become the centerpiece of American culture wars (Perry et al., 2020, 2021). Coupled with a higher prevalence of biblical literalist or fundamentalist interpretations of Christianity in the United States compared to the generally more moderate religious traditions in Germany (Cremer, 2021), perceptions of conflict can be amplified to a higher extent. Meanwhile, this polarization is less pronounced in Germany, where there is a stronger societal consensus on many scientific issues and a greater general trust in science (Wissenschaft im Dialog, 2024).

The cultural differences observed in Manuscript 2 illustrate how individual-level relationships can be modulated by cultural context. While religious individuals generally perceive less conflict at the individual level, DIF analysis in Manuscript 2 demonstrated that more religious American participants perceive more conflict than mostly secular German participants[1]. Here, although individual religiosity may overall predict a lower perception of conflict, this perceptions of the relationship between the two domains is embedded in broader cultural narratives and institutional arrangements that can attenuate this perception regardless of personal religiosity. This pattern suggests that the relationship between religiosity and perceptions of conflict operates differently at the individual level than at the group/country level.

It should be noted, however, that attributing science-religion perceptions to mere 'cultural differences' would be potentially misleading because it introduces an ecological fallacy (Freedman, 1999). Therefore, I caution against assuming that trends observed at the country or group level necessarily apply to individuals, or vice versa. At the macro level, the relationship between science and religion is shaped by specific sociopolitical dynamics and historical contexts. At the micro level – the primary scope of this dissertation – individuals can actively construct their own interpretations of this relationship (Hathcoat & Habashi, 2013).

It is important to note that the focus of this dissertation was narrowly limited to these two countries. Therefore, conducting similar research in other countries with different religious traditions would provide further insight into this topic. Such research should not aim to identify a universal pattern in how people perceive the relationship between science and religion, as this is an unrealistic goal given that people's perceptions are deeply embedded in culture and religious traditions (Davoodi & Clegg, 2022; Falade, 2019; Falade & Bauer, 2018; Payir et al., 2021). Nevertheless, it could be interesting to quantify the extent of the differences between countries as revealed by Manuscript 2.

## 9.4 Limitations and Avenues for Future Research

This dissertation presents three pillars that have provided insight into how individuals relate to science and religion. However, they have also left open questions that warrant further investigation. Additionally, the insights offered here should be taken with caution due to several important limitations discussed below.

### *9.4.1 Theoretical Development and Scope*

The flowchart presented in Manuscript 1, while helpful and intuitive, represents an early stage of theory development. Future work could benefit from formal modeling approaches (e.g.,

[1] U.S. participants were on average more religious and more likely to grow up in families where religiosity was more important than German participants, see Table 6 and 7 (pp. 128 - 129) in Manuscript 2.

computational, equation-based, and agent-based models) that would allow for more systematic testing of the boundary conditions of the theory (Smaldino, 2020b; van Rooij & Blokpoel, 2020). Such models could explore how mental models behave under different conditions: when individuals faced with uncertainty, when death is salient, or when social identity is threatened. This work can reveal the contextual factors under which the cognitive process of integrating science and religion applies.

Furthermore, previous research has shown that people's conceptualization of the relationship between the two domains can change significantly. This can occur when individuals are exposed to intercultural experiences (Rios & Aveyard, 2019; Rios & Roth, 2020) or when they transition to higher education (Scheitle & Corcoran, 2021; Shipman et al., 2002). Barbour (1998) indeed suggests that the mental models are not static and that people may change their conceptualizations when contemplating different issues, over the course of life stages, or when experiencing major life events.

Yet, these mental models likely possess some degree of stability, similar to personality traits that, while malleable, tend to remain consistent over time. Research suggests that perceptions of the science-religion relationship are often emotionally and morally laden (Bland & Morrison, 2015; E. M. Evans, 2008; Fysh & Lucas, 1998). Beliefs that are moralized, or incorporated into one's moral identity, tend to be more resistant to change and more deeply integrated into one's self-concept (Skitka, 2010; Ståhl et al., 2016). For example, some religious scientists have reported experiencing considerable cognitive and emotional strain when navigating potential tensions between their professional and religious identities (Ecklund & Park, 2009). This suggests that these mental models may not be easily reconfigured. Even when change is possible, it may resemble the gradual reshaping of personality traits rather than the immediate updating of factual beliefs.

Although a systematic investigation of the stability and change of mental models is beyond the scope of this dissertation, the developed measurement approach provides a tool for future longitudinal studies to examine how mental models evolve over time and the factors that facilitate or inhibit change. Such research could follow individuals through major life events, such as entering higher education (Scheitle & Corcoran, 2021), experiencing serious illness or bereavement, becoming parents, or encountering different cultural contexts through immigration or extended travel (Rios & Aveyard, 2019). Additionally, such work could examine whether the observed cultural differences in Manuscript 2 reflect stable cultural patterns or cohort effects that may change as the public debate on science vs. religion evolves.

### *9.4.2 Methodological Limitations*

Some scale items developed in Manuscript 2 appear to be double-barreled, which could potentially confuse participants. Coupled with the length (23 items), responding to the scale items can be cognitively demanding for participants, especially since ‘science’ and ‘religion’ here on the scale can be interpreted differently by different people. The scale items, however, were inspired by qualitative studies, and thus realistically mirror how individuals interpret the relationship. This ambiguous item format is also unavoidable when measuring a bipolar construct (Segura & González-Romá, 2003), particularly for items representing positions in the middle of the continuum (Cao et al., 2015). Future researchers building upon this measurement approach might consider several refinements to enhance its practical utility. *First*, a shortened version of the scale could be developed to reduce participant burden by identifying items with higher discrimination parameters across the latent continuum. *Second*, they could develop domain-specific versions of the scale (e.g., for evolutionary biology, disease transmission, or generative artificial intelligence) that could provide more contextually relevant measures.

The experimental design in Manuscript 3 also has notable limitations. In the experiment, I did not adequately ensure if participants’ epistemic goal was activated, whereas goal activation is crucial to confirm whether participants use scientific and religious explanations presented there to satisfy their epistemic goals. Without establishing this goal activation, it is difficult to claim that the absence of observed differences across conditions represents an absence of the dilution effect rather than simply an absence of a relevant epistemic goal in the first place.

Participants who already were knowledgeable about incidents (floods, war, climate change) might also be less motivated to find out the causes of these events. While prior scientific knowledge in these incidents was relevant in this context, I did not measure or control for this possibility. Thus, the question here is whether participants were actively pursuing an epistemic goal of understanding these incidents in the first place, which is necessary to test for dilution effects. Future research could address this issue by simply asking participants to what extent they feel motivated to find explanations for these incidents. It is also possible that in future research goal activation here can be manipulated. In this sense, when epistemic goals are explicitly activated, people should be more invested in finding useful explanations, making them more susceptible to dilution when multiple explanations are available.

### *9.4.3 Future Directions for Applied Research*

In this dissertation, I have largely focused on the role of mental models in predicting how people process different types of information, especially in Manuscript 3. Some other questions, such as whether mental models explain how people acquire and update their scientific and religious beliefs, and how mental models affect how people make decisions, such as whether or not to comply with public health measures, as illustrated in the Introduction chapter, are left untouched.

Therefore, future applied research may build upon the findings presented in this dissertation. Some questions, such as whether mental models predict science literacy, interest, and engagement, their role in (science or religious) educational contexts, or how they influence individually- and socially-relevant behaviors such as public health decision-making during crises remain important avenues for future exploration. Do mental models moderate how individuals respond to scientific messages on controversial topics? Can targeted interventions shift individuals toward non-conflict mental models, and if so, what are the implications for science communication and education? These are questions that future research can hopefully answer.

For science communicators specifically, the asymmetrical processing pattern presented in Manuscript 3 suggests that religious audiences may be more receptive to scientific information than is commonly assumed (Jackson et al., 2024). Rather than evading religious references or unnecessarily framing science as antithetical to religion, it would be more constructive to acknowledge different mental models that people have and avoid positioning scientific information as a challenge to religious beliefs. For instance, when discussing climate science with religious audiences, acknowledging stewardship perspectives (i.e., human beings as guardians or caretakers of the environment entrusted by God) could increase receptivity without compromising the scientific content.

Extending this research program into applied domains will allow us to better understand how people conceptualize the relationship between science and religion and how these conceptualizations shape their engagement with scientific and religious information in real-world contexts.

## 9.5 Concluding Remarks

Are science and religion fundamentally at odds? Three pillars in this dissertation – theoretical integration, measurement practice, and mechanistic testing – reveal that people actively construe the relationship between the two domains in fine-grained, integrative terms. People may conceptualize the relationship as conflicting (*Conflict*), as two separate domains (*Compartment*), as tools to be applied in different social contexts (*Context-Switch*), as incomplete without each other (*Complementary*), or as a unified belief system that reinforces each other (*Consonance*).

These types of conceptualizations are not purely discrete categories, but rather ordered anchors on a unidimensional, bipolar continuum. These conceptualizations predict how people evaluate the utility of religious explanations: people who perceive less conflict value them more than those who perceive more conflict. However, people rated the utility of scientific explanations similarly, regardless of conflict perceptions or religiosity, signaling that religious and scientific explanations are subject to different rules when processed psychologically.

As humanity faces challenges that might benefit from both scientific knowledge and religious wisdom, understanding how individuals navigate between these two domains is worthwhile. By demonstrating that mental models exist on a continuum (Manuscript 2), predict scientific and religious information processing asymmetrically (Manuscript 3), and emerge through identifiable cognitive and motivational processes (Manuscript 1), this dissertation establishes that science-religion relationships are more psychologically complex and culturally embedded than binary conflict narratives suggest. It is hoped that this work will help researchers, educators, and science communicators recognize how people find meaning at the intersection of science and religion.

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