Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Faith and science mindsets as predictors of COVID-19 concern: A three-wave longitudinal study☆

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ABSTRACT

The COVID-19 pandemic allowed for a naturalistic, longitudinal investigation of the relationship between faith and science mindsets and concern about COVID-19. Our goal was to examine two possible directional relationships: (Model 1) COVID-19 concern ➔ disease avoidance and self-protection motivations ➔ science and faith mindsets versus (Model 2) science and faith mindsets ➔ COVID-19 concern. We surveyed 858 Mechanical Turk workers in three waves of a study conducted in March, April, and June 2020. We found that science mindsets increased whereas faith mindsets decreased (regardless of religious type) during the early months of the pandemic. Further, bivariate correlations and autoregressive cross-lagged analyses indicated that science mindset was positive predictor of COVID-19 concern, in support of Model 2. Faith mindset was not associated with COVID-19 concern. However, faith mindset was a negative predictor of science mindset. We discuss the need for more research regarding the influence of science and faith mindsets as well as the societal consequences of the pandemic.

1. Introduction

In the early months of 2020 and beyond, people's lives around the world were changed due to the spread of a novel coronavirus (SARS-COV-2) and the disease it causes (COVID-19). Arguably the most significant global health crisis in the past century, the virus had spread to every continent by June 2020, with over 9 million cases and 400,000 deaths worldwide. In the U.S. alone, COVID-19 had caused economic hardship, stressed supply chains, exacerbated levels of depression, heightened the anxiety of individuals already experiencing poor physical health, and led to the death of over 100,000 individuals. Historically, the uncertainty, danger, and existential crises associated with non-normative events of this magnitude have compelled people to try to make sense of, and cope with, their circumstances—often turning to natural resources such as science and/or supernatural resources such as religion (Legare, Evans, Rosengren, & Harris, 2012; Legare & Gelman, 2008; Rutjens & Preston, 2020; Sibley & Bulbulia, 2012). In the present research, we conducted a longitudinal investigation of the potential causal relationships between science and faith mindsets and COVID-19 concern in a sample of individuals living in the U.S. during the early months of the pandemic.

There has been considerable interest in contrasting the characteristics, psychological profiles, and associated outcomes of reliance on science and religion in human experience. Science and religion are both multi-dimensional constructs with similar features such as their own vocabulary, orienting behaviors, norms, values, communities, and practices. However, at their respective cores, science and religion are two different approaches to making sense of and responding to events in the world (Murphy, 2007). The global beliefs (Park, 2005), knowledge networks (Murphy, 2007), worldviews (Johnson, Hill, & Cohen, 2011), or mindsets associated with science and religion are critical for meaning-making as people perceive, interpret, navigate, and respond to life events and environmental stressors. Although religious groups can serve as rich sources of social support in times of crisis, in the present research, we focused on religious *beliefs*—a religious mindset—in comparison with a scientific mindset. Henceforth, we refer to the religious mindset as "faith" or a "faith mindset" to emphasize our focus on beliefs rather than religion more broadly construed.

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In the present research, we conducted a longitudinal, quasi-experimental study during the early months of the COVID-19 pandemic in the U.S., focusing on the mindsets of science and faith. Our goal was to investigate whether COVID-19 concern shapes science and faith mindsets—mediated by disease avoidance and self-protection motivations; or, instead, whether science and faith mindsets influence the degree of COVID-19 concern. (The response to COVID-19 quickly became politicized in the U.S. Therefore, we control for political leanings in our analyses.)

1.1. COVID-19 concern as an influence on science and faith mindsets

As belief systems or mindsets, science and faith each have core tenets. The faith mindset generally includes beliefs that God or other supernatural beings exist; that religious group teachings or sacred writings are authoritative; and that God can provide comfort, protection, or help in meeting the challenges of life. The science mindset includes beliefs that logic must be used to generate testable hypotheses; empirical evidence is imperative for understanding; natural events can (eventually) be accurately explained and predicted by the community of scientists; and scientific knowledge is useful (or ideal) in addressing life's challenges.

However, science and faith—and the reliance on science and faith mindsets—have both been subject to change and reconceptualization and, at the cultural level, those changes often co-occur (Barbour, 1998; Kuhn, 1996; Wootton, 2016). At the individual level, many factors, including environmental stressors and the challenges a person faces, may also bring about personal change in reliance on science and/or faith (Farias, Newheiser, Kahane, & de Toledo, 2013; Jong, Halberstadt, & Bluemke, 2012; Lewandowsky & Oberauer, 2016; Rutjens, van der Pligt, & van Harreveld, 2010; Sinatra, Kienhues, & Hofer, 2014; Sinatra, Southerland, McConaughy, & Demastes, 2003). We expected that one such stressor would be the COVID-19 pandemic. Indeed, pathogens have presented one of the most pressing ecological threats to humankind, and SARS-CoV-2, and the disease it causes (COVID-19), is no different.

In the present research, we were primarily interested in whether COVID-19 concerns affect disease avoidance and self-protection motivations, which in turn, influence changes in individuals' reliance on science and faith mindsets. A large body of research has shown that diverse motivational systems (e.g., self-protection, disease avoidance, coalition formation, status-seeking, mate acquisition, and parenting) affect a swath of cognitive process, including what people attend to, how they reason, and their social perceptions (Kenrick, Griskevicius, Neuberg, & Schaller, 2010). These fundamental motives are theorized to be distinct systems designed to promote behavior that solves adaptive problems. For example, when motivated by self-protection, people become wary of outgroups perceived as dangerous, whereas people who are motivated to find a romantic partner focus more on others' attractiveness and, at least for men, become more risk-prone (Griskevicius, Goldstein, Mortensen, Cialdini, & Kenrick, 2006). In the present research, we consider the fundamental motivations of disease avoidance and self-protection to explain why COVID-19 concern, specifically, might lead to an increase in reliance on science or a faith mindset.

1.1.1. Disease avoidance

We expected that high levels of concern regarding COVID-19 would increase disease avoidance motives (see Makhanova & Shepherd, 2020). Pathogen prevalence and the motivation to avoid disease are often associated with traditionalist thinking, including conservativism and ingroup-oriented psychology (Boyer, Firat, & van Leeuwen, 2015; McCann, 1999), and past research has linked the threat of disease to shifts in religion, as well as personality and values (Fincher, Thornhill, Murray, & Schaller, 2008; Gelfand et al., 2011; Schaller & Murray, 2008; Varnum & Grossmann, 2016). High pathogen levels have also been linked with religiosity at the country level (Fincher & Thornhill, 2012). Additionally, many of the rituals associated with religion promote cleanliness, such as emphases on health (Reynolds & Tanner, 1995), ritual washings, and safety-minded food restrictions (Johnson, White, Boyd, & Cohen, 2011). These rituals (e.g., hand washing) might carry over to better health practices.

However, there are reasons to think people living in Western cultures (such as the U.S.) might turn to science instead of faith when motived by disease avoidance. First, some religious practices actually increase the risk of disease. For instance, communal cups and certain religious rituals (e.g., touching surfaces, hymn books, etc., in common areas) may expose people to higher pathogen levels (Reynolds & Tanner, 1995). To the extent that people intuit these dangers, they may avoid religious gatherings, and their faith may deteriorate (Exline et al., 2020). Second, given the enormous impact COVID-19 has had on daily life, we expected to find that people were more likely motivated to seek medically accurate information and look to science to develop technologies, treatments, preventative health practices, or vaccines (Murray, 2014)—resources which would not necessarily be available from sacred texts or religious engagement. Thus, a hypothesized mediated pathway from COVID-19 concern to disease motivation to reliance on a science mindset is shown in the upper half of Fig. 1.

1.1.2. Self-protection

In addition to the motivation to avoid germs, molds, contagion, and natural pollutants from contact with objects, humans possess suites of adaptations known as the “behavioral immune system,” which facilitates the avoidance of people as potential sources of pathogens (Schaller & Park, 2011). Notably, disease avoidance and self-protection motivational systems are distinct (i.e., they use distinct inputs, are assessed differently, and promote distinct behavioral patterns; Neuberg, Kenrick, & Schaller, 2010). Therefore, in addition to an increase in disease avoidance motives, we also expected levels of self-protection to increase during the pandemic as a result of a more zero-sum psychology (Van Bavel et al., 2020), perceiving other people to be potential carriers of the virus as well as competitors for resources (Olivera-La Rosa, Chuquichambi, & Ingram, 2020).

We reasoned that self-protection motives would be especially likely to prompt a faith mindset. Such a reaction might reflect the fact that, when threatened, people become especially attuned to group membership (Boyer et al., 2015). Indeed, people are more likely to form coalitions when mortality is made salient (Wisman & Koole, 2003). Given the daily reports of worldwide deaths, we expected that COVID19 concern would increase self-protection motives and, in turn, increase seeking social support from familiar, trusted groups as well as via faith in God and prayer. The hypothesized mediated pathway from COVID-19 concern to self-protection motivation to faith is shown in the lower half of Fig. 1.

In sum, we expected that the circumstances of COVID-19 would lead people to increase both reliance on a science and a faith mindset to provide different but complementary benefits. For example, science provides epistemological value, practical solutions for treating disease, and people may be particularly motivated to rely on science to regain a sense of control (Rutjens, Van Harreveld, Van Der Pligt, Kreemers, & Noordewier, 2013) as they seek to avoid disease; whereas faith can provide a sense of comfort, meaning, and hope in times of crisis (Laurin, Schumann, & Holmes, 2014; Pargament, Magyar-Russell, & Murray-Swank, 2005; Pargament, Smith, Koenig, & Perez, 1998).

1.2. Alternative model: science and faith mindsets as interpretive frameworks

However, it is possible that an individual's tendency to rely on science and faith might change very little, even in the face of an ecological crisis such as the COVID-19 pandemic. Indeed, an individual's worldview may be firmly entrenched and resistant to change. For instance, Lewandowsky and Oberauer (2016) found that many people reject scientific findings despite educated warnings of climate change,

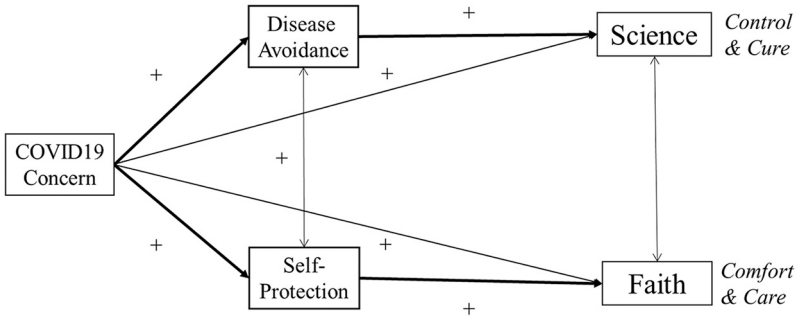

Fig. 1. Hypothesized model of changes in science and faith mindsets as outcomes of COVID-19 concern.
Note: Positive sign (+) indicates a hypothesized positive association. Correlated residuals are included because it is expected that factors outside of the model would also contribute to shared variation between disease avoidance and self-protection and between science and faith. We had no a priori hypothesis regarding the strength and direction of the correlated residuals between science and faith. In all analyses, we control for age, sex, and political conservatism.

particularly if they viewed these findings as conflicting with their religious worldview. Likewise, despite repeated findings that religious faith is associated with better health and well-being (McCullough, Hoyt, Larson, Koenig, & Thoresen, 2000), many people reject theism.

Instead, science and faith may function as meaning-making systems or interpretative frameworks in thinking about and making sense of the pandemic. Meaning-making has been conceptualized as a psychological need "to perceive events through a prism of mental representations of expected relations that organizes … perceptions of the world" (Heine, Proulx, & Vohs, 2006). In that sense, *meaning-making* refers to the cognitive process of restoring global meaning—the coherence of one's beliefs and goals and the subjective sense of satisfaction that life is at least headed in the right direction (Park, 2005). If people employ science or faith to understand, learn about, and interpret life experiences, then science or faith mindsets may, instead, influence individuals' thoughts, feelings, and attitudes about COVID-19.

Thus, the alternative model of science and faith providing coherent frameworks for making sense of the COVID-19 crisis would predict that reliance on science (i.e., the belief that science is the best source of knowledge and that the science mindset is capable of solving humankind's problems) would lead individuals to seek out scientific and statistical information (e.g., mortality rates, number of cases, potential treatments—or the lack thereof). Information about the pandemic was plentiful in the early months of the pandemic, and actively seeking this information could have elevated concerns and fears about infection, intubation, and death. The alternate pathway of science increasing COVID concern and, thereby, disease avoidance and self-protection, is shown in Fig. 2.

In contrast, people with a robust faith or religious worldview may have had long-term experience with religious coping, trusting God to provide protection, comfort, and care (Laurin et al., 2014; Pargament et al., 1998; Park, Cohen, & Herb, 1990). Indeed, monotheists are repeatedly instructed to trust in God and "fear not" in the scriptures. Thus, contrary to the predictions in our hypothesized model (Fig. 1), faith may have mitigated concern about COVID-19, indirectly reducing disease avoidance and self-protection, as shown in Fig. 2.

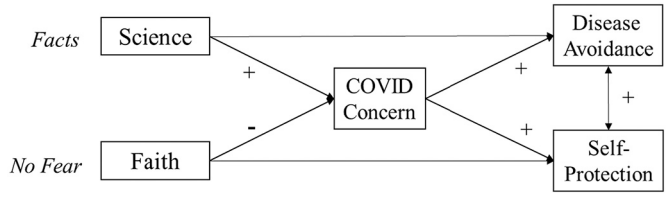

Fig. 2. Alternative model of science and faith as meaning-making systems.
Note: Positive sign (+) indicates a hypothesized positive association; a negative sign (−) indicates a hypothesized negative association. The bivariate relations between science and disease avoidance and between faith and self-protection was expected to be positive. However, these paths may be reduced to non-significance in the model after accounting for COVID-19 concern as a mediator; thus, no hypotheses for these paths were made.

1.3. Science and faith mindsets

Research shows that some people see the belief systems of science and faith as conflicting domains, often in terms of an epistemological divide (McPhetres, Jong, & Zuckerman, 2020; McPhetres & Nguyen, 2018; O'Brien & Noy, 2015). Consequently, much of the previous research has focused on investigating differences between science and faith in terms of cognitive style (Farias et al., 2017; Gervais & Norenzayan, 2012; Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012), differing knowledge structures (Lewandowsky & Oberauer, 2016), or as hydraulic cognitive processes (Preston & Epley, 2009).

However, science and faith mindsets do not necessarily conflict. People can and often do rely upon both religious and scientific beliefs (Ecklund, Park, & Sorrell, 2011; Nelson, 2009; Pew Research Center, 2015a, 2015b; Scheitle, 2011; Watts, Passmore, Jackson, Rzymski, & Dunbar, 2020). Indeed, until about the 16th century, science and faith were indistinguishable (Barbour, 1998; Wootton, 2016). Today, people often utilize both systems to understand and deal with illness and death (Clegg, Cui, Harris, & Corriveau, 2019; Cui et al., 2020; Davoodi et al., 2019; Legare & Gelman, 2008). Thus, in our hypothesized model, we expected both science and faith mindsets to increase, with science providing practical treatments and a sense of control; and faith providing a source of comfort and care.

2. Method

2.1. Participants

We conducted a naturalistic study, surveying a panel of Amazon Mechanical Turk workers in the U.S., across three time periods, in March, April, and June 2020. We report all measures, manipulations (none), and exclusions below. Sample size was determined before data collection began.

2.1.1. Time 1

Participants at Time 1 (T1; March 15–29, 2020) were 858 MTurk workers recruited using Cloud Research (Litman, Robinson, & Abbercock, 2017) (IRB # 00011534). All participants had completed one of the authors' studies during the past five years and had been informed that they might be invited to participate in subsequent studies. Participants at T1 were recruited over one week, as concern regarding COVID-19 was increasing daily, and the number of cases and deaths continued to rise. More detail regarding the data collection strategy is provided in the Supplemental Materials (Table S1).

There were 384 males and 474 females, $M_{age} = 44.84$, $SD = 13.72$. There were 121 Atheists, 176 Agnostics, 177 Mainline Protestants, 150 Catholics, 124 Evangelicals, 91 Spiritual but not Religious, 13 Jews, and 6 Muslims. The percentages of participants who identified as spiritual or religious (66%) and non-religious (34%) in our study were similar to the percentages of these groups in the U.S. (77% religious, 23% non-religious; Pew Research Center, 2015a, 2015b) but with somewhat more non-religious participants as is typical of the MTurk population

(Lewis, Djupe, Mockabee, & Su-Ya Wu, 2015). There were 79.7% Euro-Americans, 7.5% Blacks, 4.9% Asians, 4.8% Hispanics, and 3.1% of people reported multiple races/ethnicities.

We were interested in individuals' perceptions of COVID-19 rather than the actual threat. However, as a proxy for an objective measure of disease prevalence, we also grouped participants by geographic regions corresponding to the degree of lockdown orders across the U.S. Specifically, we estimated the degree of pathogen prevalence for each area of the country by comparing participants' latitude and longitude to a map of states under *no, partial*, or *total* lockdowns (Mazziota, March 26, 2020). There were six geographically oriented groups: North central west (e.g., Montana, North Dakota)/Southwest (8.9%; *no* orders), South (e.g., Texas, Florida) (21.7%; *partial* orders), Colorado and New Mexico (2.7%; *total* orders), North Central and East Central (38.9%; *total* orders), West Coast (15.2%; *total* orders), and East Coast (12.7%; *total* orders). Thus, the majority of participants in our sample were under total lockdown orders.

2.1.2. Time 2

By mid-April, all or nearly all city and state governments in the U.S. had fully initiated stay-at-home orders forcing the closure of non-essential businesses, restaurants, bars, and places of worship. There were over 600,000 active cases in the U.S., and over 36,000 deaths had been attributed to COVID-19. Following the initial data collection in March, we conducted a second survey (IRB # 00011835) on April 17–18, 2020, recruiting participants from T1 via invitation emails generated by Cloud Research (Litman et al., 2017).

To preserve the naivete of one-half of our original T1 sample for later, unrelated studies, we used a design that purposefully incorporated missing data. Specifically, the T2 survey was offered to all 858 previous participants, but recruitment was capped at $N = 400$. Seven participants missed one or more of four attention checks or failed to complete the study. These cases were incorporated into analyses as missing data, yielding a sample of 393 participants with observed data at T2.

2.1.3. Time 3

We conducted a third survey on June 4, 2020. On that date, the total number of deaths in the U.S. due to COVID-19 had surpassed 107,000. Although the number of active cases in the U.S. had more than doubled since April, cases were no longer rising exponentially, and most of the stay-at-home orders had been lifted or partially lifted across the nation. Moreover, news of COVID-19 was overshadowed by protests over the death of George Floyd.

We recruited participants from the previous waves via Cloud Research (Litman et al., 2017). Again, intentionally only incorporating a subset of the original participants, we recruited the same 393 Mechanical Turk workers from T2. However, due to attrition ($n = 54$), we failed to reach our goal of 400 participants who also completed T2. Therefore, we invited the additional participants from T1, with recruitment capped at 60. One participant failed to pass the attention checks, so the sample size at T3 was 398.

2.1.4. Participant summary

Of the 858 participants at T1, 406 participated at T1 (March) only (as designed), 54 at T1 and T2 only (March and April), 59 at T1 and T3 only (March and June), and 339 participated at all three time periods (T1, T2, and T3). By comparison, participants who completed T2 and/or T3 were significantly older than participants who had completed the survey at T1 only ($M_{Longitudinal} = 46.45$, $SD = 13.97$ vs. $M_{T1\_only} = 43.03$, $SD = 13.21$), t (855) $= -3.67$, $p < .001$, 95% CI for the difference [−5.25, −1.59]. However, Chi Square tests of independence revealed that the 452 participants who had completed follow-up surveys at T2 and/or T3 were not significantly different from the 406 non-included participants from T1 in terms of sex X^2 (1) $= 0.055$, $p = .814$; religion X^2 (9) $= 12.97$, $p = .164$; geographic location X^2 (5) $= 8.58$, $p = .127$; ethnicity X^2 (4) $= 5.17$, $p = .270$; or marital status X^2 (2) $= 2.82$, $p = .244$. The two groups also did not differ in political conservatism t (856) $= -0.25$, $p = .806$, 95% CI for the difference [−0.27, 0.21].

In terms of the main study variables at T1, the 452 who completed the surveys at T2 and/or T3 were not significantly different from T1-only participants for science mindset.

($M_{T2,3} = 4.97$, $SD = 1.41$ vs. $M_{T1} = 4.99$, $SD = 1.33$), t (856) $= -0.13$, $p = .895$, 95% CI for the difference [−0.20, 0.17]), or faith mindset ($M_{T2,3} = 3.81$, $SD = 2.26$ vs. $M_{T1} = 3.96$, $SD = 2.16$), t (856) $= 0.99$, $p = .323$, 95% CI for the difference [−0.15, 0.45]). The two groups did not differ in self-protection motivations ($M_{T2,3} = 4.79$, $SD = 1.28$ vs. $M_{T1} = 4.83$, $SD = 1.23$), t (856) $= 0.55$, $p = .583$, 95% CI for the difference [−0.12, 0.22]). However, the 406 who completed only the T1 survey, had higher scores in COVID-19 concern ($M_{T2,3} = 5.37$, $SD = 1.16$ vs. $M_{T1} = 5.52$, $SD = 1.15$), t (856) $= 1.97$, $p = .049$, 95% CI for the difference [0.00, 0.31]) and disease avoidance.

($M_{T2,3} = 4.95$, $SD = 1.34$ vs. $M_{T1} = 5.12$, $SD = 1.31$), t (856) $= 1.89$, $p = .059$, 95% CI for the difference [−0.01, 0.35]).

To address the potential bias associated with missing data due to both study design and attrition, we used Full Information Maximum Likelihood (FIML) estimation or Multiple Imputation (MI) as noted in each analysis(Baraldi & Enders, 2020). When used properly, these analysis methods can reduce non-response bias associated with some forms of systematic missingness. In the main analyses that included timepoints T2 and/or T3, we used FIML in M*plus* version 8.4 or MI (with 30 imputed data sets) in SPSS to account for the missing data. In the preliminary analyses, we report the results for the 858 participants (no missing data) at T1.

In the Supplemental Materials, we provide the results of the following analyses using the data from only the 339 participants who completed all waves of data with no missing data (i.e., with no missing data techniques). There are, not surprisingly, some minor differences in the strength (but not the direction) of the coefficients, p-values, and effect sizes. However, the conclusions drawn from the analyses with versus without the use of FIML and MI do not change.

2.1.5. Power and sensitivity analyses

As previously discussed, the present research was part of a more extensive set of preregistered studies to investigate the distinct influence of specific fundamental social motivations on religion and science as meaning-making systems. As part of that larger project, we aimed for a final sample size of $N = 800$ at Time 1 and a smaller sample size of $N = 400$ in each of the follow-up studies. These estimates were based on the statistical analyses we had planned, which assumed statistically significant correlations between the model variables and estimated mediational effects.

We also used G*Power to conduct a sensitivity analysis for the present study to determine the minimum correlation that could be detected at 80% power, $\alpha = 0.05$, with our full sample of $N = 858$. We found we had sufficient power to detect a correlation of $r = 0.09$. Our longitudinal study included 339 participants who had completed all three waves. A second G*Power analysis suggested the minimum correlation that could be detected at 80% power, alpha $= 0.05$, with a sample size of $N = 339$ (without regard to the potential increase of power from using larger sample sizes with FIML or MI) is 0.15.

2.2. Measures

Participants at each time period completed a survey assessing COVID-19 concern, disease avoidance and self-protection motivations, and the endorsement of science and faith mindsets as well as other measures to be reported elsewhere (e.g., health practices, well-being). A summary of all study measures and the order of presentation at each time period is summarized in Table 1.

2.2.1. COVID-19 concern

At Time 1, a published measure of COVID-19 concern was not

Table 1
Summary of data collected and order of presentation across three waves.

	T1	T2	T3
	N = 858	*N* = 393	*N* = 398
	March 15–29, 2020	April 17–18, 2020	June 4, 2020
First survey block		COVID-19 Concern	COVID-19 Concern & Health Practices
Randomized blocks	Disease Avoidance	Disease Avoidance	Disease Avoidance
	Self-protection	Self-protection	Self-protection
	Science/Faith mindset	Science/Faith mindset	Science/Faith mindset
	Religiosity	Religiosity	
	Interest in Science/ Scientific Logic	Interest in Science/ Scientific Logic	
	Other measures	Other measures	Other measures
	4 Attention Checks	4 Attention Checks	4 Attention Checks
Final Survey block	COVID-19 Concern	Well-being	Well-being

Note: Of the 858 participants at T1, 406 participated at T1 only (as designed); 54 at T1 and T2 only; 59 at T1 and T3 only, and 339 participated at all three time periods (T1, T2, and T3).

available. Therefore, we developed a 3-item measure tapping into compulsive checking and perceived danger regarding the COVID-19 pandemic.[1] Participants rated the items on a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). The three items were: "I am very worried I will be infected by COVID-19;" "I search for daily updates about COVID-19;" "People must protect themselves from COVID-19" ($\alpha_{T1} = 0.67$; $\alpha_{T2} = 0.70$; $\alpha_{T3} = 0.71$). The COVID-19 concern measure was assessed in all three waves of the study, but it was assessed at the end of the survey at T1 and the beginning of the T2 and T3 surveys.

2.2.2. Fundamental social motivations (FSM)

We administered the full FSM measure (Neel, Kenrick, White, & Neuberg, 2016), which includes six items for each of ten sub-scales: Disease Avoidance, Self-protection, Coalition formation, Exclusion concern, Preference for being alone, Status, Mate Acquisition, Mate Retention, Mate Guarding, and Kincare. Motives relevant to the present study were Disease Avoidance ($\alpha_{T1} = 0.89$) and Self-protection ($\alpha_{T1} = 0.89$). Sample items are: "I avoid places and people that might carry diseases" (Disease avoidance) and "I think a lot about how to stay safe from dangerous people" (Self-protection). The fundamental motives measure was assessed in all three waves of the study using a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*).

2.2.3. Science and faith mindsets

We assessed science ($\alpha_{T1} = 0.91$) and faith ($\alpha_{T1} = 0.97$) mindsets using a 10-item measure developed by Kitchens and Phillips (2018). The items are: "I trust that Science [God] can solve the major problems of humanity," "Relying on information from Science [God] is a great way to really understand the universe," "Ultimately, Science [God] is the only infallible source of knowledge and truth," "Science [God] offers excellent explanations for reality," and "Humanity has Science [God] to thank for the good things in life we enjoy." The science and faith measures are assessed on the same page of the survey and in all three waves of the study using a 7-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*).

2.2.4. Other measures

We also assessed attributes of God (including belief in a loving God), trust in God and institutions, and self-directedness at T1, T2, and T3. Additional topics measured at T1 and T2 only, and used in our preliminary analyses, included religiosity (Religious Commitment Inventory; Wood et al., 2010) and Interest in Science and Scientific Logic (Johnson et al., 2019). Additional measures assessed at T2 and T3 only were participants' estimates of mortality rates, financial hardship due to COVID-19, and subjective well-being. Exploratory measures assessed at T2 only were opinions about the origins of COVID-19, afterlife beliefs, death anxiety, and locus of control. Additional measures assessed at T3 only were participation in religious activities, engagement with science activities, disease uncertainty, aggression, and compliance with preventative health practices. Each survey also included four attention checks embedded in the questionnaires, demographic questionnaires, and a 3-item measure assessing political conservatism (Frimer, Gaucher, & Schaefer, 2014). Except as indicated above and as shown in Table 1, the presentation of all measures (including the main study variables) was randomized.

3. Results

Our data analysis plan involved several types of analyses. In preliminary cross-sectional analyses, we used the data from T1 ($N = 858$) to validate our science and faith measure, to ascertain whether our variables differed by geographic location or degree of lockdown (stay-at-home) orders, and to examine the bivariate correlations between the main study variables and control variables. Contrary to expectations, disease avoidance motivation was uncorrelated with science mindset at T1.

In a preliminary longitudinal analysis, we examined changes in the means of our five main study variables from T1 to T2 and from T2 to T3. This analysis also provided descriptive information on the magnitude of changes over time in the means for our main study variables.

The main analyses examined the longitudinal data in two different ways. The first set of analyses was conducted to probe the relations between the model variables over time (thus comparing the hypothesized and alternative models; Figs. 1 and 2, respectively), using autoregressive cross-lagged (ARCL) models. We concluded that the alternative model (Fig. 2) was more consistent with the data with one modification to our alternative model; that is, we found that faith mindset was a negative predictor of science mindset. Finally, to provide a visual summary of our findings, we conducted mediation and path analyses, fitting the data at T2 and again at T3 to our respecified model.

3.1. Preliminary analyses using cross-sectional (T1) data

We conducted preliminary analyses to (1) validate the measure of science and faith, (2) examine any differences by geographic region for the five variables in our models, and (3) examine the bivariate correlations between the five model variables. (A comparison of available pre-test and T1 scores for a subset of participants regarding science and faith mindsets, and an analysis of the full range of fundamental motives as they relate to science and faith mindsets, are provided in the Supplemental Materials.)

3.1.1. Science and faith

The science and faith mindset measure (Kitchens & Phillips, 2018) is relatively new. Therefore, we conducted a principal components analysis, which yielded two factors, accounting for 83.41% of the variance (faith Eigenvalue = 6.64 and science Eigenvalue = 1.70). To further

[1] A 36-item measure of COVID-19 stress became available in May 2020 (Taylor et al., 2020). However, due to our survey's length and the need to repeat our same measure across all three time periods, we continued to assess COVID-19 concern using just these three items. In later studies not reported here ($N = 685$), we found that our 3-item measure was positively correlated with Concern, $r(673) = 0.78$, Compulsive Searching, $r(673) = 0.57$, and Fear of Contagion, $r(673) = 0.58$, three relevant subscales of the longer new COVID-19 stress measure.

validate the measure, we found the Faith subscale was strongly, positively correlated with religiosity (Religious Commitment Inventory; Wood et al., 2010) and belief that God exists (single item), but negatively correlated with measures of Interest in Science and commitment to Scientific Logic (Johnson et al., 2019). In contrast, the Science mindset subscale was positively correlated with Interest in Science and Scientific Logic but negatively correlated with religiosity and belief in God. The correlations are shown in Table 2.

The magnitude of the negative correlations was unexpected because science and faith are seen as complementary by many religious people (Ecklund et al., 2011; Legare et al., 2012; Longest & Smith, 2011; Pew Research Center, 2015a). However, our results seemed to suggest that many of the study participants viewed religion and science as conflicting–regardless of the measures used to assess faith and science mindsets. Nevertheless, we concluded that the Kitchens and Phillips (2018) measure was valid for assessing science and faith mindsets.

3.1.2. Differences by geographic region and lockdown severity

Our subjective measure of COVID-19 concern may or may not have been related to more objective indicators of perceived disease prevalence (e.g., areas with government-issued stay-at-home orders). Therefore, we conducted a MANOVA to examine whether there were significant differences by geographic region (North and Southwest, South, Colorado/New Mexico, North Central and East Central, West Coast, and East Coast) for the five variables in our model and found there were no significant differences at the multivariate level, Wilks' Lambda = 0.979, F (25, 3151) = 0.723, p = .839. There were also no significant differences for any of the variables at the univariate level, p's ranging from 0.413 to 0.876.

A second MANOVA, focusing only on potential differences by the degree of lockdown severity (i.e., no lockdown, partial lockdown, and total lockdown) in the region in which the participants lived. The effect of lockdown severity was non-significant at the multivariate level, Wilks' Lambda = 0.994, F (10, 1702) = 0.533, p = .868. There were also no significant differences related to the degree of lockdown for any of the variables at the univariate level, p's ranging from 0.337 to 0.940.

3.1.3. Bivariate correlations at T1

Our goal was to understand whether and to what extent perceived pathogen threat was associated with science and faith mindsets. To investigate the hypothesized associations at T1 between COVID-19 Concern (M_{T1} = 5.44, SD = 1.16), Disease Avoidance (M_{T1} = 5.44, SD = 1.16), Self-protection (M_{T1} = 5.44, SD = 1.16), Science (M_{T1} = 5.44, SD = 1.16), and Faith (M_{T1} = 5.44, SD = 1.16), we computed the correlations between these variables, as well as their association with age and sex as demographic variables (Table 3).

Because concern over COVID-19 would later become increasingly politicized, we also examined the association between COVID-19 concern and political leanings as a potential control variable. The correlations among the five main study variables were mostly consistent with our hypothesized model except that Disease Avoidance was not significantly correlated with Science, and Faith was uncorrelated with COVID-19 concern.

We had not expected to find the strong, negative correlation between science and faith mindsets. To probe whether the negative correlation between faith and science mindsets depended upon religious affiliation, we examined the partial correlations, controlling for political conservatism, between science and faith mindsets, at each of the three time periods, for each of six religious groups with $n > 30$ (i.e., Atheists, Agnostics, Catholics, Evangelicals, Mainline Protestants, SBNRs). Our measure of science and faith mindsets (Kitchens & Phillips, 2018) is presented on a single survey page. Therefore, as a supplement, we also examined the correlations between religious commitment (Wood et al., 2010) and Interest in Science (Johnson et al., 2019)–our similar, multi-page measures of faith and scientific commitments (Table 4).

There was a negative correlation at each timepoint, for each of the six religious groups, with only two exceptions (a non-significant correlation between science and faith among Evangelicals at T2 and SBNRs at T3). These results indicate that the negative correlation between science and faith is robust across religious groups.

3.2. Preliminary analyses of longitudinal data

Analysis of the longitudinal data began with an investigation of changes in the means of our five model variables over time. We had intentionally assessed COVID-19 concern at specific time points: Time 1 when the extent of the pandemic first became apparent, Time 2 as cases and deaths escalated daily with nationwide stay-at-home orders, and at Time 3 after the exponential increase in cases had leveled off for the time being and many nations around the world—including the U.S.—had fully or partially lifted lockdown orders. To examine the change in the means of each of the variables in our model between March and April (when cases escalated daily) and between April and June (when cases had plateaued or declined), we conducted a series of paired-samples t-tests, using a multiple imputation data file created in SPSS with 30 imputed data sets to address the missing data.

In calculating the paired samples t-tests and effect sizes (i.e., Cohen's ds), we compared (1) T2 scores with T1 scores and (2) T3 scores with T2 scores. We found significant differences but all effect sizes were small except for COVID-19 concern, which had a medium, positive effect size (T3 versus T2). The results can be seen in Table 5. Similar results without using multiple imputation can be found in the Supplemental Materials, Table S5.

We found that COVID-19 concern in March (T1) did not differ from April (T2), suggesting that the subjective perceptions may have differed from the objective circumstances with the number of cases and deaths increasing daily. Additionally, as cases leveled off in June, COVID-19 concern decreased significantly.

Disease Avoidance increased significantly from March to April but then declined to March levels in June. Self-protection increased significantly from March to April and remained elevated in June—possibly due to the civil unrest following the death of George Floyd. Science mindsets increased significantly from March to April and remained elevated in June. In contrast, faith mindsets declined during the early months of the pandemic from T1 to T2 and remained lower at T3.

Table 2
Correlations between alternate measures of faith and science mindsets.

	Faith Mindset[3]	Religiosity	God Exists	Interest in Science	Scientific Logic
Religiosity[1]	0.89***				
God Exists	0.86***	0.80***			
Interest in Science[2]	−0.30***	−0.24***	−0.30***		
Scientific Logic[2]	−0.56***	−0.56***	−0.55***	0.57***	
Science Mindset[3]	−0.60***	−0.57***	−0.56***	0.48***	0.76***

Notes: [1](Wood et al., 2010); [2](Johnson et al., 2019); [3](Kitchens & Phillips, 2018).
N = 858; *** $p \leq .001$.

Table 3
Bivariate correlations among the study and control variables at T1.

	r						
	COVID	DA	SP	Science	Faith	Age	Female
COVID-19 Concern	_						
Disease Avoidance	0.53***	_					
Self-protection	0.42***	0.55***	_				
Science	0.18***	0.06	−0.01	_			
Faith	0.00	0.05	0.18***	−0.61***	_		
Age	0.03	0.00	−0.02	−0.18***	0.17***	_	
Sex (female)	0.19***	0.11***	0.25***	−0.13***	0.16***	0.14***	_
Conservative	−0.12***	−0.01	0.12***	−0.41***	0.49***	0.18***	−0.01

Note: COVID = COVID-19 Concern, DA = Disease Avoidance, SP = Self-protection; $N = 858$.; ***$p \leq .001$.; **$p \leq .01$. *$p \leq .05$.

Table 4
Partial correlations between science and faith mindsets, by wave, by religious group, controlling for political conservatism.

	Science & Faith Mindset[1]						Interest in Science[2] & Religiosity[3]	
	T1		T2		T3		T1	T2
Religion	*df*	*r*	*df*	*r*	*df*	*r*	*r*	*r*
Atheist	118	−0.17	46	−0.17	56	−0.19	−0.15	−0.05
Agnostic	173	-0.44^{0120}	82	-0.22^{0125}	85	-0.37^{0130}	-0.24^{0135}	-0.38^{0140}
Catholic	147	-0.36^{0145}	74	-0.43^{0150}	67	-0.40^{0155}	-0.40^{0160}	-0.44^{0165}
Evangelical	118	-0.47^{0170}	49	0.07	48	−0.12	-0.31^{0175}	−0.10
Protestant	174	-0.33^{0180}	78	-0.34^{0185}	73	-0.37^{0190}	-0.25^{0195}	-0.37^{0200}
SBNR	86	−0.18	39	−0.01	44	0.06	−0.12	-0.43^{0205}

Note: [1](Kitchens & Phillips, 2018), [2](Wood et al., 2010), and [3](Johnson et al., 2019).; ***$p \leq .001$.; **$p \leq .01$.; *$p \leq .05$.

Table 5
Differences in means for COVID-19 concern, motivations, science and faith mindsets at three time periods.

	M (*SE*)			T2 vs. T1		T3 vs. T2	
Variable	T1	T2	T3	*t*	*d*	*t*	*d*
COVID19 Concern	5.44 (1.16)	5.46 (1.16)	4.90 (1.36)	0.20	0.02	−11.38***	−0.62
Disease Avoidance	5.03 (1.33)	5.16 (1.26)	5.01 (1.32)	3.16**	0.15	−3.00**	−0.18
Self-Protection	4.81 (1.25)	4.99 (1.28)	4.93 (1.27)	3.91***	0.19	−1.48	−0.07
Science mindset	4.98 (1.37)	5.10 (1.36)	5.08 (1.43)	2.91**	0.14	−0.29	−0.03
Faith mindset	3.88 (2.21)	3.77 (2.19)	3.76 (2.20)	−2.91**	−0.13	−0.18	−0.01

Note: The *t*-test values and Cohen's *d*s are positive when the mean increased from the earlier to the later wave, and they are negative when the mean decreased from the earlier wave to the later wave. ***$p \leq .001$, **$p \leq .01$, *$p \leq .05$.

3.2.1. Changes in faith and science mindsets by religious group

To investigate the possibility that the decline in faith mindsets depended on religious group, we conducted a mixed ANOVA with time (T1 vs. T3) as the within-subjects variable and religious affiliation as the between-subjects factor for 391 participants who had completed the study in both March (T1) and June (T3). In these analyses, we included only the religious groups with $n > 30$. There were 59 Atheists, 88 Agnostics, 70 Catholics, 51 Evangelicals, 76 Mainline Protestants, 47 SBNR.

As would be expected, there was a significant main effect of religious type, $F(5, 385) = 141$, $p < .001$, partial $\eta^2 = 0.646$, with Atheists' and Agnostics' scores being significantly lower than the other groups on Faith, all p's < 0.001. There was also a significant within-subjects main effect of time, $F(1, 385) = 7.84$, $p = .005$, partial $\eta^2 = 0.020$, with Faith declining from T1 to T3. However, the interaction of time x religious group was not significant, Wilks' Lambda $= 0.979$, $F(5, 385) = 1.69$, $p = .137$, partial $\eta^2 = 0.021$, suggesting that the six religious groups did not differ significantly in Faith decline.

In a second mixed ANOVA with Science mindset as the dependent variable, there was a significant main effect of religious type, $F(5, 385) = 50$, $p < .001$, partial $\eta^2 = 0.397$, with Atheists' and Agnostics' scores being significantly higher than the other groups in terms of Science mindset, all p's < 0.001. There was also a significant within-subjects main effect of time, $F(1, 385) = 4.13$, $p = .043$, partial $\eta^2 = 0.011$, with Science mindsets increasing from T1 to T3. However, the interaction of time x religious group was not significant, Wilks' Lambda $= 0.981$, $F(5, 385) = 1.50$, $p = .188$, partial $\eta^2 = 0.019$, suggesting that the six religious groups did not differ significantly in increasing reliance on science.

3.3. Main analyses of longitudinal data

To investigate the effects of COVID-19 concern and its association with reliance on science and faith mindsets, we analyzed the changes and most likely direction of effects in each of our model variables across the three waves using autoregressive cross-lagged (ARCL) models. We conclude with a mediation analysis and a final, revised model illustrating our overall findings.

3.3.1. Directional effects of COVID-19 concern, science, and faith

Path models for both the hypothesized and alternative models provided an adequate fit for the data (Supplemental Materials, Table S6). However, it is not appropriate to compare the fit of the two models because they are non-nested, almost fully saturated, and a particular causal direction cannot be inferred by comparing model fit.

To further probe the relationships (and infer causality based on temporal precedence) one strategy would be to run multiple regression models predicting scores on a variable, *Y*, at a later time period from

scores on a variable, *X*, at an earlier time period, while controlling for scores on variable *Y* at the earlier time. So, for example, if we wanted to understand the extent to which COVID-19 concern can be predicted by Science mindset, we could carry out a multiple regression analysis in which COVID-19 concern at T3 is the dependent variable, Science at T2 would be the predictor variable, and COVID-19 concern at T2 would be the control variable (covariate). Indeed, the standardized beta coefficients for this model suggest that Science at T2 was a positive predictor of COVID-19 concern at T3, $\beta = 0.13$, $p = .003$. COVID-19 concern at the earlier period (T2) was also a positive predictor of COVID-19 at T3, $\beta = 0.72$, $p < .001$. These coefficients are shown in the upper right corner of Fig. 3.

However, we would need to compare a series of multiple regression analyses to tell us whether the alternate hypothesis may (or may not) be more accurate (i.e., that COVID-19 concern at T2 predicts Science mindset at T3 controlling for Science mindset at T2). Also, we could not tell from multiple regression analysis whether there might be cross-lagged effects because we cannot specify two dependent variables in a single regression analysis. (Cross-lagged effects occur when a variable, *X*, at T1 predicts a variable, *Y*, at T2, but also that same variable, *Y*, at T1 predicts that same variable, *X*, at T2.) Multiple regression analyses are also insufficient because we could only analyze one time period in each analysis (e.g., T2 predicting T3 but not T1 predicting T2 in the same analysis). Therefore, we would be unable to account for differences in the effects across time *in a single regression model*. For example, any effect of science mindset on COVID-19 concern might be negligible in an early period but significant in a later period (as was the case), or vice versa. What is needed is a strategy to simultaneously solve a set of multiple regression analyses, incorporating all possible effects for the given set of variables over time.

3.3.1.1. Autoregressive cross-lagged models. Therefore, to investigate the hypothesized and alternative directional effects, we used autoregressive, cross-lagged modeling (ARCL). An ARCL modeling strategy can be understood as a set of regression models to provide complete information about the relations between variables over time. ARCL analyses sequentially compare models with no effects between variables (no cross-lagged pathways; e.g., the effect of Science at T2 on COVID-19 concern at T3) to models with hypothesized, alternative, and cross-lagged paths, controlling for all possible associations between the variables and across time (and any control variables). Thus, an ARCL model can provide information about: (1) the effects of a predictor variable on the hypothesized outcome variable (e.g., COVID-19 concern at T1 ➔ Science at T2); (2) the alternative pathway, from the hypothesized outcome variable to the predictor variable at the later time period (e.g., Science at T1 ➔ COVID-19 concern at T2; (3) cross-lagged effects such that the hypothesized and the alternative pathways are equally robust; (4) the stability of effects *within* each variable across time (referred to as the auto-regressive pathways); (5) the correlations between the variables at the prior time period; and (5) the correlations between the variables at the later period. Models with significantly improved goodness of fit to the data relative to baseline (or less complex) models are deemed the best representation of the associations between the variables.

Because COVID-19 concern, Science, and Faith may have mediated effects, we compared the fit statistics in three separate ARCL analyses to isolate these effects, with one analysis for each pair of variables. Analysis 1 investigated the effects between COVID-19 concern and Science, Analysis 2 investigated the effects between COVID-19 concern and Faith, and Analysis 3 investigated the effects between Science and Faith. In each of the three analyses, we examined four models specifying (1) no cross-lagged effects (i.e., the baseline model assuming no effects between the two variables), (2) the hypothesized effects of COVID-19 concern ➔ Science (or COVID-19 concern ➔ Faith; or Science ➔ Faith), (3) the alternative hypothesized effects of Science ➔ COVID-19 concern (or Faith ➔ COVID-19 concern; or Faith ➔ Science), and (4) a model with cross-lagged effects. All ARCL models used FIML estimation. We included age, sex, and political conservatism measured at T1 as time-invariant covariates by including them as exogenous predictors of the T1 variables; all other control is indirect thereafter (Little, 2013, p. 196–197). The correlation matrix for the model variables for all three time periods can be found in the Supplemental Materials (Table S9).

For ARCL Models 2 and 3, we tested whether the model fit was improved over the baseline Model 1. Model 4 was compared to what we had found to be the best fitting of Model 1, 2, or 3. Comparisons of the fit statistics for the ARCL models are shown in Table 6.

3.3.1.2. Science and COVID-19 concern. A comparison of the fit statistics for the four possible models of the association between Science and COVID-19 concern across three time periods was shown in the upper section of Table 6. The best-fitting model indicated that science mindset might be better conceptualized as a predictor of COVID-19 concern. Thus, our original hypothesis was not supported. Instead, it appears more likely that science mindset functions as an interpretive framework influencing COVID-19 concern.

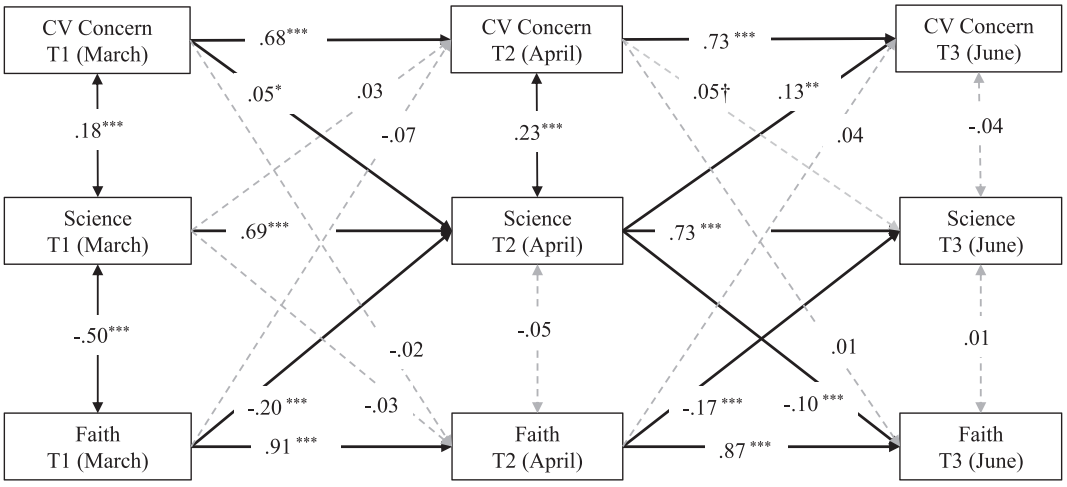

Fig. 3. Standardized path coefficients for the autoregressive cross-lagged model.
Note: CV = COVID-19 concern. Correlations between COVID-19 concern and Faith were not significant in March, $\beta = -0.01$, April, $\beta = 0.02$, or June, $\beta = 0.01$, and are not shown here. Dashed lines indicate non-significant pathways. ***$p \leq .001$, **$p \leq .01$, *$p \leq .051$, †$p = .057$. The model specified age, sex, and political conservatism at T1 as control variables.

Table 6
Fit statistics for competing autoregressive cross-lagged models.

	X^2	*Df*	CFI	RMSEA	ΔX^2	Δdf	*p*
Analysis of Associations between COVID-19 Concern and Science Mindsets							
#1 No cross-lag (Baseline)	231	20	0.89	0.11			
#2 CV Concern➔Science	227	18	0.89	0.12	4.00	2	0.135
#3 Science➔CV Concern	215	18	0.90	0.11	16.00	2	<0.001
#4 Reciprocal vs. Science➔CV Concern	212	16	0.90	0.12	3.00	2	0.878
Analysis of Associations between COVID-19 Concern and Faith Mindsets							
#1 No cross-lag (Baseline)	158	20	0.95	0.09	†		
#2 CV Concern➔Faith	156	18	0.95	0.09	2.00	2	0.368
#3 Faith➔CV Concern	149	18	0.95	0.09	9.00	2	0.011
#4 Reciprocal vs. Faith➔CV Concern	146	16	0.95	0.10	3.00	2	0.223
Analysis of Associations between Science Mindsets and Faith Mindsets							
#1 No cross-lag (Baseline)	279	20	0.93	0.12			
#2 Science➔Faith	256	18	0.93	0.12	23.00	2	0.019
#3 Faith➔Science	215	18	0.94	0.11	64.00	2	<0.001
#4 Reciprocal vs. Faith➔Science	194	16	0.95	0.11	21.00	2	0.015

3.3.1.3. Faith and COVID-19 concern. A comparison of the fit statistics for four possible models of the association between Faith and COVID-19 concern across three time periods is shown in the middle section of Table 6. The best fitting model suggested that Faith had a greater effect on COVID-19 concern than vice versa. However, the cross-sectional bivariate correlations at T1 indicated that the association between Faith mindset and COVID-19 Concern was non-significant, calling into question whether Faith is a predictor of COVID-19 Concern.

3.3.1.4. Faith and science. Both the path from Faith to Science mindset (Model 2) and the path from Science to Faith mindset (Model 3) were significant. However, the improvement in goodness of model fit relative to the baseline model was substantially larger in Model 3 (Chi Square change = 64) as compared to Model 2 (Chi Square change = 23). This suggests that Faith mindset may be a predictor of Science mindset.

3.3.1.5. Full ARCL model. In the preceding analyses, we found that the best fitting models were Science ➔ COVID-19 Concern, and Faith ➔ COVID-19 concern, suggesting that our alternative model (Fig. 2) may explain the relations between the variables better than our hypothesized model (Fig. 1). However, it was less clear which was the best fitting model in the third analysis investigating the associations between science and faith mindsets. Moreover, we had observed the non-significant correlation between Faith mindset and COVID-19 concern in the cross-sectional data. The ARCL models summarized in Table 6 explored the relations between *pairs* of variables. Thus, these models ignored the relations among the three variables. To address this issue, we investigated the relations among Faith mindset, Science Mindset, and Covid-19 Concern in a single ARCL model. We examined autoregressive effects (associations within variables across time), the prospective effects (i.e., Science ➔ COVID-19 Concern; Faith ➔ COVID-19 Concern; and Faith ➔ Science), and the reciprocal effects (i.e., COVID-19 Concern ➔ Science; COVID-19 Concern ➔ Faith; and Science ➔ Faith), accounting for all three variables, across all three time periods, with age, sex, and political conservatism at T1 as exogenous control variables. The model provided a good fit for the data, X^2 (27) = 251; RMSEA = 0.10; CFI = 0.95; SRMR = 0.04. The standardized path coefficients for the model are shown in Fig. 3.

As indicated in Fig. 3, Science was a predictor of COVID-19 concern and this effect was amplified between T2 and T3. Perhaps, from April to June, the availability of scientific information about the disease increased as scientists, medical professionals, and the media became better informed. Thus, in terms of a direct association between science mindset and COVID-19 concern, the alternative model was supported.

The results of the full ARCL model indicate that the association between Faith mindset and COVID-19 concern was non-significant suggesting that Science mindset may mediate the effect of Faith on COVID-19 concern. Thus, in terms of a direct association between faith mindset and COVID-19 concern, neither the hypothesized nor alternative models were supported.

Although the association between Science and Faith mindsets was cross-lagged in the later period (Fig. 3), the prospective paths showing Faith as influencing Science were stronger in both time periods. The increase in science mindset coupled with the apparent decline in faith, and the results of the final ARCL model suggest that the decline in faith mindset may have facilitated the increase in science mindset during the early months of the pandemic.

3.3.1.6. Disease avoidance and self-protection. Additional ARCL models (not shown here) confirmed that COVID-19 concern was a significant predictor of disease avoidance and self-protection motivations. However, despite the moderate correlations between Faith mindset and Self-protection observed in the cross-sectional data at T1, the ARCL analyses showed that the cross-lagged pathways were non-significant. Cross-lagged pathways for Faith mindset and Disease Avoidance were also non-significant. The cross-lagged pathways for Science mindset and motivations were also non-significant. Contrary to our predictions, we conclude that the two motivations were not mediators of the effects of COVID-19 concern but, instead, were better conceptualized as outcomes of COVID-19 concern.

3.3.2. Final revised path model

Thus far, we have shown that there were small but significant changes over time in each of the variables in our hypothesized model (see paired samples *t*-tests). As predicted, the bivariate correlations between the five model variables at T1 showed that disease avoidance and self-protection motivations were positively associated with COVID-19 concern. However, contrary to our predictions, Disease Avoidance was not correlated with a Science mindset, and COVID-19 concern was not correlated with a Faith mindset. Moreover, ARCL analyses suggested that Faith mindset negatively predicted Science mindset and that Science mindset positively predicted COVID-19 concern (T2 to T3).

Taken together, these results provide converging evidence that the alternative (interpretative framework) model of Faith and Science as predictors of COVID-19 concern appears to be a more accurate representation of the directional effects between the five variables in our model, with the caveat that a Faith mindset only influences COVID-19 concern indirectly, via Science, if at all. Thus, the associations between the variables in our alternative model would need to be respecified with no direct effect of Faith mindset on COVID-19 concern.

3.3.2.1. Science mediates effects of faith on COVID-19 concern. To further investigate the relations between Science, Faith, and COVID-19 concern, we focused on the proposed mediational pathway, testing the indirect effect of Faith (at T1) on COVID-19 concern (at T3) via Science (at T2) (i.e., Faith_{T1} ➔ Science_{T2} ➔ $\text{COVID-19 concern}_{T3}$). In the model, we also controlled for prior period scores (i.e., COVID-19 concern at T2, Science at T1), age, and political conservatism at T1. There was a significant, negative, direct effect of Faith at T1 on Science at T2, $\beta = -0.14$, $p = .004$, Bootstrapped 95% CI [−0.23, −0.05] and a significant direct effect of Science at T2 on COVID-19 concern at T3, $\beta = 0.16$, $p = .010$, Bootstrapped 95% CI [0.04, 0.28].

We used bias-corrected bootstrapping and the corresponding asymmetric confidence interval to assess the mediated effect (Fairchild &

Mcdaniel, 2017; Fritz & MacKinnon, 2007; Hayes, 2013). Thus, we explicitly do not provide exact *p*-values for the mediated effect and instead interpret the confidence intervals. There was a significant ($p < .05$) negative indirect effect of Faith at T1 on COVID-19 concern at T3 via Science at T2, $\beta = -0.02$, Bootstrapped 95% CI [−0.05, −0.00]. The direct effect of Faith at T1 on COVID-19 concern at T3 was not significant when partialling out the effect of Science at T2, $p = .174$, $\beta = 0.07$, Bootstrapped 95% CI [−0.03, 0.17]. The total effect of Faith on COVID-19 concern was not significant, $\beta = 0.05$, Bootstrapped 95% CI [−0.05, 0.14], reflecting the cancellation of the significant negative indirect effect of Faith mindset on COVID-19 concern via Science mindset by the nonsignificant, but positive, direct effect of Faith mindset on COVID-19 concern.

3.3.2.2. Final path model. To illustrate the results of our study, the structure of the final path model, and the strength of the associations between the variables, we specified two final path models. In the first model, we used T2 (April) scores and in the second model we used T3 (June) scores. In both models, we controlled for the demographic variables, age and political conservatism at T1. (Due to convergence issues stemming from incorporating missing data with FIML, we removed the binary control variable, sex, from the models.) The standardized path coefficients for the two models are shown in Fig. 4.

The model for T2 (April) provided a good fit for the data, X^2 (5) = 23; RMSEA = 0.06; CFI = 0.98; SRMR = 0.03. The model for T3 (June) also provided a good fit for the data, X^2 (5) = 17; RMSEA = 0.05; CFI = 0.98; SRMR = 0.03. Together, the two models illustrate the structure of the relationships between (1) Faith and Science mindsets; (2) Science and COVID-19 concern; and (3) COVID-19 concern and Disease Avoidance and Self-protection. Similar results using only the data from the 339 participants who completed all three waves can be found in the Supplemental Materials, Fig. S5.

Taken together, the results of the paired samples *t*-tests showing changes in the model variables, the autoregressive cross-lagged models showing the relative strengths of the directional pathways between the model variables from prior periods to later periods, and the analysis of the mediated effects of Faith mindset on COVID-19 concern via science mindset, provide converging evidence consistent with the path model structure shown in Fig. 4.

However, we acknowledge that the final structural model specified in Fig. 4 can only represent an approximation of reality because it is not possible for the fit of such a model to "prove," for example, that a faith mindset influences a science mindset; nor that a science mindset elevates COVID-19 concern. There are undoubtedly many other factors and confounding variables not accounted for in our final model. While the longitudinal nature of our study allows us to establish the temporal precedence required for causality, because this was not a true randomized experiment our conclusions about causality require further research. Additional studies, including randomized experiments, are needed to investigate further the isolated effects for each of our model variables.

4. Discussion

The worldwide threat of the COVID-19 pandemic has created social and psychological dilemmas that people must solve in order to survive and flourish (Van Bavel et al., 2020). The purpose of the present research was to investigate whether people turn to their science and faith mindsets in the face of COVID-19 concern and/or whether science and faith mindsets affect the level of concern that people have about COVID-19. To that end, we asked participants to rate the extent to which they believed that science and faith in God were generally valuable for providing information, explaining reality, solving humanity's problems, and bringing good things to life (Kitchens & Phillips, 2018). We had expected that concern about the pandemic would increase both a science mindset (see also Luna, Bering, & Halberstadt, 2021) and a faith mindset, mediated by two related fundamental motivations, disease avoidance and self-protection. Specifically, we reasoned that the activation of disease avoidance would lead people toward science in a search for preventative health practices, treatments, or cures, whereas self-protection would lead people to turn to faith in God in search of protection and comfort.

We also acknowledged the possibility of an alternative model whereby science and faith affected perceptions of COVID-19 concern (i.e., science and faith mindsets functioned as interpretive frameworks or meaning-making systems (Park, 2005). Specifically, reliance on science may have increased concern about the disease, whereas faith in God may have reduced COVID-19 concern. As in our hypothesized model, COVID-19 concern was, in turn, expected to activate the fundamental motivations of disease avoidance and self-protection. In analyses of data collected from three surveys administered in March, April, and June of 2020, we found that this alternative model provided a better explanation for the changes we observed in the five model variables. That is to say that science mindset predicted COVID concern.

Analysis by religious groups showed a small but significant increase in a science mindset in the early months of the pandemic. Indeed, in a subsample of participants with pre-test scores for interest in science, we found that interest in science had also increased as our study began (see Supplemental Materials). A likely explanation is that when people (at least people living in the U.S. in the 21st century) are exposed to pathogen threat, they are likely to first look to science for practical and accurate information about the disease, available treatments, and potential cures.1 Consistent with the interpretative framework model, we found that people who looked to science for information and understanding were subsequently more likely to have elevated COVID-19 concerns.

However, the results of our naturalistic, longitudinal study were somewhat more complicated than either model would have predicted in terms of a faith mindset. First, we had not expected faith to decline (across all religious groups), which contrasts with other studies showing that self-reports of faith increased during the pandemic (Gecewicz, 2020). A post hoc examination of pre-test scores available for a subsample of participants revealed that scores for belief in a loving God (a proxy for our measure of faith) were also higher before our study began (see Supplemental Materials). Thus, the decline in faith from April to June in the present research may simply reflect a more general decline in religiosity that was already occurring before the pandemic began (Cooperman, Funk, & Smith, 2019; Pew Research Center, 2015b).

Another possibility for the decline in faith mindset is that, as the pandemic worsened, people found this interpretative framework less helpful in coping with their circumstances; when religion is no longer helpful or salient, faith wanes in importance (Krause & Pargament,

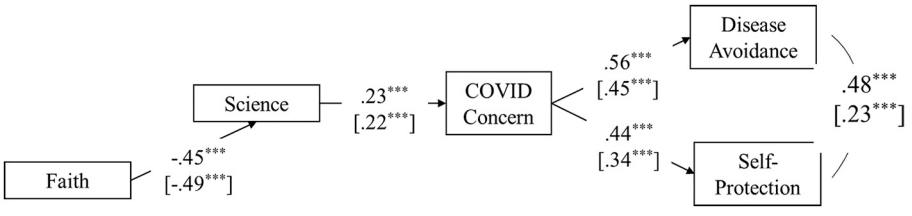

Fig. 4. Standardized path coefficients for the final path model at T2 [T3].
Notes: Coefficients for the associations between variables at T2 are shown without brackets; coefficients for the associations between variables at T3 are shown in [brackets]. Scores at T2 [T3] for all variables were also regressed on age and political conservatism as control variables, not shown in the diagram. $^{***}p \leq .001$, $^{**}p \leq .01$, $^{*}p \leq .05$.

2017). It is also possible that there may have been some level of dissatisfaction with U.S. religious leaders' response in addressing the threat of COVID-19, which included the cessation of religious services during the early months of the pandemic or, in some cases, downplaying the severity of the pandemic. More research is needed to investigate whether faith continued to decline during the pandemic or whether faith returned to pre-lockdown levels once religious services resumed.

4.1. Faith and science

An additional, unexpected finding was the strength of the negative correlation between science and faith mindsets ($r = -0.61$ at T1). This is surprising in light of previous research showing that scientific and religious explanations are often seen as complementary (Ecklund et al., 2011; Legare et al., 2012; Pew Research Center, 2015a), orthogonal (Jackson et al., 2020), or in many ways overlapping (Watts et al., 2020). There are several possible explanations and important implications. First, the larger than expected negative association may be attributable to the religious composition of our sample. Our participants were Mechanical Turk workers who had completed prior studies for our lab. Although MTurk samples are similar to other more representative samples in the U.S. in terms of most demographic variables, MTurk workers are, on average, less religious (Lewis, Djupe, Mockabee, & Su-Ya Wu, 2015). We had accounted for this in previous research by using quotas to limit the number of non-religious participants. However, the present study included 34% non-religious compared with 23% in the U.S. population (Pew Research Center, 2015b). Therefore, the negative association between science and faith mindsets may not generalize to a more religiously representative sample.

Second, we demonstrated that the measure we used (Kitchens & Phillips, 2018) to assess science and faith as distinct mindsets or meaning-making systems is reliable and valid. However, the items are presented together in one questionnaire and may invoke perceptions of science and faith as conflicting. Although religious individuals are often able to reconcile scientific and religious beliefs (Ecklund et al., 2011; Evans & Evans, 2008; Longest & Smith, 2011), there is some evidence that many people think of science and faith as in automatic opposition (McPhetres & Zuckerman, 2018; Preston & Epley, 2009; Preston, Ritter, & Hepler, 2013) and our measure may have activated these beliefs resulting in an unusually high negative correlation.

We note that the increase in a science mindset was significant but with a small effect size. Given the negative correlation between science and faith mindsets, one interpretation is that faith may have suppressed what would have been even more significant increases in reliance on science. We can speculate that to sustain the sense of well-being and a strong belief in a loving God, theists were (and possibly are) less inclined to seek out or accommodate negative information about the pandemic as a form of worldview defense. This would be consistent with previous research showing that people often reject information that would challenge their worldview (Lewandowsky & Oberauer, 2016; Preston & Epley, 2009).

Another explanation is that the pandemic led to or exacerbated religious struggles. Most people represent God as benevolent (Johnson et al., 2019), yet experiencing adverse events can lead to views of God as distant or punishing accompanied by the distress of religious struggles (Aten et al., 2008; Krause & Pargament, 2017; Wilt, Exline, Grubbs, Park, & Pargament, 2016). Again, when faith fails to provide comfort and God seems distant, people may focus on other beliefs, belief systems, or ideologies to make sense of the world's events. However, another, perhaps more likely, explanation for the small changes in science and faith mindsets is that both belief systems are accessible and relatively stable across short periods of time.

4.2. Fundamental motives

Consistent with our hypotheses, COVID-19 concern led to significant increases in disease avoidance and self-protection (see also Makhanova & Shepherd, 2020; Olivera-La Rosa et al., 2020). The activation of these motivations is likely to influence intrapersonal, interpersonal, and societal outcomes not examined here. For example, social upheaval has been shown to activate apocalyptic perspectives (Dein & Littlewood, 2005).

Moreover, perceived vulnerability to disease is associated with changes in ethnocentric attitudes, sociosexuality, and personality traits such as extraversion and openness to experience (Fincher et al., 2008; Park et al., 2003; Schaller & Murray, 2008). Additionally, when self-protection motives are high, outgroup members are likely to be viewed as potential threats, and aggression is expected to increase as an evolved response to perceived threats (Doty, Peterson, & Winter, 1991; McCann, 1999; Schaller & Neuberg, 2008). More research is needed to assess what may be the short- and longer-term effects of COVID-19 concern and future pandemics due to increases in disease avoidance and self-protection motivations.

4.3. Limitations

In addition to the limitations previously discussed regarding MTurk samples and the need for additional randomized experiments, there are several other noteworthy limitations. First, we assessed changes in the variables within three months. We may have found stronger (or weaker) effects with a longer lag time. Additionally, there are surely other motivations, individual experiences, moderating traits, cultural norms, and historical trends that influence whether individuals and groups find science and/or faith more (or less) relevant in making sense of the world and life events. For example, theologian and scientist Ian Barbour (1998) has posited that individualism and self-reliance contributed to the scientific revolution in the 17th century. Today, the increased social isolation during the pandemic may have made science more appealing as an interpretative framework for self-reliant people.

Secondly, despite the seemingly hydraulic effects of faith and science that we found in the current study during the early months of the pandemic, others have found more complementary relationships between science and faith historically (Barbour, 1998), currently among scientists (Ecklund et al., 2011), among the clergy (Colburn & Henriques, 2006), and in the general population (Pew Research Center, 2015a). Both science and faith in God can provide explanations, a sense of control, and meaning—although perhaps in different ways (Rutjens & Preston, 2020). Like the two rails required for a train track, it may be that a balance of science and faith is most advantageous for navigating ecological threats and the vicissitudes of life. Future research should continue to test hydraulic versus complementary models of science and faith mindsets by examining how perceptions about the relationship between science and faith might influence people's willingness to draw on both sources for comfort, care, and control.

Nevertheless, pathogen prevalence may pose a unique kind of threat that leads people to turn toward scientific thinking in a search for very practical solutions and medical innovations (Rutjens et al., 2013). We note that, during the pandemic, science information was readily available, and the need to "follow the science" to find practical solutions was often mentioned. The news media regularly presented statistics, symptoms, mortality rates, discussions of possible treatment options, images of hospital settings, and reports of a search for a cure. In contrast, religious groups generally ceased gatherings, perhaps contributing little to the conversation. COVID-19 was novel, the origins were unknown, and there is limited information for fighting pandemics provided by sacred writings or religious leaders. Thus, the salience and availability of scientific information in U.S. culture, coupled with the lack of religious information relevant to the pandemic, may have created unique circumstances explaining our findings.

A further limitation in the present study is that we have not accounted for the effects of scientific misinformation as scientists learned more (e.g., the efficacy of medical face masks or ventilators) or

contradicted one another (e.g., the efficacy of hydroxychloroquine), or as people produced scientific-sounding misinformation (e.g., links between COVID-19 and 5G technology) (Gregory & Mcdonald, 2020). Perceptions of misinformation may have undermined reliance on science, thus dampening the turn to science for guidance and effective treatments.

Finally, "science" is a very broad term encompassing a wide range of interests, concerns, and methodologies. It may be that people are quite likely to endorse medical science—possibly even more so during a pandemic—but still reticent to accept other scientific theories or endeavors. For instance, research shows that religious people are generally knowledgeable about and open to scientific information but reject evolutionary theory or anthropogenic explanations of climate change (Pew Research Center, 2015a). Thus, the broad claim that a science mindset was more salient or increased at the expense of faith should be interpreted with caution as this result may be due to the interpretation of the term "science" in our study or (to some extent) the over-inclusion of non-religious individuals in the MTurk sample, and the cultural and political context in the U.S.

Similarly, we have limited our focus to faith in God, but religion is a multidimensional construct that entails social norms, practices, communities, etc. (Saroglou et al., 2020). More research is needed to investigate how the perceptions of the pandemic may have influenced, or been influenced by, other dimensions of religion or other beliefs about the divine. For example, faith in God may depend on individual differences in beliefs about God's attributes or God's engagement in the world (Kay, Gaucher, Napier, Callan, & Laurin, 2008).

5. Conclusion

The COVID-19 pandemic is a worldwide threat that has spawned social dilemmas requiring everyone's coordination and cooperation (Johnson, Dawes, Fowler, & Smirnov, 2020). To solve health concerns, people must have access to accurate medical and scientific information. We found that, to the extent that people looked to science as a meaning-making system or mindset, concern about COVID-19 increased significantly with corresponding increases in disease avoidance and self-protection motives.

We also found that faith as a meaning-making system—a system of beliefs also helpful in understanding events in the world and finding solutions to problems—had often decreased for theists and non-theists alike. It remains to be seen whether this trend will continue and what effect a decline of faith might have on society or on individuals' future subjective well-being.

Today, there is still some disagreement about best medical practices, the social situation remains fluid, and the SARS-CoV-19 virus continues to flourish and mutate. We hope our findings might help guide future research and public policy-making as we wind our way, as a nation and as a global community, in overcoming the novel coronavirus.

Open practices

The longitudinal study in this article earned Open Materials and Open Data badges for transparent practices. Materials and data are available at https://osf.io/ q4rau.

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Appendix A. Supplementary Materials

Supplementary information for this article can be found online at https://doi.org/10.1016/j.jesp.2021.104186.

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