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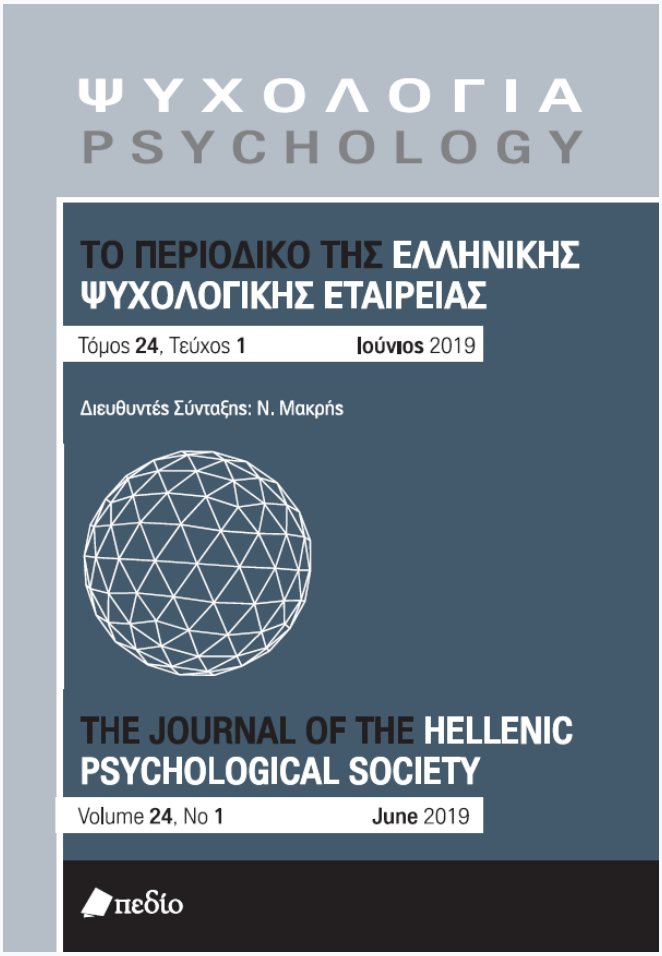

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The explanatory coexistence of scientific and supernatural explanations: A meta-analysis

Dimitris Pnevmatikos[1] & Triantafyllia Georgiadou[1]

ABSTRACT

The explanatory coexistence of scientific and supernatural explanations in the same mind challenges the most influential theories of knowledge acquisition in psychology. Namely, although individuals acquire the scientific theories, the supernatural explanations are also used as causal explanatory frameworks even by experts. The present review and meta-analysis aimed to explore the factors that could influence the coexistence of supernatural and scientific explanatory frameworks regarding the concepts of the origins of life, illness, and death/afterlife. On the basis of 35 identified articles (45 studies) which have been published between 1985 and 2016 and examined both scientific and supernatural explanations within these concepts, the impact of age, religiousness, scientific expertise, cultural background, and contextual factors was explored. Results suggest that although religiousness, cultural background, and contextual information have a large effect on the concepts of death/afterlife, illness, and the origins of life respectively, the magnitude of the average effect depends on the concept.

Keywords: explanatory coexistence; the concept of illness; origins of life; the afterlife

Introduction

There is an increased amount of evidence suggesting that when individuals acquire scientific concepts, they do not abandon the previous, based on their everyday experience, non-scientific explanations. Several studies showed that students make more errors and spend more time to make inferences when the stimuli express a misconception that is compatible rather than incongruent with their everyday experience (Babai & Amsterdamer, 2008; Babai, Sekal, & Stavy, 2010; DeWolf & Vosniadou, 2015; Potvin, Masson, Lafortune, & Cyr, 2015; Vosniadou, Pnevmantikos, Makris, Ikospentaki, Lepenioti, Chountala, & Kyrianakis, 2015, 2018; Vosniadou, Pnevmantikos, & Makris, 2018). Moreover, students make more errors and spend more time to verify scientific concepts when the latter are inconsistent rather than consistent with their initially acquired non-scientific theories (Shtulman & Valcarcel, 2012; Vosniadou *et al*., 2015, 2018). Other reaction time studies showed that, under time pressure, even experts in a domain are likely to endorse teleological (Kelemen, Rottman, & Seston, 2013)

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or animistic (Goldberg & Thompson-Schill, 2009) explanations of phenomena. This evidence has been interpreted as an indication that, after the acquisition of scientific concepts, the initially acquired non-scientific explanations of phenomena are not replaced by the scientific ones (Carey, 2000) but they coexist with the scientific explanations, interfering with them (Vosniadou *et al*., 2015, 2018; Vosniadou et al., 2018).

Scholars in the field explicitly use the term "explanatory coexistence" to describe the phenomenon of the maintenance of the non-scientific explanations that individuals construct on the basis of everyday experience, after they are confronted with the scientific explanations for the same phenomenon (e.g., Shtulman & Valcarcel 2012). It is expected that understanding coexistence of, usually, mutually exclusive explanations for the same phenomenon on the individuals' mind, could offer a new standpoint on how humans represent knowledge with critical consequences on educational interventions.

Many non-scientific explanations are based on a variety of supernatural explanations. Supernatural explanations are those offered by religion, divination, and witchcraft, and appeal to causes that "violate, operate outside of, or are distinct from the realm of the natural world or known natural law" (Legare, Evans, Rosengren, & Harris, 2012, p. 780). Scholars avoid judging the "empirical and objective accuracy" of the supernatural explanations (Watson-Jones, Busch, & Legare 2015, p. 2), perceiving them as a developmental achievement rather than as an artifact (Legare & Shtulman, 2018). The supernatural explanations are more resilient than other non-scientific explanations in society, and thus have attracted research interest.

In order to develop new instructional designs and interventions, it is critical to understand better whether some explanations are more sensitive to the phenomenon of explanatory coexistence than others and to know the possible factors that might affect the phenomenon. However, there is no systematic meta-analysis of the phenomenon, and the potential factors that might influence the coexistence of supernatural and scientific explanations in the same mind have not yet been systematically discussed. Furthermore, up to date, studies providing evidence on explanatory coexistence have not aimed at exploring coexistence *per se*. Thus, explanatory coexistence has been as yet discussed mainly on a theoretical level, as an attempt to interpret empirical evidence. Systematic documentation of the explanatory coexistence of scientific and supernatural explanations would facilitate our understanding of the phenomenon (e.g., scholars in the future should consider explanatory coexistence as an important psychological variable providing explicit evidence), and would open the discussion for new instructional approaches (Shtulman, 2013).

The present review and meta-analysis is an attempt to explore explanatory coexistence in a more systematic and thorough way. We focus on the coexistence of scientific and supernatural explanations for the concepts of origins of life, death/afterlife, and health/illness, and we examine various factors that are likely to influence coexistence: age, religiousness, cultural background, scientific expertise, and context. These three concepts have been studied enough in the past as an integral part of the cross-culturally widespread *vitalist* biology (see Carey, Zaitchik, & Bascandziev, 2015). Moreover, our knowledge for the coexistence of the supernatural explanations for certain existential phenomena, such as the origin of life, illness, death, and immortality, in parallel to the scientific ones is so far more rich than in other domains. Questions regarding human existence provide an optimal framework in order to investigate explanatory coexistence. Both scientific theories and religion are considered coherent frameworks that explain the origins and the end of life.

Theoretical challenges of the coexistence of supernatural and scientific explanations

The coexistence of scientific and supernatural explanations challenges the well-established and underlying idea in developmental research that the Western-educated adults' rational mind is the endpoint of development and that the Western child is psychologically closer to the "primitive" adult (see

Baldwin, 1967). For instance, Piaget (1928/2009) argued that egocentrism, animism, and magic –the dominant ways of young children's thinking– are *replaced* by logical and rational thinking, which is characterized by the ability to think abstractly and hypothetically. Similarly, theory-theory scholars, who explain the development in terms of "framework theories", suggested the discontinuity and qualitative differences at the representational level between children's "intuitive theories" and scientists' rational theories with overlapping content (e.g., Carey, 1985; Carey *et al.*, 2015). The new representational resources permit thoughts previously unthinkable (Carey *et al.*, 2015).

The existence of contradictory beliefs (P & not-P) in the mind of the same adult is considered to be irrational because it violates the principle which Ohlsson (2013) described as 'belief - belief conflict'. It was expected that when children can think rationally, and/or are informed about scientific theories, they tend to abandon naïve explanations formulated by their everyday experience and no longer use them to explain these phenomena. This claim, however, reflects the idea of *how the world should be*, disregarding that psychology, as a *descriptive* science, provides accounts of *reality as it is* (for further discussion see Ohlsson, 2013). Thus, although anthropological research has shown that magical and non-scientific irrational explanations – mainly for the concepts of the origins of life, death, and health or illness– are widespread among adult population in both contemporary Eastern and Western societies, psychologists defied the persistence of non-scientific explanations, avoiding to ask questions about the reasons for their existence in the individual's mind. They usually attributed their existence to specific populations who adopted childlike causality (Piaget, 1928/2009).

However, recent evidence has shown that the endorsement of non-scientific beliefs in adulthood could not be attributed to the lack of scientific knowledge and, hence, non-scientific explanations can no longer be considered as "primitive or immature ways of thinking that are suppressed over the course of development" (Gelman & Legare, 2011, p. 399; Legare *et al.*, 2012, p. 781). Research so far has shown that educated adults recruit the scientific and supernatural explanation frameworks to interpret the same phenomenon (Evans, Legare, & Rosengren, 2011; Legare *et al.*, 2012). Moreover, recent research has shown that children are more skeptical of some non-scientific explanations than adults (see Woolley & Ghossainy, 2013).

The coexistence of scientific and supernatural frameworks raises important questions for future research. First, the systematic coexistence of both scientific and supernatural frameworks should be established. Studies have found that a certain percentage of participants use both causal frameworks in their explanations. However, without a systematic review of the studies that investigate the explanations, individuals endorse for these concepts, the systematic appearance of explanatory coexistence could not be claimed. Secondly, it would be interesting to examine whether the explanatory coexistence differs within the various concepts, or whether the same mechanisms support coexistence in different concepts. Thirdly, it would be important to investigate the factors that impact the existence and parallel use of two different and mutually exclusive frameworks. Knowing the factors that influence the persistence of the non-scientific explanatory frameworks might explain the student's resistance to accepting and using certain scientific theories. Finally, the idea that scientific theories do not always replace prior supernatural theories, but in some cases, these theories coexist with the acquired scientific explanations, could have practical educational implications. The possible systematic coexistence of scientific and supernatural explanatory frameworks might be an indication that the acquisition of scientific knowledge does not always ensure its use in everyday life problems.

Evidence for the coexistence of scientific and supernatural explanations

The first systematic attempts of human beings trying to give answers to matters of life, death, and illness or health, created explanatory frameworks related to magic and later to religion. Thus, anthropological evidence systematically shows that the

answers which individuals in different societies at the same time provide to questions about life and death (illness is included as causing death) are usually embedded in their religious beliefs (e.g., Shweder, Much, Mahapatra, & Park, 1997). Current psychological evidence shows that individuals in modern societies, even after systematic instruction and familiarization with scientific explanations, continue to endorse religious and eventually magical explanations in their everyday life in order to answer these questions.

Origins of life. Studies that investigated the acceptance of the theory of evolution found that some participants provide both scientific and religious-biblical explanations. The coexistence of both explanatory frameworks has been evidenced both in children and adults, either from religious or non-religious backgrounds (Evans, 2001). An interesting finding is that the integration of the two explanatory frameworks is evident even among the biology experts (Mansour, 2011). This finding provides strong support for the idea that the coexistence of scientific and supernatural explanations among adults could not be explained as a lack or misunderstanding of scientific knowledge.

Illness. Evidence for the coexistence of two explanatory frameworks can also be found in the studies that explored beliefs about illness, namely, the causes of illness and recovery from it. Individuals tend to endorse both biological and supernatural explanations in order to justify a life-threatening condition (e.g., AIDS; Legare & Gelman, 2008), as well as the common flu (Legare & Gelman, 2008). For example, Legare and Gelman (2008) showed that the majority (93%) of children, adolescents, and adults from Sesotho-speaking South African communities, where Western biomedical and traditional healing frameworks were both available, justified the causes of common illness and AIDS by using both biological and bewitchment explanations at least once. The explanatory coexistence is more prevalent in adults than in children and adolescents (Legare & Gelman, 2008), suggesting, again, that the explanatory coexistence could not be attributed to the lack of scientific knowledge. However, children and adults are likely to endorse prayer as an effective practice to recover from a common illness (Pnevmatikos, 2014), while fundamentalist religious groups perceive prayer as the most effective treatment for illness (Vess, Arndt, Cox, Routledge, & Goldenberg, 2009).

Death-afterlife. The question of death and whether death is the end of our existence is another important conceptual framework. Current developmental evidence indicates that children younger than 10 understand the irreversibility of death and that all functions cease with human death. However, older children and adults claim that although life ends with death, at the same time specific capacities (e.g., emotions) continue to function after death (Harris & Giménez, 2005). The same developmental pattern has been found in different countries and different cultural and religious groups (Astuti & Harris, 2008; Gutiterrez, Rosengren, & Miller, 2014; Watson-Jones *et al.*, 2015).

Factors influencing explanatory coexistence. Research has also addressed some influential factors that might affect the explanatory coexistence of these three concepts. Additionally to the changes one could expect due to development (Legare & Gelman, 2008), other factors that have been examined are cultural and/or religious background (e.g., Legare *et al.*, 2012), individuals' scientific expertise (e.g., Poling & Evans 2004a, 2004b) and, finally, contextual influences (e.g., Harris & Giménez, 2005). Thus, in the following meta-analysis, we focused on the role of these factors in the coexistence of scientific and supernatural explanations.

Meta-analysis of factors influencing coexistence

Research questions

Based on the theoretical considerations discussed above, it is plausible to claim that the explanatory coexistence of supernatural and scientific beliefs is an existing phenomenon that needs further attention. In the present meta-analysis we addressed the following questions:

1. To what extent do age, religiousness, culture, scientific expertise, and contextual information have an impact on the coexistence of explanatory frameworks concerning the origins of life, illness and death, and how large are the effect sizes?
2. Do the effect sizes of the independent variables differ regarding the concept examined?

Literature Search

We conducted a computerized literature search in the following databases: The Web of Science, Scopus, PsycINFO, ScienceDirect, The Education Resources Information Center (ERIC) and PubMed. Additional research was conducted using Google Scholar.

The exact search terms were: "natural OR biological AND explanations OR reasoning OR justifications AND supernatural OR religious AND explanations OR reasoning OR justifications". The term "beliefs" was excluded from the search terms, due to the enormous number of articles and the great range of subjects that examine and thus include the term "religious beliefs". Finally, the reference list of every identified study was examined, as well as relevant articles that we were aware of.

The literature search focused on studies that (1) were written in English; (2) appeared in published article form in peer-reviewed journals from January, 1st, 1985 (the year that the pioneering book of Susan Carey was published) to December, 31st, 2016; (3) examined and provided results on both scientific and supernatural explanations for the same population for at least one of the three concepts, namely the origins of life, illness, and death/afterlife; and (4) provided information concerning the reliability of the measures used. The initial search identified 2,481 records, which were reduced to 2,074 after removing the duplicates. After the first screening, 182 articles were assessed for eligibility on the basis of the above four criteria. After the first screening, a second researcher screened 10% of the eligible as well as the excluded articles. The two researchers agreed in 97% of the assessments. Moreover, as we were interested in examining the explanatory coexistence in typically developing individuals, studies that examined causal explanations in specific populations (such as the clergy, patients with severe physical or mental conditions, or bereaved parents) were excluded. For example, we did not include studies that had explored scientific and supernatural explanations of illness exclusively in cancer patients or cancer survivors, because the explanations that participants provided were considered as part of coping with illness and of attributing meaning to their experiences.

After the removal of 131 articles that examined causal reasoning in specific populations, we ended up with 51 articles that provided evidence for the typically developing individuals. Sixteen of these articles could not be used in the meta-analysis because either the data were incomplete or they did not provide quantitative data, focusing instead on qualitative differences in participants' explanations. Nevertheless, these 16 articles provide some important descriptive information concerning the explanatory coexistence and, thus, we included this information in our review and concluding remarks (information for these studies are provided as Supplemental Material). Therefore, the current meta-analysis was based on the remaining 35 articles. Multiple studies that were combined into a single article were coded and analyzed separately, and only the studies that could provide utilizable data were used in the meta-analysis. Consequently, data from 45 different studies (recruited from 35 articles) were used to extract effect sizes (see Figure 1). A detailed description of each study is available in Appendixes 1, 2 and 3.

Recorded variables

The present review was based on the PRISMA statement for reporting systematic reviews and meta-analysis (Liberati *et al.*, 2009). The following information was recorded: (1) publication information (author(s), title, publication year, the focus of the study), (2) number of participants (overall or in comparison groups), (3) mean age of participants and/or educational level, (4) religion or religious affiliation, (5) cultural background information, (6) participants' scientific expertise, and (7) effect sizes

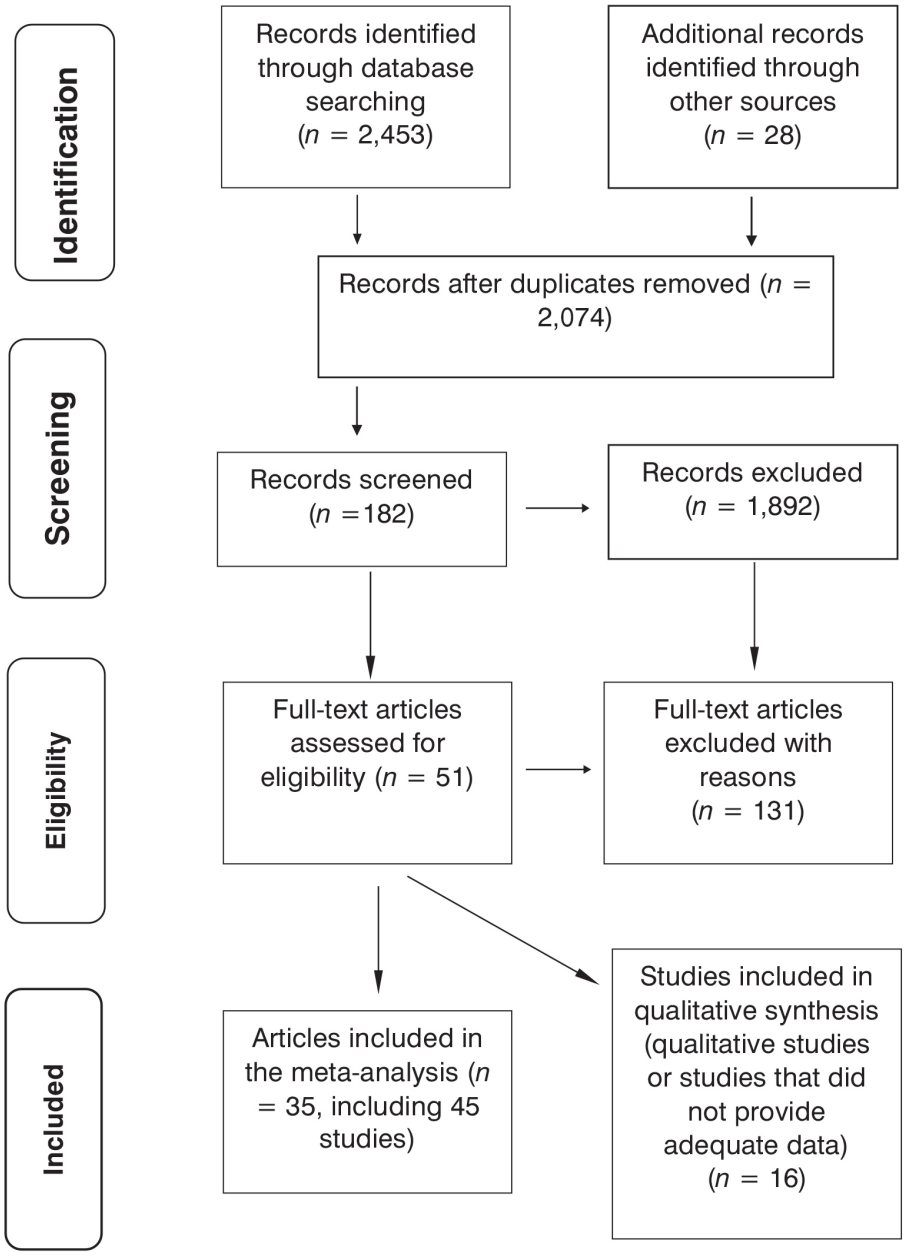

Figure 1. Studies' selection process.

or all the statistical measures that could permit the computation of effect sizes. A second researcher also coded 20% of the articles. The two researchers agreed in 91% of the coding, which was raised to 100% after discussion.

Independent Variables. Age, religiousness, scientific expertise, cultural background, and contextual information were the five independent variables examined in the present meta-analysis. More specifically, out of the 45 studies that were included in the meta-analysis, 18 provided data concerning developmental differences in the endorsement of both explanatory frameworks. The existence of supernatural explanations after the exposure to systematic instruction during childhood and the developmental milestone for the acquisition of the scientific explanatory frameworks for death (i.e., the biological concept of death), illness (i.e., the biological concept of illness), and origins of life (i.e., the theory of evolution) were also accounted as evidence for explanatory coexistence. The role of religiosity was examined in 12 studies. Religiosity was examined either by recruiting religious and non-religious participants or participants from different religious groups (e.g., Christians vs. Buddhists) or by assessing through questionnaires the perceived religiousness of the participants. The influence of scientific expertise was considered in seven studies, mainly by including scientists (e.g., biologists, science teachers, doctors) or students in the study's sample. Cross-cultural differences, as well as the influence of immediate cultural background (i.e., family), were examined in 11 out of the 45 studies. Finally, the fluctuations in explanatory coexistence as a result of the questions that were addressed or/and the influence of other contextual information were examined in 12 out of the 45 studies.

Dependent Variable. As mentioned above, no study so far has examined explanatory coexistence per se. Explanatory coexistence is evidenced when participants use both explanatory frameworks to explain a phenomenon. The dependent variable (the explanatory coexistence) was examined separately for the three topics included in the meta-analysis (origins of life, illness, death/afterlife). More specifically, causal explanations about the origins of life were explored in nine studies, 16 studies examined beliefs about illness, whereas 20 studies explored beliefs about death/afterlife. Regarding the concept of death and afterlife, apart from the studies that explored the biological concept of death, studies that examined the functionality of various human capacities after death or even before biological conception were included in the review. In addition, studies that examined the properties of human mind, brain, and soul –as these provide information for the continuity of some capacities attributed to mind or soul after death or before biological conception– were also included.

Effect sizes calculation. We calculated effect sizes of the independent variables on coexistence using Hedges' *g* (Hedges & Olkin, 1985). Hedge's *g* is a variation of Cohen's *d* (Cohen, 1988) which corrects small sample size biases and, thus, is considered an unbiased estimator. When means and standard deviations were not provided, we used estimation procedures recommended by Friedman (1982), Wolf (1986), as well as Peterson and Brown (2005). One single effect size per study was calculated for each one of the independent variables, and, finally, the average *g* was calculated. The magnitude of Cohen's *d* may also be used for Hedge's *g* interpretation.

Results

The influence of age, religion, culture, scientific expertise and context on explanatory coexistence

The results of the present meta-analysis (see Table 1) indicate that all independent variables examined have an impact on explanatory coexistence. Whereas, in some cases, confidence intervals (C.I.) overlap, we discuss the findings based on the average *g*, as an indication of the effect which each independent variable has on coexistence. Below, the explanatory coexistence will be discussed separately for each of the three concepts.

Table 1
Mean effect sizes and 95% confidence intervals for age, religion, culture, scientific expertise and context in explanatory coexistence

Study's concept	*Independent Variables*	Number of studies	Hedge's *g**	95% CI	*z*-value	*p*-value
Origins of life						
	Age	3	0.63	[0.14-1.43]	5.71	.05
	Religion	4	0.43	[0.24-0.62]	3.76	.05
	Culture	2	0.40	[0.20-0.60]	2.85	.05
	Scientific expertise	6	-0.36	[-0.60-0.12]	10.41	.05
	Contextual information	1	0.96	[0.77-1.14]	7.32	.05
Health/Illness						
	Age	4	0.79	[0.57-1.00]	12.07	.05
	Religion	4	0.63	[0.55-0.71]	10.89	.05
	Culture	7	0.71	[0.66-0.76]	13.00	.05
	Scientific expertise	-	-	-	-	-
	Contextual information	2	0.76	[0.53-0.99]	4.61	.05
Death/afterlife						
	Age	11	0.48	[0.40-0.56]	9.13	.05
	Religion	4	0.94	[0.87-1.01]	12.88	.05
	Culture	2	0.30	[0.14-0.47]	2.66	.05
	Scientific expertise	1	-0.48	[-0.73-0.23]	2.53	.05
	Contextual information	11	0.56	[0.52-0.60]	8.54	.05

Note. *g effects: small ≥ .20, medium ≥ .50, large ≥ .80 (Cohen, 1988).

Age. Age was found to have a small effect size on coexistence concerning death/afterlife (g = 0.48, 95% C.I. = 0.40-0.56) and a moderate effect size for origins of life (g = 0.63, C.I. = 0.14-1.43), and illness (g = 0.79, C.I. = 0.57-1.00). The developmental pattern shows that explanatory coexistence for death/afterlife (e.g., Bering & Bjorklund, 2004), origins of life (e.g., Evans, 2000, 2001), and illness (e.g., Legare & Gelman, 2008) emerges during late childhood and in most cases increases during adulthood. The small effect sizes for death/afterlife indicate the small progressive

change of explanatory coexistence in the adult population since its first appearance. This finding indicates that supernatural explanatory frameworks emerge during late childhood, after the acquisition of scientific explanations. Therefore, their existence could not be attributed to the lack of scientific explanations, but rather to socio-cultural norms. The prominent supernatural explanations in a given society are more likely to remain active in the adult population. Indeed, for illness, the developmental pattern differs among cultures (Legare & Gelman, 2008; Raman & Gelman, 2004). For example, Raman and Gelman (2004) found that, although both Indian and American participants endorsed multiple causes of illness, the number and type of explanations differed across development between the two cultures. Nevertheless, when society does support supernatural beliefs, these are more likely to be evident among adults. Although the power of prayer to facilitate recovery from illness is evident from childhood to adulthood, its endorsement was more common among children than among young educated adults (Pnevmatikos, 2014).

Similarly, for the origins of life, the developmental pattern differs across cultures, but the type of formal education moderates this difference. More specifically, although in some societies adults are more likely than children to endorse the theory of Evolution, in cultures that are not familiar through formal education with the theory, a shift in beliefs could not be evidenced at all (Busch, Watson-Jones, & Legare, 2016). Thus, the existing evidence suggests that for the coexistence of scientific and supernatural beliefs there is a need for support from both formal education and society.

Therefore, supernatural explanations emerge during late childhood, and since then, the two explanatory frameworks coexist whereas the fluctuations found during the lifespan concern only a small size of the population (as the effect size indicates), and when this is greater (e.g., in the cases of illness and origins of life), it is due to education or cultural upbringing.

Religion. Although religion was found responsible for individual differences in the explanatory coexistence within all three concepts, its effect size is greater for the concept of death/afterlife (g = 0.94, 95% C.I. = 0.87-1.01), and illness (g = 0.63, 95% C.I. = 0.55-0.71), than for the origins of life (g = 0.43, 95% C.I. = 0.24-0.62). Although the reference to the continuity of some functions after death is usual even among non-believers (Bering, 2002), children from religious schools and religious families refer more to religious explanations about afterlife than children from secular schools and non-religious families (Bering, Blasi, & Bjorklund, 2005; Rosengren, Gutierrez, & Schein, 2014b). Additionally, although it is expected from adults to have acquired the biological concept of illness, religious fundamentalists were found to perceive prayer as a more effective treatment for an illness than medicine, and they were more likely to rely only on faith to treat illness (Vess *et al.*, 2009). Concerning the origins of life, relevant qualitative studies indicate that the religious participants refer more to supernatural-religious explanations about the origins of life, while those who conflict (e.g., religious scientists) may try to reconcile the scientific and the religious explanation (Winslow, Staver, & Scharmann, 2011). In other words, religion is responsible for the individual differences in explanatory coexistence mainly for the concepts of death/afterlife and the recovery from illness (but not for the causes of illness). These are the issues in which religion might moderate psychological pain that presuppose a kind of punishment from a supernatural agent.

Scientific expertise. Scientific expertise had a close to medium negative effect size (g = -0.48, 95% C.I. = 0.23-0.73) for the beliefs about afterlife. As expected, scientific experts (biology experts 76% and medical students 56%) use in their discourse scientific terms, such as decomposition, more frequently than lay adults (3%). Nevertheless, they engage in some spiritual discourse which is more evident among the biology students (biology experts 3% and biology students 26%) (Polling & Evans, 2004b). On the other hand, the small negative effect size (g = -0.36, 95% C.I. = -0.60-0.12) of scientific expertise for explanatory coexistence regarding origins of life resulted from alternative explanations for evolution among the majority (73%)

of undergraduate biology students (Opfer, Nehm, & Ham, 2012). Finally, none of the studies about illness included in this literature search provided sufficient information to calculate the effect size of scientific expertise on explanatory coexistence.

Culture. The studies which have been included in the present meta-analysis indicate that explanatory coexistence for illness might be culturally moderated (g = 0.71, 95% C.I. = 0.66-0.76), whereas the effect sizes for the origins of life (g = 0.40, 95% C.I. = 0.20-0.60), and for death/afterlife (g = 0.30, 95% C.I. = 0.14-0.47) are small. Indeed, the developmental pattern of explanatory coexistence concerning death/afterlife is replicated in different countries and cultural groups (Astuti & Harris 2008; Gutiterrez *et al.*, 2014; Watson-Jones *et al.*, 2015), whereas the preliminary results of a qualitative study that was conducted in Tana, Vanuatu showed that none of the participants provided evidence of explanatory coexistence concerning the origins of life (Watson-Jones *et al.*, 2015). However, the majority of these participants did not report any formal education. Hence, the explanatory coexistence is a phenomenon that presupposes the systematic instruction of scientific explanations. However, studies that examined cross-cultural differences in the beliefs about illness indicated that (whereas the biological explanation is dominant across cultures), the explanatory coexistence of scientific and supernatural beliefs may differ between the various cultural groups (Nguyen & Rosengren, 2004). Cross-cultural differences are greater between geographically distant cultures than in nearby cultures (Raman & Gelman, 2004).

Another aspect of culture, that is, the immediate cultural background (e.g., family), has also been found responsible for individual differences in explanatory coexistence, with small effect size. Preadolescents tend to agree with their mothers' and their communities' beliefs when they include the issue of evolution (Evans, 2001), whereas Christian biology students report conflicts with their religious families in their attempt to talk about evolution (Winslow *et al.*, 2011). In other words, if the family does not endorse the evolution theory, individuals –at least in some contexts– use supernatural explanations to avoid conflicts with their immediate environment.

Contextual Information. Studies included in the present review also highlighted the contribution of contextual information in the coexistence of explanatory frameworks, in particular for the concept of origins of life, in which the effect size was large (g = 0.96, 95% C.I. = 0.77-1.14). Individuals, regardless of their religious commitment, in their effort to reconcile the explanatory frameworks (i.e., the creationist and the evolutionist) for origins of life, generate synthetic or integrated explanations, endorsing evolution for dinosaurs but creation for humans (Evans, 2001). Additionally, contextual information affects the coexistence of explanatory frameworks regarding death/afterlife (g = 0.56, 95% C.I. = 0.52-0.60). It seems that, depending on the context, individuals shift through explanatory frameworks and choose to refer to the scientific or to the supernatural explanation. For example, they tend to use scientific explanations in a medical context. On the contrary, when religious and spiritual beliefs are mentioned, individuals are more likely to provide supernatural explanations for life after death (e.g., Harris & Giménez, 2005; see also Astuti & Harris, 2008). In other words, contextual information is critical for individuals to choose the appropriate explanation for the specific frame of reference. This might mean that (a) the two explanations are available and easily accessible, and (b) individuals choose (consciously or unconsciously) between the two explanatory frameworks, the one that each time, according to their perspective, promotes communication with others.

Discussion

The present meta-analysis comprises a comprehensive set of quantitative reviews of the literature on concepts that have been studied as an integral part of the *vitalist* biology. It showed that supernatural explanations for the origins of life, health/illness, and death/afterlife coexist with scientific explanations in the same mind. Most of the evidence on explanatory coexistence came from

studies investigating the acquisition of the scientific concepts in the course of schooling within the framework theories. It was expected that when acquiring the scientific concepts, learners would abandon the initially acquired intuitive ideas for the same concepts (Carey, 1985). Nonetheless, the present review showed that explanatory coexistence is evident even among experts in biology; scientific expertise in biology had small or medium effect sizes (g = -.36 and g = -.48 for the studies on origins of life and death/afterlife, respectively) on the explanatory coexistence. The evidence for explanatory coexistence challenges the mainstream notion among the framework theories according to which, when conceptual change occurs, the initially intuitive or supernatural explanations are abandoned and replaced by the scientific explanations for the same concepts (e.g., Carey, 1985, 2000).

Additionally, age produced medium (g =.48 for studies on death/afterlife) or even large (g = .63 and g = .79 for studies on the origins of life and health/illness, respectively) effect sizes. These studies indicated a progressive enrichment of supernatural explanations among older children, adolescents, and adults. This evidence is in accordance with a previous review showing that belief in counter-perceptual entities and improbable events is more likely to be found among adults than among children (see Lane & Harris, 2015; Woolley & Ghossainy, 2013). Although some scholars had already suggested that non-scientific explanations are likely to survive even after individuals acquire scientific knowledge, as a part of the individual's worldview or ideological commitments (e.g., Caravita & Halden, 1994), it is only recently that scholars began to acknowledge explanatory coexistence of scientific and non-scientific understandings of the same phenomena in the same mind (see also Vosniadou et al., 2018). Hence, supernatural explanations should no longer be examined as primitive or immature ways of thinking abandoned by individuals when they encounter scientific explanations (see also Gelman & Legare, 2011; Legare *et al.*, 2012), whereas explanatory coexistence should be considered as a psychological variable that needs to be investigated *per se*.

The above acknowledgment, however, challenges the notion that individuals are working towards logical consistency between their representations. Thus, it is necessary to formulate other theoretical frameworks in order to interpret these findings. It is plausible to assume that individuals might successfully work to test the consistency of the statements within a particular explanation (e.g., Pnevmatikos, 2002; Pnevmatikos & Makris, 2010, 2011), but it might be hard for them to prove the consistency between alternative representations. Indeed, testing the consistency of a simple explanation is a less demanding process which requires more straightforward skills (e.g., to define the causal relationships between the several factors based on modus ponens and modus tollens inferences) than those demanded for testing the consistency between two alternative explanations. Examining the truth and validity of two alternative explanations requires the ability to encode the general principles that support the inferences and to test alternative hypotheses for their truth and validity based on these general principles. These abilities, however, are acquired during adolescence (e.g., Makris, Tachmatzidis, & Demetriou, 2017). Although this might be the case for some individuals, the appearance of explanatory coexistence among adults and even experts illustrates that cognitive constraints should not be the only reason explaining why individuals use scientific and supernatural explanations alternatively.

Another possible explanation might be that at least some individuals are primarily interested in being consistent with their environment rather than with their representations, ignoring whether alternative representations are logically inconsistent and mutually exclusive. This interpretation is supported by evidence provided from the present meta-analysis showing that, based on the context, individuals are selective for which explanation they will use, and recruit the explanation that is 'suitable' for the particular context and time. Contextual information had a large effect size (g = .96) in the one study investigating the origin of life, and medium effect sizes for the concept of health/illness (g = .76), and the concept of death/afterlife (g =

.56). The use of alternative explanations in different contexts might be indicative of the different functionality of scientific and supernatural explanations. Scientific explanations might be used for the rational explanation of a phenomenon (logos); the Big Bang theory presents a rational cosmological model for the observable universe. Supernatural explanations might be used for the interpretation (mythos) of the phenomenon, by answering questions such as *who* and *why* created the universe.

The appearance of explanatory coexistence in the same mind after late childhood may indicate that its emergence requires both familiarization with scientific explanations through systematic schooling and exposure to culturally-based supernatural explanations. Interestingly enough, culture and religion had different effect sizes for explanatory coexistence across the three concepts were examined in the current meta-analysis. Culture had medium effect size on the concept of health/illness (g = .71), and small effect size for the concepts of the origins of life (g = .40) and death/afterlife (g = .30). Religion had large effect size (g = .94) for the concept of death/afterlife, medium effect size (g = .63) for health/illness, and small effect size (g = .43) for the concept of origins of life. The impact of cultural or religious commitment on explanatory coexistence does not necessarily mean that culture and religion are the causes of explanatory coexistence. According to the 'naturalistic approach of culture' and the idea of the 'epidemiology of representations' in particular (Sperber, 1996), the causal relationship between supernatural explanations (as mental representations) and culture is perceived as more complex than a passive imitation or replication of cultural products in the individuals' mind. Causality alternates and can be seen as a process of transformation. According to this approach, supernatural explanations are seen as long-lasting public products that have mental representations among their causes, and mental representations have public representations among their causes. The distribution and the stability of mental representations that are associated with a cultural product are explained by the evolved properties of the human mind. The particular properties and cognitive predispositions of the human mind serve as 'attractors' allowing limited transformations over the space of possibilities. Explaining explanatory coexistence is, then, a matter of defining the 'attractors' of the human mind and the reasons that support their maintenance. The magnitude of the effect sizes shows that neither exposure to a particular culture nor religious commitment alone could explain explanatory coexistence, whereas the variability of the effect sizes for the different concepts shows that there is room for examining other factors that might have unique contribution to explanatory coexistence in some but all the concepts.

Given such evidence, we need new theory-driven studies that could provide answers for the reasons why individuals hold these alternative explanations. In particular, to understand the psychological mechanism that facilitates explanatory coexistence, we should also bypass the debate about whether supernatural explanations are empirically justified in terms of the *objective* scientific processes (see also Watson-Jones *et al*., 2015), and take more seriously the *subjective* empirical justifications. For instance, for individuals who have the personal experience of God intervening in their lives (see also Pnevmatikos, 2000 for the role of religious experience as intrinsic motivation for religious thinking), any objective justification about God's existence is odd. The subjective-personal experience about God's presence is enough to construct a reality that goes beyond what we can justify with the current scientific methods and tools. In contrast, explanations that include supernatural entities are even more real than scientific explanations which, by their nature, question the 'absolute truth' and are subjected to reformations. In other words, both scientific and supernatural explanations might be *empirically* justified, with the supernatural subjecting entirely to subjective justifications. In their Greek Epistemological Beliefs Evaluation Instrument for Physics (GEBEP), Stathopoulou and Vosniadou (2007) consider every day/sensory experience (although occasionally misleading) to be useful for the justification of knowledge and an acceptable statement for the sophisticated epistemology. Nevertheless, we lack explicit evidence for the role the

epistemological beliefs might have on the endorsement of the supernatural explanations. We need further research on how the individuals perceive supernatural beliefs epistemologically, and their role in explanatory coexistence.

By endorsing both scientific and supernatural explanations, individuals may perceive them as complementary (both are justified) and not as mutually exclusive explanations. The coordination between subjective and objective sources of knowledge might result in different types of synthesis. Kallio (2011) described at least two kinds of synthesis. One might connect the subjective with the objective experience, without any profound qualitative change integrating the two sources of knowledge mechanistically ('additive integration'). Alternatively, one might make a new synthesis using elements from different sources of knowledge to create a new explanation that has not existed before, which is called 'transformational integration'. For instance, individuals who understand the biological explanation of AIDS still insist on supernatural explanations, saying that this happened because someone else performed bewitching against the ill person (Legare & Gelman, 2008).

Additionally, personality factors might serve as 'attractors' to supernatural explanations. For instance, Saroglou (2010) in his meta-analysis on the relation between personality and religion found that the combination of personality factors such as *Agreeableness* and *Conscientiousness* not only influence but can consistently predict religiousness. He suggested that individuals high on Agreeableness and Conscientiousness are likely to be, remain, or become religious when these personality traits interact with the offer of religion in the environment. In particular, religious beliefs that emphasize positive qualities in human relationships might meet the traits of agreeable individuals, while religious beliefs that emphasize the meaningfulness of life and disciplined pursuit of valued goals might meet the traits of conscientious individuals. Nevertheless, to our knowledge, there is as yet no study investigating the relation between personality traits and particular supernatural beliefs or explanatory coexistence *per se*.

Understanding explanatory coexistence will trigger the development of new teaching methods including this concept, with the aim of helping students cope with their non-scientific explanations, not only at the very beginning of the construction of the scientific theories but also throughout learning activities (Shtulman & Harringhton, 2016). For instance, Legare and Shtulman (2018) suggested that students should learn to recognize and prioritize scientific explanations among other available ones.

Moreover, explanatory coexistence of two mutually exclusive explanations might demand different instructional designs that will emphasize the recruitment of cognitive mechanisms, such as executive function (Vosniadou *et al*., 2015, 2018; Vosniadou et al., 2018). Research findings showed that inhibitory control and cognitive flexibility are involved in the process of the construction and deployment of scientific knowledge, mainly when scientific knowledge is incongruent with the initially acquired explanations and requires the involvement of conceptual change processes. Scholars have begun to investigate the role of executive function in the efficiency of teaching practices used to promote conceptual change. Mason, Zaccoletti, Carretti, Scrimin, and Diakidoy (2018), for instance, tested the role of executive function (inhibitory control) to conceptual learning through the text structure (refutation vs. standard expository text). They found that inhibitory control predicts conceptual learning at the delay post-test, when students learned through the refutation text, in contrast to students who learned through the standard expository text. This evidence provides a more comprehensive understanding of refutation text's efficiency in conceptual understanding; additionally, refutation text readers learn that their prior knowledge is false and that they should avoid to use it. It seems that we are in a new era of educational research, during which teaching methods and learning science should emphasize, in parallel with the construction of new scientific knowledge, the necessity of de-construction of non-scientific explanations. In other words, non-scientific beliefs for various phenomena should be subjected to the

same theoretical and empirical scrutiny as scientific ones (Shtulman, 2013).

Limitations

The present meta-analysis is not without limitations. First, the meta-analysis was conducted on the basis of relatively few studies. Thus, there were some constraints. For example, many effect sizes were extracted from only two studies (or even one study), a fact that could restrict us from drawing firm conclusions. However, we decided to include these effect sizes in the meta-analysis, because we assumed that they indicate a trend. Second, in many studies, the information needed for the calculation of effect sizes for all variables was not available, therefore we could not determine any interdependence of variables as well as its influence on the results. Additionally, some studies did not provide sufficient information about coexistence, and the effect sizes were calculated using estimation procedures or were not calculated at all.

Conclusions

The results of the present meta-analysis indicate that supernatural explanations for the origins of life, illness, and death/afterlife are surprisingly resilient and persist not only across minds but also within the same mind. The studies included in the present meta-analysis showed that a certain number of individuals endorse mutually exclusive explanations. The coexistence of scientific and supernatural explanations within the same mind indicates that, with learning, many individuals do not abandon or replace their supernatural beliefs (either these appear during preschool years or later in the course of socialization due to schooling), but instead they extend their repertoire of ideas for the scientific and supernatural world. Individuals may construct parallel explanations serving other purposes or make different types of synthesis of the two explanatory frameworks. This synthesis has been labelled by Kallio (2011) 'transformational integration', and is likely to be a part of the individual's worldview or ideological commitments (Caravita & Halden, 1994). Finally, the coexistence of scientific and supernatural explanations may be an epiphenomenon of the individuals' need for balance between explanation (logos) and interpretation (mythos) of phenomena such as the origins of life, health/illness, and death/afterlife.

Although we are aware of the critical differences found between the three concepts that were reviewed here, we know little about the extent of the phenomenon in the population. Furthermore, explanatory coexistence is moderated by factors such as age, religion, culture, scientific expertise, and context of reference. The impact of each factor is different across the three concepts, thus further systematic comparative research across concepts is needed with the aim of gaining a deeper understanding of the phenomenon, as well as new initiatives in the field of educational sciences are required. There is possibly a common psychological mechanism which supports explanatory coexistence across these concepts. This mechanism is subjected to influences from the same factors but in different intensities. Religion was found to have a large effect size for the coexistence of explanatory frameworks regarding death/afterlife; the explanatory coexistence for illness appears to be a cultural issue; and the context plays a crucial role for the origins of life. Therefore, a generalization of the impact of these factors across the three concepts, based on evidence from only one concept, should be avoided. The systematic study of the unique influence of each factor on the specific concept and the possible interactions between these factors might highlight the causes that constrain the individuals' rational abilities. Comparative developmental studies across concepts and cultures measuring the impact of each independent variable onto explanatory coexistence are more than welcome.

This evidence indicates that the teaching approaches we use so far have not succeeded in facilitating the replacement of the non-scientific explanations with scientific ones. In other words, there is a need to look deeper at explanatory co-

existence and attempt to understand its origins. Moreover, we should re-orientate the purpose of the instruction from the replacement to the re-analysis of the non-scientific explanations (e.g., Caravita & Hallden, 1994). The new instructional design should emphasize the recruitment of cognitive mechanisms, such as the executive function (Vosniadou *et al*., 2015, 2018; Vosniadou et al., 2018) and the awareness that the early acquired non-scientific beliefs might intervene when individuals try to make inferences based on scientific knowledge.

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Appendix 1

Origins of life – Controversial topics in science

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Lawson and Worsnop (1992)	Effect of reflective reasoning skills, religiosity and prior knowledge on the acceptance of evolution	107 high school students	Highly religious students were less likely to change their beliefs in favor of evolution after the instruction.	
Dagher and BouJaoude (1997)	Biology major's accommodation of the theory of evolution with religious beliefs	62 students (17 Christian and 45 Muslim)	15% of the students tried to reconcile religion with the theory of evolution (6% of the Christian sample and 18% of the Muslim sample).	
Evans (2000) Study 1	The development of children's understanding of the origins of species	49 children	Developmental pattern in children's explanations. Natural history knowledge related to creationist and spontaneous generationist beliefs.	
Evans (2000) Study 2	The role of parents' beliefs in the development of children's understanding of the origins of species	83 children 45 mothers or guardians	Age, parents' beliefs and natural history knowledge related with children's explanations.	
Evans (2001)	Children's beliefs about the origins of species	185 children with their mothers (N = 92) divided into two groups (Christian fundamentalist and Non-fundamentalist)	8-10 year-old children were exclusively creationists, whereas preadolescents agreed with their mothers' and their community's beliefs. Natural history knowledge and religious interest predicted children's beliefs.	

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Losh and Nzekwe (2011)	Preservice science teachers' science knowledge and pseudoscience beliefs	663 preservice teachers (religiosity was used as variable)	Participants who endorsed the scientific explanation about the origins of species (evolution) also endorsed fantastic beasts or extraterrestrials. The level of religiosity predicted beliefs about the origins of life.	The sample may not be representative. Measures did not focus on origins of life. The denominational measures were not precise.
Opfer, Nehm and Ha (2012)	Evaluation of a scale designed to assess the use of natural selection in order to explain evolutionary change	320 undergraduate biology students	In 73% of the participants key concepts and cognitive biases coexisted. The use of key concepts was associated with higher academic achievement.	Assessment of scientific expertise was based on students' grades in an evolutionary biology course.
Short and Hawley (2015)	Knowledge and attitudes towards evolution in college students	437 biology students, 366 political science students and 65 evolutionary psychology students	Biology students referred less to creationism by the end of the semester (smaller mean), but the variability of creationist reasoning increased.	Students from the same University
Busch, Watson-Jones and Legare (2016)	Explanatory coexistence across development in death, illness, and origins of life	72 children, adolescents and adults from Tana, Vanuatu	The coexistence of natural and supernatural explanations for the origins of life was infrequent. Interaction of age and explanation type.	

Appendix 2

Illness – Recovery from illness

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Furnham (1994)	Lay beliefs about health and illness	338 adults	Participants with strong religious beliefs tend to endorse beliefs about God's mediating role in health and illness.	
Landrine and Klonoff (1994)	Cross-cultural differences in supernatural causal attributions for illness	149 undergraduate students (79 white, 70 ethnic minorities)	Ethnic minorities tend to rate supernatural causes of illness as more important than white participants. However, when asked to generate causes, the two groups did not differ concerning their evaluation of generated supernatural causes.	Participants were college students, Small number of participants in each minority group (did not allow comparisons).
Furnham, Akande and Baguma (1999)	Cross-cultural examination of beliefs about health and illness	500 university students (195 British, 153 Ugandan, 152 South African)	Both African groups (especially South African) tended to rate higher supernatural agents' contribution to current and future health, or recovery from illness, than British participants.	A great number of items. Problems in response types. The instrument was based on Western culture.
Furnham and Baguma (1999)	Cross-cultural examination of beliefs about health and illness	335 university students (195 British, 140 Ugandan)	Ugandan students were more likely to refer to supernatural forces and religious factors regarding their current or future health and speed of recovery from illness.	Cultural differences in responding styles.
Raman and Gelman (2004)	Examination of developmental and cultural aspects of illness' causal frameworks	American and Indian children (preschoolers, 1st-3rd-5th-graders, N = 173) and college students (N = 48)	71% of the American college students (but only 7% of the Indian group) attributed moral causes to illness and at the same time provided biological explanations.	Biological and folk-biological explanations were integrated. Younger participants might have misunderstood research question.

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Nguyen and Rosengren (2004) Study 1	Cross-cultural investigation of children's understanding of the causes of illness	68 children and adults 52 children (4-7 years old) and 16 adults divided into two groups (European-American and Vietnamese-American)	Although magical explanations were less common than biological ones in both groups, Vietnamese-Americans provided significantly more magical explanations than European-Americans.	
Jobanputra and Furnham (2005)	Cultural differences in beliefs about health and illness	165 British Caucasian and 169 British Gujarati Indian	Gujarati Indian participants were found to endorse supernatural explanations in a greater extent than British Caucasian participants.	1st and 2nd generation immigrants were included in both British Gujarati Indian age groups.
Furnham and Igboaka (2007)	Cultural differences in beliefs about schizophrenia	95 Nigerian and 76 British young adults (162 were students)	Supernatural explanations and religious or traditional treatments were more popular among Nigerian participants than British participants.	The Nigerian sample is not representative of lay people's beliefs (better educated).
Legare and Gelman (2008) Study 1	The coexistence of natural and supernatural explanations for illness and disease transmission (developmental perspective)	128 children (and adolescents) and 10 adults from a Sesotho-speaking, South African, peri-urban community	Adults endorsed both biological and bewitchment explanations more often than children and adolescents.	Small number of adults. The community was exposed in AIDS educational programs.
Legare and Gelman (2008) Study 2	The coexistence of natural and supernatural explanations for illness and disease transmission (developmental perspective)	96 children (and adolescents) and 32 adults from a Sesotho-speaking, South African, rural community	Adults endorsed both biological and bewitchment explanations more often than adolescents.	The vignettes did not provide sufficient contextual information.

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Legare and Gelman (2008) Study 3	The coexistence of natural and supernatural explanations for illness and disease transmission (developmental perspective)	110 adults (15-75 years old) from a Sesotho-speaking, South African, rural community	93% of the participants used both biological and bewitchment explanations at least once. In the experimental condition, where only biological information was presented, coexistence scores were lowest than in all other conditions.	
Vess et al. (2009) Study 2	Perception of the efficacy of prayer in treating physical illness	51 young adults (M = 19.36)	Participants high in religious fundamentalism perceived prayer as a more effective treatment.	The findings could be associated with palliative outcomes of the decisions that were not assessed.
Vess et al. (2009) Study 4	Beliefs about the efficacy of prayer to treat illness	48 adults (M = 18.44)	Participants high in religious fundamentalism were more likely to rely only on faith to treat illness.	The findings could be associated with palliative outcomes of the decisions that were not assessed.
Mathews (2011)	Causal explanations of mental disorder	842 Singaporean Chinese college students (Christians, Buddhists, non-religious)	The endorsement of supernatural explanations for mental disorders was stronger for religious participants and in accordance with their religion.	
Pnevmatikos (2014)	The beliefs about prayer as a cause of recovery from illness (developmental perspective)	120 children (8-, 10-, 12-year old) and 40 young adults (M = 20.01)	Children and half of the young adult group strongly believed that prayer could aid recovery from illness.	
Busch, Watson-Jones and Legare (2016)	Explanatory coexistence across development in death, illness, and origins of life	72 children, adolescents and adults from Tana, Vanuatu	Children, in contrast to adolescents and adults, were more likely to endorse both natural and supernatural explanations. An interaction between priming and preference for explanation was also found.	

Appendix 3

The concept of death, afterlife, body-mind dualism

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Brent and Speece (1993)	Conceptualization of irreversibility in adults	165 undergraduate students	Adults were less consistent in endorsing the concept of irreversibility of death compared to children that participated in a previous study.	
Bering (2002)	The representation of dead agents' minds	84 undergraduate students (with different types of afterlife beliefs)	Even those who did not believe in afterlife (extinctivists) were likely to state that emotional (68%), desire (68%) and epistemic (64%) states continue to function after death.	
Bering and Bjorklund (2004) Experiment 2	Discontinuity of psychological functions after death	82 children, divided into three groups (kindergartners, early elementary and late elementary group)	3% of the kindergartners, 30% of the early elementary and 20% of the late elementary group provided discontinuity answers for all questions.	
Bering and Bjorklund (2004) Experiment 3	Discontinuity of varied psychological states after death	66 children divided into two groups (kindergartners and late elementary) and 20 adults (M = 19.1)	Older children and adults were more likely to state that biological and psychological states stop functioning after death in contrast to emotional, desire and epistemic states.	
Poling and Evans (2004) Study 1	The development of concepts of death and extinction	68 children (4-9 years old) and 32 parents	53% of adults' answers about what happens to humans after death reflected spiritual beliefs, in contrast to 22% of 8-year-olds (who referred to cultural practices more than adults).	Selection bias (parents reported talking to their children about death).

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Poling and Evans (2004) Study 2	The development of concepts of death and extinction	74 adults (18-65 years old) with increasing levels of expertise in biological sciences (lay adults, medical students, biology experts)	59% of lay adults' answers about what happens to humans after death referred to spiritual beliefs. In contrast, 76% of biology experts and 56% of medical students referred to decomposition.	
Harris and Giménez (2005)	Beliefs about death in the context of a religious and a secular narrative	48 children (7 and 11 years old)	In older children, biological and religious explanations appear to coexist.	
Bering, Blasi and Bjorklund (2005)	The development of afterlife beliefs	168 children (5-12 years old), divided into two groups (religiously schooled and secularly schooled)	Within age groups, secularly schooled children were more likely to be classified as consistent cessation theorists than religiously schooled children.	Task with puppets
Richert and Harris (2006)	The development of the concept of soul	48 children (1st, 3rd and 5th graders), recruited from two Catholic schools	Overall, for children souls are stable constructs that perform spiritual functions. However, 1st graders were less likely than older children to claim that a baby has a soul or that souls influence a person's identity.	The experiment relied on children having been exposed to the word 'soul'.
Astuti and Harris (2008) Study 1	The concept of death in a non-Western culture	56 children (8-17 years old) and 46 adults (19-71 years old) from rural Madagascar	Vezo children and adults were more likely to state that functions cease at death, but their responses were more frequent for bodily than mental functions and for the corpse than the religious narrative.	

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Astuti and Harris (2008) Study 2	The concept of death in a non-Western culture	34 children, 5 and 7 years old (five 5-year-olds and two 7-year-olds were excluded), from rural Madagascar	The 7-year-old, Vezo children have a relatively coherent concept of human and animal death.	
Cohen and Barrett (2008) Studies 1&2	Intuitions about body-mind relationship in adults	25 university students (study 1) 26 university students (study 2)	In both studies, participants stated that performance in mental tasks would be affected after a hypothetical mind transfer.	
Preston, Ritter and Hepler (2013) Experiment 1	Exploration of exposure to neuroscience impacts belief in the soul	151 university students	Belief in soul was affected by the presence of neuroscientific evidence. Religiosity correlated with belief in soul.	
Preston, Ritter and Hepler (2013) Experiment 2	Exploration of exposure to neuroscience impacts belief in the soul	75 university students	Exposure to strong neuroscientific evidence increased willingness to sell a 'soul card'. Religiosity negatively correlated with willingness to sell a 'soul card'.	
Anglin (2014)	Investigation of the relationship between implicit, childhood and current soul and afterlife beliefs	349 university students	Students stated strong beliefs in soul and the afterlife. The soul and afterlife beliefs were significantly correlated with religiosity.	Childhood belief assessment was based on participants' statements. Sample was not representative.
Emmons and Kelemen (2014) Study 1	Children's beliefs about their mental and physical capacities prior to biological conception	211 children 5-12 years old [the youngest group (5-6 year olds, $N = 63$) was excluded from the analysis], from Ecuador (urban sample, recruited from nonreligiously affiliated public schools)	From 7-8 years, urban children believed that the time prior to their conception, emotion and desire states could have functioned. Overall, 33% of the participants were characterised as nonfunction theorists.	Urban children's limited exposure to nature (biological events related to life and death).

Study	Focus of the study	Sample	Results on coexistence	Study's limitations
Emmons and Kelemen (2014) Study 2	Children's beliefs about their mental and physical capacities prior to biological conception	72 children 5-12 years old [the youngest group (5-6 year olds, *N* = 13) was excluded from the analysis], from Ecuador (rural sample, recruited from nonreligiously affiliated schools)	Children were more likely to endorse emotion and desire states as functional prior to conception. Overall, 37% of the participants were characterised as nonfunction theorists.	
Panagiotaki et al. (2014)	Developmental, cultural and religious influences on the acquisition of the subcomponents of the concept of death	188 children (4-7 years old), White British, British Muslim and Pakistani Muslim, recruited from secular schools, except British Muslim (recruited from London mosques)	British and Pakistani children had significant differences in their responses for irreversibility, applicability and causality. British children were more likely to refer to religion in their answers about irreversibility and applicability of death.	Translation issues. Religiosity in White British children was not assessed. Cultural practices/ experiences were not assessed.
Emmons and Kelemen (2015)	Children's capacities during prenatal period from a cross-cultural perspective	283 children (5-12 years old, 211 from urban Ecuador and 72 rural indigenous Shuar)	Children attributed mental capacities (emotions and desires) to themselves as fetuses.	
Busch, Watson-Jones and Legare (2016)	Explanatory coexistence across development in death, illness, and origins of life	72 children, adolescents and adults from Tana, Vanuatu	Participants endorsed both biological and spontaneous explanations.	Forced-choice responses may not be indicative of participants' beliefs.

Η επεξηγηματική συνύπαρξη επιστημονικών και υπερφυσικών εξηγήσεων: Μια μετα-ανάλυση

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ΠΕΡΙΛΗΨΗ

Η επεξηγηματική συνύπαρξη επιστημονικών και υπερφυσικών εξηγήσεων στον ίδιο νου αποτελεί πρόκληση για τις ψυχολογικές θεωρίες που επιχειρούν να ερμηνεύσουν την απόκτηση των γνώσεων. Υποδεικνύει ότι οι υπερφυσικές εξηγήσεις συνεχίζουν να χρησιμοποιούνται ως αιτιώδη επεξηγηματικά πλαίσια, παράλληλα με τη χρήση των επιστημονικών ερμηνειών, ακόμα και από άτομα με επιστημονική εξειδίκευση στον συγκεκριμένο τομέα. Η παρούσα ανασκόπηση και μετα-ανάλυση αποσκοπεί στη διερεύνηση των παραγόντων που θα μπορούσαν να επηρεάσουν τη συνύπαρξη και κοινή χρήση των υπερφυσικών και των επιστημονικών επεξηγηματικών πλαισίων σε τρεις έννοιες: την προέλευση της ζωής, την ασθένεια και τον θάνατο/μετά θάνατον ζωή. Βασιζόμενη σε 35 άρθρα (περιέχουν 45 μελέτες) που έχουν δημοσιευθεί μεταξύ του 1985 και του 2016 και εξετάζουν τόσο τις επιστημονικές όσο και τις υπερφυσικές εξηγήσεις για τις έννοιες αυτές, η παρούσα μελέτη διερευνά τον αντίκτυπο της ηλικίας, της θρησκευτικότητας, της επιστημονικής εξειδίκευσης, του πολιτισμού και των παραγόντων πλαισίου στην επεξηγηματική συνύπαρξη επιστημονικών και υπερφυσικών εννοιών. Τα αποτελέσματα δείχνουν ότι, αν και η θρησκευτικότητα, το πολιτισμικό υπόβαθρο και οι πληροφορίες πλαισίου έχουν μεγάλη επίδραση στις έννοιες του θανάτου/μετά θάνατον ζωής, της ασθένειας και της προέλευσης της ζωής, το μέγεθος της επίδρασης εξαρτάται από την έννοια.

Λέξεις κλειδιά: επεξηγηματική συνύπαρξη, έννοια της ασθένειας, προέλευση της ζωής, μετά θάνατον ζωή.

1. Πανεπιστήμιο Δυτικής Μακεδονίας

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