Religious thought and behaviour as by-products of brain function

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Religious concepts activate various functionally distinct mental systems, present also in non-religious contexts, and 'tweak' the usual inferences of these systems. They deal with detection and representation of animacy and agency, social exchange, moral intuitions, precaution against natural hazards and understanding of misfortune. Each of these activates distinct neural resources or families of networks. What makes notions of supernatural agency intuitively plausible? This article reviews evidence suggesting that it is the joint, coordinated activation of these diverse systems, a supposition that opens up the prospect of a cognitive neuroscience of religious beliefs.

Religious beliefs and practices are found in all human groups. What makes religion so 'natural'? A common temptation is to search for the origin of religion in general human urges, for instance in people's wish to escape misfortune or mortality or their desire to understand the universe. However, these accounts are often based on incorrect views about religion (see Table 1) and the psychological urges are often merely postulated [1,2]. Recent findings in psychology, anthropology and neuroscience offer a more empirical approach, focused on the mental machinery activated in acquiring and representing religious concepts [1,3–7]. This approach suggests three crucial changes to common views of religion:

(1) Most of the relevant mental machinery is not consciously accessible. People's explicitly held, consciously accessible beliefs, as in other domains of cognition, only represent a fragment of the relevant processes. Experimental tests show that people's actual religious concepts often diverge from what they *believe* they believe [8]. This is why theologies, explicit dogmas, scholarly interpretations of religion cannot be taken as a reliable description of either the contents or the causes of people's beliefs [9];

(2) What makes religious thoughts 'natural' might be the operation of a whole collection of distinct mental systems rather than a unique, specific process;

(3) In each of these systems religious thoughts are not a dramatic departure from, but a predictable by-product of, ordinary cognitive function.

In the past five years, substantial progress has been made in the description of these different systems and their contribution to the 'naturalness' of religious beliefs.

A limited catalogue of the supernatural

Religious notions are products of the supernatural imagination. To some extent, they owe their salience (likelihood of activation) and transmission potential to features that they share with other supernatural concepts, such as found in dreams, fantasy, folktales and legends. This might be why one finds recurrent templates in religion despite many variations between cultures (see Table 1 on misleading notions about cultural similarities and differences). Imagination in general is strongly constrained [10]. Supernatural concepts are informed by very general assumptions from 'domain concepts' such as *person*, *living thing*, *man-made object* [11,12]. A spirit is a special kind of *person*, a magic wand a special kind of *artefact*, a talking tree a special kind of *plant*. Such notions are salient and inferentially productive because they combine (i) specific features that violate some default expectations for the domain with (ii) expectations held by default as true of the entire domain [9] (see Fig. 1).

For example, the familiar concept of a *ghost* combines (i) socially transmitted information about a physically counter-intuitive person (disembodied, can go through walls, etc.), and (ii) spontaneous inferences afforded by the

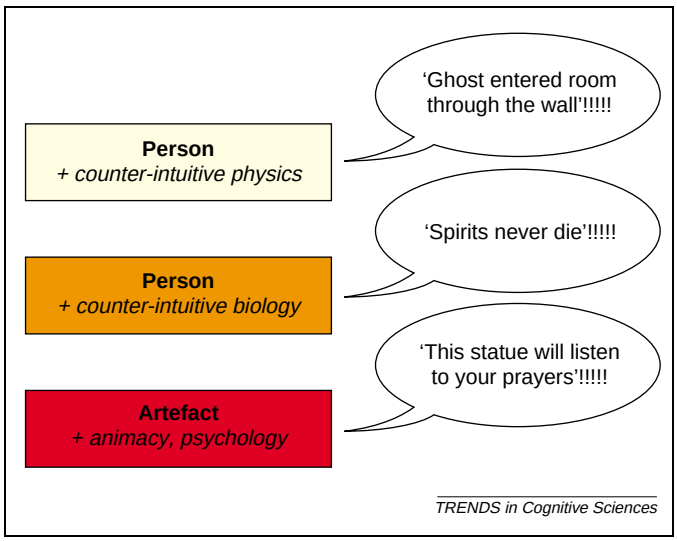

Fig. 1. Culturally widespread supernatural concepts (only the most frequent are represented here) correspond to a small number of templates that combine [a] activation of a domain concept with its default assumptions and [b] culturally transmitted, limited violations of expectations for that domain.

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Table 1. Do's and dont's in the study of religion

Do not say…	But say…
Religion answers people's metaphysical questions	Religious thoughts are typically activated when people deal with concrete situations (this crop, that disease, this new birth, this dead body, etc.)
Religion is about a transcendent God	It is about a variety of agents: ghouls, ghosts, spirits, ancestors, gods, etc., in direct interaction with people
Religion allays anxiety	It generates as much anxiety as it allays: vengeful ghosts, nasty spirits and aggressive gods are as common as protective deities
Religion was created at time t *in human history*	There is no reason to think that the various kinds of thoughts we call 'religious' all appeared in human cultures at the same time
Religion is about explaining natural phenomena	Most religious explanations of natural phenomena actually explain little but produce salient mysteries
Religion is about explaining mental phenomena (dreams, visions)	In places where religion is *not* invoked to explain them, such phenomena are not seen as intrinsically mystical or supernatural
Religion is about mortality and the salvation of the soul	The notion of salvation is particular to a few doctrines (Christianity and doctrinal religions of Asia and the Middle-East) and unheard of in most other traditions
Religion creates social cohesion	Religious commitment can (under some conditions) be used as signal of coalitional affiliation; but coalitions create social fission (secession) as often as group integration
Religious claims are irrefutable. That is why people believe them	There are many irrefutable statements that no-one believes; what makes some of them plausible to some people is what we need to explain
Religion is irrational/superstitious (therefore not worthy of study)	Commitment to imagined agents does not really relax or suspend ordinary mechanisms of belief-formation; indeed it can provide important evidence for their functioning (and therefore should be studied attentively)

general *person* concept (the ghost perceives what happens, recalls what he or she perceived, forms beliefs on the basis of such perceptions, and intentions on the basis of beliefs) [13]. These combinations of explicit violation and tacit inferences are culturally widespread and may constitute a memory optimum [11]. Associations of this type are recalled better than more standard associations but also better than oddities that do not include domain-concept violations [14,15]. The effect obtains regardless of exposure to a particular kind of supernatural beliefs, and it has been replicated in different cultures in Africa and Asia [14].

Informed agents and moral intuitions

A subset of the supernatural repertoire consists in *religious* concepts proper, which are taken by many people as, firstly, quite plausibly real and secondly, of great social and personal importance. Religion is largely about intentional agents [3] that one does not physically encounter. Far from being intrinsically irrational or delusive, the capacity to imagine non-physically present agents and run 'off-line' social interaction with them can be said to be characteristic of human cognition [16,17]. A good deal of spontaneous reflection in humans focuses on past or future social interaction and on counterfactual scenarios. This capacity to run 'off-line' social interaction is already present in young children [18]. Thinking about supernatural agents certainly activates such off-line capacities, although in a particular way because most information about such agents is socially transmitted and they are seen as quite real.

What psychological processes create this intuition of actual presence? Some psychologists of religion emphasize the role of salient personal experience, such as a vision or trance (see Box 1). However, most religious people find supernatural agents plausible without the benefit of such experience. A possible explanation is that the representation of supernatural agents activates and modifies inference systems involved in the representation of ordinary agents.

As an illustration, concepts of gods and ancestors with whom you can interact require a minor but consequential 'tweaking' of standard theory of mind. Normal adults pass standard false-belief tests because they assume a 'principle of imperfect information': that a situation s is the case does not entail that all agents represent s [19–21]. Social intelligence requires that we gauge other agents' true and false beliefs about the situation at hand. But supernatural agents are represented as *simpler* intentional agents. They are tacitly construed as 'perfect-access' intentional agents [22] (if s is the case, then the god or spirit knows s).

Another illustration is the way supernatural agents are involved in moral judgments. Moral intuitions bind a particular type of social interaction with a specific feeling [23,24], according to principles developed early in life [25]. The principles are implicit so that people often have definite moral intuitions that they cannot entirely explain. This explanatory background can be provided by religious concepts. Gods and ancestors are sometimes represented as 'legislators' or moral exemplars but the most widespread connection with morality is that they are 'interested parties' in moral judgments [6]. The ancestors know, for instance, what you are up to, know you feel bad about it, and know that it is bad; the spirits know that you are generous, know how proud you feel and know that that is praiseworthy. A default assumption in such inferences is that gods and ancestors empathise with one's own moral intuitions. One's own moral feelings are made easier to represent when construed as resulting from another agent's judgments, because of our intuitive capacity for emotional empathy [26].

Misfortune and death

A popular explanation of religion is that people create gods and spirits to explain misfortune, accidents and disease in

Box 1. Trance vs. doctrine: does salient experience shape ordinary practice?

In many different places around the world, rituals induce what are called 'altered states of consciousness': trance, possession, meditation, and so on (Fig. I). The techniques include self-stimulation, visual fixation, verbal satiation, hyper-ventilation, mood-enhancing or hallucinogenic drugs, sensory deprivation, and music [67]. How do such techniques contribute to the creation, spread and intuitive plausibility of religious notions?

Psychologists of religion have often suggested that the specific phenomenology of such states inform religious notions [68], and propose the following causal links:

(1) specific brain events in a particular person lead to specific experience of supernatural entities or agents;
(2) a mystic's specific experience leads to that person's specific concepts;
(3) the mystic's concepts lead to the group's religious tradition.

This is the path taken in the modern study of altered states of consciousness, including the very few experimental studies of their neural underpinnings [66].

Such studies might one day be able to document causal links 1 and 2 above. But what about link 3? As anthropologists point out, most religious concepts in most minds at most times in most cultures are built on the basis of other people's statements (e.g. 'the gods are awesome'), sometimes completed by some personal experience (e.g. feeling awed at the thought of the gods), and very seldom accompanied by any 'mystical' experience (e.g. of feeling the presence of the god). So it is difficult to say whether extraordinary experience really has much impact on religious concepts. Many anthropologists argue that the phenomenology of altered states is intrinsically indeterminate. Culturally transmitted concepts are required to give the experience any content at all [69].

The production of exceptional experience could be part of what R.N. McCauley and E.T. Lawson call the 'high sensory pageantry' of rituals that create exceptional emotional states, from elation to terror and from intense pleasure to excruciating pain [70]. By contrast, many rituals are based on repetitive lessons. Why this difference? For McCauley and E.T. Lawson, high sensory rituals have supernatural agents *acting*; low sensory rituals are those in which they are being acted upon. The two ritual modes perhaps also use two distinct resources of human memory: salient perceptually encoded autobiographical events versus conceptually integrated scripts [71].

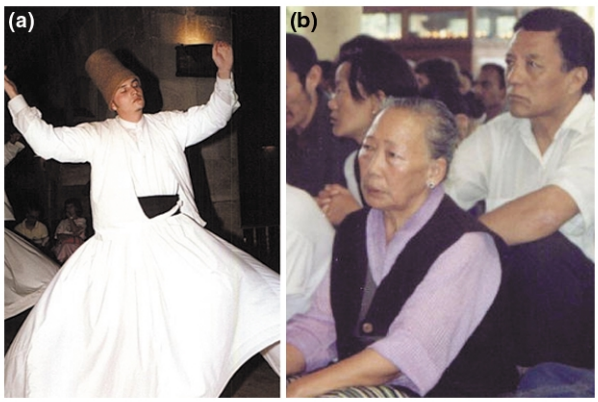

Fig. I. Two contrasted aspects of religious practice: (a) exceptional experience (here *darwish* Muslim mystic) and (b) routinized worship (Christians in the Philippines).

particular, and that people need such explanations because they misunderstand probability. Psychologists have often described folk understandings of chance as irrational [27] although this is in fact mostly confined to situations where people represent the probability of a *single* event (versus judging the relative frequencies of multiple occurrences) [28]. Interestingly, many of the events for which supernatural causes are invoked are either represented as single events (e.g. death of a relative) or repeated misfortune that deviates strongly from expected frequencies (e.g. 'this is the third time my house has been hit by lightning').

This could explain why such events are remarkable but not why agents are thought to be involved. A possible explanation is that many cases of misfortune are represented in terms of social interaction in the first place, whether the person is religious or not. This might be a by-product of the hypertrophy of 'social intelligence' in humans, itself a reflection of how much human beings depend on each other for survival [16]. Two facts seem to

Box 2. Magic, pollution, ritual and other obsessions

Magic and ritual the world over obsessively rehash the same themes, in particular 'concerns about pollution and purity [...] contact avoidance; special ways of touching; fears about immanent, serious sanctions for rule violations; a focus on boundaries and thresholds' [72]. These themes are also characteristic of obsessive–compulsive disorder (OCD). Indeed, the domains of magical ritual and personal obsessions do not just share similar themes but also similar principles characteristic of magical thinking [55]:

(1) dangerous elements or substances are invisible;
(2) any contact (touching, kissing, ingesting) with such substances is dangerous;
(3) the amount of substance is irrelevant (e.g. a drop of a sick person's saliva is just as dangerous as a cupful of the stuff).

Many situations to which people spontaneously apply these principles include sources of pathogens and toxins: dirt, faeces, bugs, diseased or decayed organisms. The three principles are particularly apposite when dealing with such situations, as most pathogens are invisible, use diverse vectors for transmission, and there is no dose effect.

So 'magical' thoughts could be an extension of inferences about contagion [73]. Rituals are often performed with a sense of urgency, an intuition that great danger would be incurred by *not* performing them. This particular emotional tenor of rituals might derive from their association with neural systems dedicated to the detection and avoidance of invisible hazards.

Further light is shed on this question by the study of OCD pathology. Neuroimaging studies generally show a significant increase of activity in the caudate nucleus in response to stimuli perceived as dangerous. Specific activity modulation extends beyond the basal ganglia, however, to a network comprising anterior cingulate and orbitofrontal cortex as well as the caudate [57,74]. The pathology might consist in a failure to inhibit or keep 'off-line' a set of normal neural reactions to potential sources of danger.

We are still far from understanding to what extent this network is also involved in the production of 'mild', controlled, socially transmitted notions about purity and the need for magical ritual. But it seems that the salience of a particular range of ritual themes to do with hidden danger and noxious contact [72] and a susceptibility to derive rigid, emotionally vivid sequences of compulsory actions from such themes [55], could be spectacular cultural by-products of neural function.

Table 2. A framework for a cognitive neuroscience of religion*

Gods and spirits as agents: they do things and react to one's behaviour	[1]System independent from Theory-of-Mind [41] from infancy [42], needs no human-like agent [43]. NC: involvement of STS in inferring goals and other social cues from static displays [44], modulation of sup. PC in detecting agency from reactivity [45]. *Questions:* Is activation of such systems involved in representing non-directly perceived agency?
Goal detection[1]	
Agents = objects that react to others[1,2]	
Gods and spirits have perceptions, beliefs	[2]Specific system [46], selective impairment [47,48]. NC: joint activation of medial FC [49,50] and regions dedicated to social cues [44], imitation [51] and emotional empathy (see below). *Questions:* How do these systems generate inferences about non-physically present agents (imaginary companions, spirits)?
Ordinary mind reading[2]	
The dead as supernatural agents	
Ordinary mind reading[2,5]	
Social relations with dead people[2,3]	
Sacredness, purity, pollution and taboo	[3]Face-recognition [52] and agency cues (above). NC: those of social agency and person files [53]. *Questions:* Do dead bodies produce disjunction between social agency and animacy detection? How does this connect with emotional effects of mortality?
[normal] fear of contagion[4]	
Rituals protect against invisible danger	[4]Contagion-avoidance system: early developed [54], like magic [55], specific emotions [56]. Joint activation of Ac, Caud., OFC [57]. *Questions:* How does magical ritual modulate this activity? Are contagion-related cues sufficient?
[normal] fear of contagion[4]	
Gods as interested parties in moral judgement; moral empathy	[5]Empathy, emotion and off-line simulation, NC: those of emotional states in general (including sub cortical structures, amygdala, thalamus, also involved in moral feelings [58] together with STS for social cues. *Questions:* Is moral feeling neurally (as well as phenomenologically) distinct? Does moral feeling presuppose other's a well as own viewpoint on action?
Detection of emotional states[5]	
Moral feelings and empathy[5]	
Gods and spirits 'really there' despite no physical presence	[6]Monitoring of self-non-self distinction in action [59,60] breaks down in particular pathologies [61]. NC: disjunction between insula and inferior PC activity for self-initiated vs. non-self initiated action [62], also later-alization of inf. PC activation as effect of imitation vs. being imitated [51]. *Questions:* Is limited suspension/modulation of such activity involved in "real presence" of supernatural agents?
[normal] imaginary companions, off-line interaction[2,6]	
[pathological] thought insertion, delusions[2,6]	
Gods and spirits give and receive (sacrifice, protection)	[7]Inferential systems detached from general mental logic [63] and cultural factors [64], possible selective im-pairment [65]. *Questions:* Are the emotions triggered specific to these systems? How are the emotions transferred to non-physical resources?
Social exchange, trust-signalling, cheater-detection[2,7]	
Mystical experience, fusion with supernatural agent	[8]NC: Probably specific modulation of sub-cortical structures and TC [66]. *Questions:* Does phenomenology of such states constrain conceptual descriptions of supernatural agency? (see Box 1)
Altered states, meditation[8]	

*The argument presented in this article is that religion does not involve a specific mental faculty or neural system. A cognitive neuroscience of religion would require a two-step reduction. First, different aspects of religion (left column, bold) require diverse inference systems (left column, below headings) also found in non-religious contexts. Second, each inference system corresponds not to a single neural system but to the joint activation of a family of systems (right column). Abbreviations: NC: neural correlates; FC: frontal cortex; PtdCho: parietal cortex; STS: superior-temporal cortex; Ac: anterior cingulate; OFC: orbito-frontal cortex; Caud.: caudate nucleus; TC: temporal cortex. All numbers refer to main text bibliography.

support this interpretation: (1) when people explain salient misfortune without mentioning supernatural agents, they still assume *agents* as causally involved (e.g. in witchcraft accusations, a human agent is said to use special techniques to bring about misfortune); (2) the way people connect misfortune or protection on the one hand and gods, spirits or ancestors on the other is generally in terms of social exchange, that is, in terms of services and goods given versus received. They attribute to supernatural agents an intuitive 'logic of social exchange' [29] that is active in non-religious contexts.

Fear of death is also often described as the 'origin' of religion (although all not religion is reassuring; see Table 1). Social psychologists know that reminding people of their mortality triggers a whole variety of non-obvious cognitive effects (e.g. a punishing attitude towards social deviance, ethnic-racial intolerance or stereotyping, illusory consensus) [30,31]. The mechanisms responsible are not yet properly understood [32] but they probably highlight culturally acquired notions of powerful and protective agents [7].

The association between death and concepts of supernatural agency is most obvious in death rituals. However, rather than commenting on mortality, these rituals are usually mostly concerned with what to do with corpses. This is partly to do with the fear of contamination, apparently a salient aspect of magical thinking and ritual (see Box 2). Dead people also create a discrepancy between the output of different mental systems. On the one hand, systems that regulate our intuitions about animacy have little difficulty understanding that a dead body is a non-intentional, inanimate object [33]. On the other hand, social-intelligence systems do not 'shut off' with death; indeed most people still have thoughts and feelings about the recently dead. This discrepancy between incompatible intuitions about a single object might explain why recently dead people are so often seen as supernatural agents [6]. The effect of these different mental systems is also visible in

culturally widespread distinctions between the social part of the dead person that is still sentient and the 'impure' and dangerous decaying body [34].

Evolved disposition or multiple by-product?

Some aspects of religion have a long history, as documented by Palaeolithic drawings of imaginary objects [35] and apparently ritualized burials in both humans and Neanderthals [36]. Most attempts at an evolutionary account of religion have proved unsatisfactory because a single characteristic identified as crucial to the origin of religion is not in fact general (Table 1). The attempt to find the single evolutionary track for religion is another manifestation of a general urge to identify the single mechanism that motivates religious thought or makes it plausible to believers. However, evolution by natural selection is certainly relevant to understanding the functional properties of each of the distinct mental systems described here [37]. The way animate beings are detected, agents represented, moral intuitions processed or contagion feared are all plausible outcomes of evolutionary processes. There is now a growing body of evolutionary thinking that connects the following elements of a potential evolutionary framework: (1) features of religious concepts; (2) experimental evidence for underlying cognitive systems; (3) clues about the genetic basis of these systems; and (4) precise hypotheses about the reproductive advantage provided by possession of such capacities [6,7].

Belief and neuroscience

People do not generally have religious beliefs because they have pondered the evidence for or against the actual existence of particular supernatural agents. Rather, they grow into finding a culturally acquired description of such agents intuitively plausible. How does that happen? We know a lot about the external factors that predict differences in religious adherence [38] but we know little about the cognitive processes involved, about the difference between imaginary companions and supposedly real protective ancestors. The cognitive findings summarized here offer a speculative explanation.

First, religious representations activate a variety of specialized (non-religious) conceptual capacities. In this review, I mentioned the effect of several of these systems, and many more are certainly involved. None of these systems handles explicit judgments about the existence of spirits, for example, but all of them run off-line inferences on the *assumption* of spirits being around.

Second, belief in supernatural agents (like many other explicit beliefs) is a high-level, conscious and meta-representational state. That is, people are aware of their assumption that ancestors are around (by contrast, they also assume that objects fall downwards but are not necessarily aware of that assumption). In other words, explicit beliefs of this kind are *interpretations* of one's own mental states [39].

It is a plausible hypothesis in cognitive neuroscience that some mental systems, possibly supported by specific networks, are specialized to produce such explicit, relevant interpretations or post-hoc explanations for the operation and output of other mental systems [40].

Perhaps the impression that elusive agents really are around is an interpretation of this kind, as a result of the coordinated activity of many automatic mental systems [6]. In this view, spirits and ancestors would be seen by some as plausibly real because thoughts about them activate 'theory-of-mind' systems *and* agency-detection *and* contagion-avoidance *and* social exchange. Whether or not this interpretation holds will depend on progress in the cognitive neuroscience of religion (see Table 2).

Religious believers and sceptics generally agree that religion is a dramatic phenomenon that requires a dramatic explanation, either as a spectacular revelation of truth or as a fundamental error of reasoning. Cognitive science and neuroscience suggests a less dramatic but perhaps more empirically grounded picture of religion as a probable, although by no means inevitable by-product of the normal operation of human cognition.

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