Magical thinking in judgments of causation: Can anomalous phenomena affect ontological causal beliefs in children and adults?

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In four experiments, 4-, 5-, 6- and 9-year-old children and adults were tested on the entrenchment of their magical beliefs and their beliefs in the universal power of physical causality. In Experiment 1, even 4-year-olds showed some understanding of the difference between ordinary and anomalous (magical) causal events, but only 6-year-olds and older participants denied that magic could occur in real life. When shown an anomalous causal event (a transformation of a physical object in an apparently empty box after a magic spell was cast on the box), 4- and 6-year-olds accepted magical explanations of the event, whereas 9-year-olds and adults did not. In Experiment 2, the same patterns of behaviour as above were shown by 6- and 9-year-olds who demonstrated an understanding of the difference between genuine magical events and similarly looking tricks. Testing the entrenchment of magical beliefs in this experiment showed that 5-year-olds tended to retain their magical explanations of the anomalous event, even after the mechanism of the trick had been explained to them, whereas 6- and 9-year-olds did not. In Experiment 3, adult participants refused to accept magical explanations of the anomalous event and interpreted it as a trick or an illusion, even after this event was repeated 4 times. Yet, when in Experiment 4 similar anomalous causal events were demonstrated without reference to magic, most adults acknowledged, both in their verbal judgments and in their actions, that the anomalous effects were not a fiction but had really occurred. The data of this study suggest that in the modern industrialized world, magical beliefs persist but are disguised to fit the dominant scientific paradigm.

The fact that anomalous data (i.e. data that contradict established views) are often ignored or reinterpreted to make them fit established views has long been acknowledged in philosophy of science (Humphreys, 1968; Kuhn, 1970; Lacatos, 1970). It has also been shown in developmental research that students often retain their naive

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physical (Champagne, Gunstone & Klopfer, 1985; Chi, 1992; Kuhn, 1989; Levin, Siegler, Druyan, & Gardosh, 1990; McCloskey, 1983) and psychological (Nemeroff & Rozin, 2000; Subbotsky, 1997, 2000) theories, even after they received appropriate scientific instructions.

In their comprehensive account of people’s reactions to anomalous data, Chinn and Brewer (1993) argued that preserving the original theory includes six main forms of responding to anomalous data: (1) ignoring the data; (2) rejecting the data; (3) excluding the data; (4) holding the data in abeyance; (5) reinterpreting the data; or (6) making minor peripheral changes to the original theory. The authors presented ample evidence from both the history of science and psychological research, which shows that scientists and students use similar strategies to discount anomalous data before they succumb to those data and change their original theories. Among the factors that influence the way in which people respond to anomalous data, Chinn and Brewer mentioned characteristics of prior knowledge, such as the entrenchment of the original theory, and characteristics of the anomalous data, such as credibility of these data.

Although the majority of examples discussed by Chinn and Brewer fall in various specific domains (biology, physics, and geography), the authors suggest that there are special kinds of beliefs—ontological beliefs—which are particularly deeply entrenched and hard to change. These include beliefs about the most basic properties of the world, such as the belief about the structure of matter. However, empirical evidence about how people react to anomalous data in the scope of ontological beliefs is scarce: ‘We would . . . hypothesize that in the domain of magic children and adults make the full range of responses to data that they make in the domain of science and religion, but further research on responses to anomalous data in these areas is needed’ (Chinn & Brewer, 2000, pp. 345–346). To partially fill this gap, in the present study, children’s and adults’ reactions to anomalous data in the scope of beliefs about physical and magical causation were examined.

The belief that the law of physical causality governs the natural world belongs to the scope of ontological beliefs because it is fundamental for maintaining the rational view of the world. It has been established in developmental research that preschool and early-school children acquire a physical natural view of the world. Thus, in their replication of Piaget’s early data (Piaget, 1927), Laurendeau and Pinard (1962) reported that in children between 5 and 11 years of age, physical explanations of natural phenomena gradually replaced ‘pre-causal’ explanations (animistic, artificialistic, and magical). This shift from pre-causal to causal thinking was observed by other researchers as well (Carey, 1985; Rosengren, Kalish, Hickling, & Gelman, 1994; Samarapungavan, 1992; Schultz, Fisher, Pratt, & Rulf, 1986; Smith, Carey, & Wiser, 1985). Regarding manual, sensorimotor objects, this shift from magical to physical thinking occurs even at an earlier age. According to Piaget (1986/1954), around 2 years of age, children start handling manual objects in accord with the objects’ physical and spatial properties. As a result, early beliefs in magical causality eventually die out, at least as far as it concerns physical objects that are within the scope of the child’s everyday practical experience. At the same time, it is not yet clear at what age this fundamental shift in causal beliefs occurs. Specifically, questions remain open as to when exactly children start viewing magical events as anomalous. To what extent are children’s early magical beliefs entrenched in preschoolers and children of various school ages? Can these beliefs be undermined by an explanation that an apparently magical event is, in fact, an ordinary event or a trick?
By the same token, the belief in the universal power of physical causality,\(^1\) which replaces early magical beliefs, can vary in its degree of entrenchment as well. One might expect preschool children, when shown an anomalous event that looks like magic, would be quick in dropping their newly acquired scientific causal beliefs and acknowledging that magic is real, whereas schoolchildren and adults would resist the anomalous experience by ignoring, rejecting, or reinterpreting the anomalous data. But would adults stick to their physical causal beliefs if the anomalous causal events (for instance, magical events) were repeatedly shown to them within a short period of time? Likewise, would adults be consistent in their scientific views and deny the reality of anomalous causal phenomena if these phenomena were structurally identical to magical events but framed in a non-magical context? And would adults be able to persist in their disbelief in the anomalous causal effects not only in their verbal judgments but in their actions as well, when this disbelief can be costly for them? In other words, the studies presented in this paper aimed to examine the extent to which children’s and adults’ causal beliefs could be affected by the presentation of anomalous (magical) causal events.

In the studies related to the problem, three main issues were addressed. The first issue dealt with the problem of how frequently children of varying ages refer to magic in their spontaneous explanations of phenomena unknown to them. It has been reported that even 4- and 5-year-old children can discriminate between possible and impossible transformations, without spontaneously invoking the concept of magic (Huang, 1930; Rosengren et al., 1994). In other reports, however, children aged 4, 6, and 8 years quite often used the term ‘magic’ when confronted with phenomena for which they did not have correct physical explanations (Chandler & Lalonde, 1994; Phelps & Woolley, 1994).

These conflicting reports raise the question of what children of varying ages actually mean by magic. In some studies on children’s magical thinking, it remains unclear if children who used the concept of magic meant real magic that involved supernatural powers, or just tricks and parlour magic (Chandler & Lalonde, 1994; Rosengren & Hickling, 1994; Rosengren et al., 1994). In other studies, children’s responses indicated their growing awareness of magic as events different from tricks and involving violations of fundamental physical laws (for instance, in Phelps and Woolley’s 1994 study, one 8-year-old commented that magicians cannot make a house appear in an instant, while a fairy can make it appear just like that). Altogether, there is some evidence that at the age of 5 or 6 years, children acquire the understanding that genuine magic is different from stage magic and is impossible in the real world.

The past research reviewed, however, only examined children’s verbal reactions about magic. The second issue targeted children’s behavioural responses to events that involve magical transformations, like the creation of some entity by only thinking hard about it. Most studies suggest that children and adults’ tendency to engage in magical practices during an experiment is a function of ‘cost’ of these practices for participants (Woolley & Phelps, 1994). In their verbal judgments, schoolchildren and adults usually show scepticism towards magic. Yet, if scepticism towards magic involved a potentially high cost, children (Johnson & Harris, 1994; Harris, Brown, Mariott, Whittall, & Harmer, 2002; Laurendeau & Pinard, 1962; Piaget, 1927), and, at some level, can even be traced in adults (Nemeroff & Rozin, 2000).
1991; Subbotsky, 1985, 1994) and even adults (Rozin, Markwith, & Ross, 1990; Rozin, Millman, & Nemeroff, 1996; Subbotsky, 1997; Subbotsky & Quinteros, 2002) behaved as if they were engaged in magical thinking.

The third issue is most closely related to the problem raised in the present study: At what age do children start viewing events that violate physical laws as anomalous and dismiss or reinterpret these events to preserve their scientific view of the world? In a study by DeLoache, Miller, and Rosengren (1997), 2½-year-old children typically failed to repeat scientific explanations of magical phenomena when describing the experiment to a non-accompanying parent; instead, they said that a real magical transformation had been observed. In another study, 4- and 5-year-old children were confronted with commonplace and impossible transformations after the children were asked to judge the possibility of these transformations (Rosengren & Hickling, 1994). Although, in the beginning, most children denied the reality of impossible transformations, after seeing the ‘impossible’ events, many 4-year-olds changed their minds and acknowledged these events to be ‘really magical’, whereas 5-year-olds insisted that they were tricks. This suggests that at the age of 5 years, children already hold the fundamental belief in the universal power of physical causality.

Altogether, the reviewed studies illuminated a number of important questions in the development of causal thinking, yet they also shared some methodological limitations. In some of these studies, participants did not really observe any magical transformations, and in others, the phenomena that were supposed to look magical were, in fact, classical tricks with which children could have been familiar from their past experience (watching movies, TV programmes, or going to the circus). This created the ambiguity in interpreting children’s answers: Most children could view these phenomena as tricks, even if they labelled them as magic. If this were the case, observing these phenomena could not present a serious challenge to the older children’s belief in the universal power of physical causality. To overcome this limitation, a trick should be presented that does not come from a traditional set of tricks available in magic shops and would, therefore, look more convincingly like an instance of real magic.

To summarize, the shift from early magical beliefs to the belief in the universal power of physical causality warrants more systematic examination. Specifically, the following questions remain open: Is the acquisition of the knowledge that magical events are incompatible with physical events a sufficient condition for children to drop their belief in magic? And under what conditions is verbal scepticism toward magical events accompanied (not accompanied) by the appropriate behavioural responses?

Theoretically, there can be two types of judgment about magic: a conceptual judgment and an ontological judgment. On the conceptual level, a person whose magical beliefs are examined has to be able to understand the difference between magical and ordinary (non-magical) events. In other words, the person has to have a concept of magical events as events that violate known physical laws. Such violations include at least four types of events (see Boyer, 1994; Frazer, 1922; Jahoda, 1969; Seligman, 1948; Tambiah, 1990). The first type involves a direct effect of ‘consciousness over matter’, like moving, creating or changing physical objects by a magic spell or the sheer effort of will or thought (‘thought over matter magic’). The second type involves a sudden acquisition of spontaneity (like feelings or independent movements) by a non-animate physical object (‘coming to life magic’). The third type implies violation of the fundamental law of object permanence: if a physical object spontaneously changes its shape, appears from thin air, and disappears without a trace (‘transformation magic’). Lastly, the widely spread belief about certain objects (stones, skulls, and mascots) and
actions (crossing fingers and tapping on wood) as bringing luck or affecting the flow of natural events can also be considered as magical (‘participation or sympathetic magic’). If a person can distinguish clearly between magical events (like a piece of paper changing its shape as a result of a magic spell) from ordinary events (a piece of paper changed by applying a physical action to it), and from a similarly looking trick (a piece of paper is changed by inconspicuously replacing it by another one), then the person can be qualified as having a proper concept of the ‘thought over matter’ magic.

Yet, to qualify a person as a believer or non-believer in magic, along with the person’s conceptual understanding of magic, their ontological judgment needs to be examined. If a person who has a proper concept of magic also thinks that magic is possible in the real world, then this person can be viewed as a believer in magic, at least as far as the person’s verbal responses are concerned.

Accordingly, one problem of this study was to examine at what age children acquire the adequate knowledge of magical events as something that involves the supernatural, and at what age they start viewing this kind of causal events as anomalous and non-existing in the real world. Another problem was to investigate under what conditions children and adults are prepared to abandon their belief in physical causality if they are faced with anomalous causal events.

In Experiment 1, children’s and adults’ capacity to distinguish between magical and ordinary transformations was examined, and the entrenchment of their belief in the universal power of physical causality was tested. In Experiment 2, we examined children’s capacity to distinguish between genuine magical events and similarly looking tricks. In addition, the entrenchment of their beliefs in the reality of magical causal events was investigated. In Experiment 3, adults’ capacity to distinguish between magic and tricks was tested, and the entrenchment of their beliefs in physical causality was further assessed by a repeated demonstration of anomalous events that were presented as magical events. Lastly, in Experiment 4, the entrenchment of adults’ belief in the universal power of physical causality was examined in the conditions in which anomalous causal events were presented without the magical context, and at different levels of processing—verbal and non-verbal (behavioural) processing.

EXPERIMENT 1

Method

Participants

Participants were 48 children, with 16 children in each age group of 4-year-olds (age range 4.0–4.11, $M = 4.5$), 6-year-olds (6.0–6.11, $M = 6.6$), and 9-year-olds (9.0–9.11, $M = 6.5$), all attending schools in Lancashire County. Thirty-three undergraduate university students also participated in this experiment: 17 participants ($M = 21.5$, 18–28 years) in Condition 1 (restoration), and 16 participants ($M = 22.6$, 18–35 years) in Condition 2 (destruction).

Materials

A wooden box of dimensions 15 × 11 × 11 cm was used for the demonstration of ‘magical’ phenomena. A special construction of the lid and a hidden trap door allowed
one to show an event that looked like a violation of object permanence: A new postage stamp placed in the box could become torn and crumpled (destruction) or the other way round (restoration). The box could be manipulated (i.e. turned upside down or shaken) without revealing the secret of the trick. There were two postage stamps: one brand new and the other torn and crumpled. One of the stamps was hidden between the trap door and one of the box’s walls, and the other was available on the table next to the box.

**Procedure**

Participants were tested individually. There were two trials: an interview trial and a demonstration trial. In the interview trial, participants were asked questions in which their understanding of magical events was tested. There were four pairs of items, each pair presenting an ordinary and a magical outcome. The magical outcomes involved various instances of object permanence violation: disappearance, creation, destruction, and restoration of a solid physical object (a postage stamp) that occurred in an empty box under the influence of a magic spell. For instance, in the ‘disappearance’ pair of items, the ordinary and magical outcomes were presented as follows: ‘Suppose, a person puts a postage stamp in an empty box like that, then says some magic words, opens the box and finds the same stamp in it (ordinary)’ and ‘Suppose, a person puts a postage stamp in an empty box like that, then says some magic words, opens the box and there is no the stamp in the box, it disappeared. Please, bear in mind that it disappeared because the magic words made it disappear, not because it was some kind of trick, OK? (magical)’. After presenting each item (the order of presentation was randomized), the participant was asked two questions: a conceptual question (would this be magic, or would there not be any magic in it?) and an ontological question (can this event really happen or not?)

The aim of the demonstration trial, which followed the interview trial, was to examine the entrenchment of participants’ belief in the universal power of physical causality. In this trial, the participant was shown the box and asked to make sure that it was empty. Next, the participant was asked to examine the postage stamp, tell whether it was new or old, place the stamp into the box, and close the lid. The experimenter then proceeded with the following instruction: ‘Now, I am going to put a magic spell on this box’. The experimenter pronounced some words that sounded like a magic spell and asked: ‘Now, what do you think . . . has the postage stamp that you placed in the box changed, or does it remain the same?’ If the answer was ‘Yes, it changed’, the question followed ‘How did it change?’.

Next, the participant was asked to open the box and remove the stamp. On opening the box, the participants would discover a brand-new postage stamp inside the box, instead of the crumpled stamp. Questions that followed were: ‘What is this?’ and ‘Is this the same postage stamp that you had placed into the box but changed, or is it a different postage stamp?’ If the participant said that it was a different postage stamp, they were encouraged to search for the original postage stamp inside the box. This was done to create the impression in the participant that something really unusual had happened: An old and broken postage stamp became a new one after the magic spell was said. Participants were then asked two key questions: ‘What do you think has happened to the postage stamp, why has it become new?’ (spontaneous explanation) and ‘If I told you that I did this with the help of my magic words, as wizards do in fairy tales, would you believe me or not?’ (suggested explanation). The participant’s
scepticism toward (disbelief in) magic can be considered entrenched if the participant does not produce or accept magical explanations, even if they were shown an anomalous causal event that looked like an instance of magic.

For adults, the procedure was the same, except that in the demonstration trial, instead of one phenomenon, two ‘magical’ phenomena were demonstrated. One phenomenon was ‘restoration’ (Condition 1), which was identical to that shown to children, and another was ‘destruction’ (Condition 2). In the ‘destruction’ condition, participants observed a new postage stamp becoming torn and crumpled after it had been placed in the box, and a magic spell was put on the box. This condition was introduced to control the ‘type of phenomenon’ factor (i.e. to identify whether participants’ credulity or scepticism towards magic was specific or not specific to the demonstrated phenomenon). The rationale for this manipulation was that in a popular view, magic is more often associated with destruction than with renovation of objects (Seligman, 1948). If this is the case, participants could be expected to show stronger credulity towards anomalous events in the ‘destruction’ condition than in the ‘renovation’ condition.

Results

In the interview trial, participants were assigned two sets of scores, for answers to each of the two questions (a conceptual question and an ontological question), separately. For answers to the conceptual question (would this be magic, or would there not be any magic in it?), a score of 1 was given to a participant if their answer to the non-magical outcome (magic spell did not affect the object in the box) was ‘no’, and to the magical outcome (magic did affect the object) ‘yes’. This score certified that the participant could correctly identify magical and ordinary outcomes. In any other distribution of answers (a wrong identification of either the magical outcome or the non-magical outcome, or both), the participant was given a zero score. As a result, participants could receive a maximum score of 4 and a minimum score of zero. For answers to the ontological question, a score of 1 was given if the answer was ‘yes’. This score certified that the participant believed that this particular ordinary or magical event could occur in the real world. If the participant denied the possibility that the outcome could occur, they were given a zero score. The participant’s belief in the

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<thead>
<tr>
<th>Table 1.</th>
<th>Mean scores (standard errors) for conceptual and ontological questions in the interview trial (maximum possible score: 4), and for magical beliefs in the demonstration trial (maximum possible score: 2) of Experiment 1 as a function of age and outcome</th>
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<tbody>
<tr>
<td><strong>Interview trial</strong></td>
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<td><strong>Conceptual</strong></td>
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<td>Age (years)</td>
<td>Conceptual</td>
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</tbody>
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possibility of events described as ordinary or magical could therefore be assessed on the scale from 4 (a firm believer) to zero (a non-believer).

Children’s mean scores on their answers to the conceptual questions and ontological questions in the interview trial are shown in Table 1. As this table shows, all the children were positive about the real existence of the ordinary outcomes. A one-way ANOVA of age (3) for ontological judgment about the magical outcomes showed a main effect, $F(2, 45) = 23.22, p < .0001$. A post-hoc Fisher’s protected LSD indicated that 4-year-olds scored higher on their verbal beliefs in magic than 6-year-olds ($p < .05$) or 9-year-olds ($p < .05$). Within-age comparisons by chi-square test\(^2\) between numbers of children who believed in the real existence of all four magical events and those who believed in the reality of all four ordinary events showed that in 4-year-olds, this difference was insignificant, whereas in 6- and 9-year-olds, significantly smaller numbers of children believed in reality of magical events than in reality of ordinary outcomes, $\chi^2(1) = 21.9, p < .01$, for both age groups. There were no age differences found between children’s answers to the conceptual questions.

In the demonstration trial, a participant was given a score of 1 if they evoked the concept of magic in their spontaneous explanations of the phenomenon (answers to the first key question), and a score of 1 if the participant said ‘yes’ in response to the second key question (a suggested magical explanation of the phenomenon). For the alternative answers, participants received a score of zero. The degree of participants’ beliefs in a magical causal explanation of the anomalous event could therefore be assessed on the scale from zero (a low degree of belief) to 2 (a high degree of belief).

Participants’ scores on the results of the demonstration trial are shown in Table 1. A one-way ANOVA for age (3) showed the main effect, $F(2, 45) = 30.8, p < .0001$. Fisher’s protected LSD indicated that 9-year-olds scored lower on this trial than did either 6-year-olds ($p < .01$) or 4-year-olds ($p < .01$). The differences between the scores of 6-year-olds and 4-year-olds were not significant.

In addition, participants’ general patterns of responses in both trials were assessed and classified. Participants who scored at least 3 on both conceptual and ontological questions about magical outcomes in the interview trial, were classified as believers in magic, and participants who scored at least 3 on the conceptual questions but zero on the ontological question about magic were classified as non-believers in magic. The second class of participants was further divided in two subclasses. The non-believers in magic were considered as having entrenched disbelief if they scored zero on the demonstration trial. If these participants scored 1 or 2 in the demonstration trial, they were qualified as those whose disbelief in magic was not entrenched.

General patterns of participants’ responses in both trials are shown in Table 2.\(^3\) A chi-square test showed that the number of believers in magic was significantly larger among 4-year-olds than among either 6-year-olds or 9-year-olds, $\chi^2(1) = 15.36, p < .0001$, the number of non-believers with the ‘entrenched’ pattern was significantly larger among 9-year-olds than among 6-year-olds, $\chi^2(1) = 6.51, p < .01$, and the number of non-believers with the ‘not entrenched’ pattern was the largest among 6-year-olds: This number significantly exceeded the respective numbers in either 4-year-olds, $\chi^2(1) = 10.8, p < .001$, or 9-year-olds, $\chi^2(1) = 8.29, p < .004$. Pairwise comparisons between categories of adult participants and those distinguished in 9-year-olds showed

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\(^2\)In this study, chi-square test with Yate’s correction for continuity was used (Ferguson, 1971).

\(^3\)As long as there were no significant differences found between the ‘restoration’ and ‘destruction’ conditions, the results of both conditions were collapsed.
that the number of non-believers in adults only marginally exceeded that in 9-year-olds, $\chi^2(1) = 3.73, p = .053$.

**Discussion**

The data indicated that children of all age groups had no difficulty in distinguishing between magical and ordinary outcomes. While supporting the results of earlier studies that showed the capacity of young preschoolers to distinguish between magical and non-magical events (Johnson & Harris, 1994; Phelps & Woolley, 1994; Rosengren *et al.*, 1994), the data of this experiment also add a new element: In this experiment, the meaning of magic (as a kind of event that involves the supernatural and is different from tricks) was made more distinct. Yet, while most 4-year-olds also believed that magical events could occur in the real world, most 6- and 9-year-olds denied this. This again confirms the data of previous studies in which it was shown that 4-year-old children were credulous towards magic (Rosengren & Hickling, 1994), and 5- to 8-year-olds were increasingly sceptical towards it (Johnson & Harris, 1994; Phelps & Woolley, 1994). Nevertheless, in 6-year-olds, their disbelief in magic was not entrenched: When children were confronted with anomalous causal events that looked like instances of real magic, most of them were quick to retreat to magical explanations. In other words, most 6-year-olds fit the category of non-believers with the ‘not entrenched’ pattern: They changed their scepticism toward magic for credulity as soon as they were shown a phenomenon that looked like an instant of real magic.

This result deviates from the data of previous studies. A similar pattern was reported to exist in 4-year-olds (but not in 5-year-olds) with regard to the extraordinary transformations based on the professional quality magic tricks (like a nickel changing its visible size or a dot changing its colour; Rosengren & Hickling, 1994). The question arises as to why, in the study by Rosengren and Hickling, 5-year-olds produced few magical explanations after observing unusual phenomena, while in this study, the majority of 6-year-olds acted as if experiencing a magical event eliminated their scepticism towards magic.

One possible answer to this question lies in the nature of phenomena that were presented to the children as ‘magical phenomena’. Indeed, what children of 4 years and older generally view as magic is deeply embedded in the existing cultural tradition. Typically, in Western cultures, children are acquainted with magic through books,
films, and stories in which characters with special powers are involved (like Santa Claus, Easter Bunny, or Tooth Fairy). The type of magical events that these characters represent is usually ‘consciousness over matter’, i.e. changing things in the external world through sheer will power or magic spells. Along with this concept of magic, children are acquainted with the parallel concept of parlour magic that involves professional tricks usually performed by stage magicians. It is possible to assume that, while observing the tricks in Rosengren and Hickling’s study, children as young as 5 years were already quite reluctant to call these events magical. In contrast, in this study, the magical event observed was from the same class of events that usually are performed by fairy characters (consciousness over matter); as a result, even children older than 5 years were quite impressed by seeing this kind of event for real and quick to change their original scepticism for credulity.

Another way to account for the difference between the results obtained is to explain it by the differences in methodology. In this study, the experimenter explicitly talks about magic and uses magic words in conjunction with the event, while in the study by Rosengren and Hickling, no magic words were uttered during the demonstration of unusual events, and the interview about magic occurred after the children had seen all the events. The creation of magical context in this experiment may have increased the likelihood that magical explanations would be accepted, even by children over the age of five. While these different accounts warrant further investigation, it has to be noted that in both studies discussed, children denied the reality of the transformations prior to the demonstration of the tricks. Yet, in this study, the demonstration changed the children’s ontological judgments, while in Rosengren and Hickling’s study, it did not.

A different pattern of behaviour was shown by 9-year-olds, most of whom had entrenched disbelief in magic. Even if they saw an event that looked like magic, they discredited the anomalous data and interpreted them as tricks.

As expected, the great majority of adults were non-believers in magic with the ‘entrenched’ pattern. Like 9-year-old children, most adults interpreted the observed anomalous events as tricks, and not real magic. No one, though, was able to reveal the secret of the trick.

To summarize, it appears from these results that in 4-year-olds, the belief in physical causality coexists with the belief in magical causality. It is evident from the fact that children of this age attributed equally high ontological scores to both magical and ordinary events in the interview trial, and the majority of these children proved to be believers in magic in the demonstration trial. In contrast, 6-year-olds start viewing magical events as anomalous: They assessed magical outcomes as significantly less likely to occur in real life than ordinary outcomes. Yet, it is only in 9-year-olds that the scepticism toward magic becomes sufficiently entrenched to withstand a personal encounter with anomalous causal events.

However, there can be some problems raised regarding the interpretation of these results. First, it could be argued that, in the interview trial, the capacity of children to distinguish between magical and ordinary outcomes did not necessarily mean that they could also distinguish between magical events and similarly looking tricks. Indeed, calling the event in which the magic spell was followed by a change of the object in the box ‘magical’, 4- and 6-year olds could think that the magic words simply preceded the change, whereas the change itself was a trick. In other words, it may have been the case that the children distinguished between magical and ordinary events not because they understood the true nature of magic, but because the wording of the interview only involved the change of an object in ‘magical items’ (the objects appeared or
disappeared after the magic spell words were said) but not in ordinary items (magic words were said but nothing happened).

Second, in the demonstration trial, the transformation of an old stamp into a new stamp may not have looked convincing enough to persuade children to accept it as a magical event. Indeed, in most stories and books for children that involve magic, magic is associated with some kind of burning or transformation, rather than with restoration.

Finally, observing magical events can challenge children’s disbelief in magic (i.e. their belief in the universal power of physical causality), but not the magical beliefs per se. To examine the extent to which their beliefs in magic are entrenched, children should be shown that some events that they labelled magical could, in fact, be explained as tricks. One might expect that younger children with entrenched magical beliefs would ignore this demonstration and stick to the magical explanations, whereas older children would be ready to abandon their magical beliefs and shift to non-magical explanations. Experiment 2 was conducted to clarify these questions and investigate the entrenchment of magical, as well as physical, causal beliefs.

The first objective of Experiment 2 was to replicate the results of Experiment 1 using a refined methodology—an amended interview trial that targeted the children’s capacity to distinguish between real magical phenomena and similarly looking tricks, and a more authentic magical phenomenon (burning half of a postage stamp, instead of transforming an old postage stamp into a new one). The second objective was to examine the degree of entrenchment of magical beliefs in 5-, 6-, and 9-year-old children.

EXPERIMENT 2

Method

Participants
Participants were twenty-seven 5-year-olds (M = 5.4, range 5.1–5.12), twenty-seven 6-year-olds (M = 6.4, 6.1–6.11), and twenty-five 9-year-olds (M = 9.4, 9.1–9.11), with approximately equal numbers of boys and girls. All children came from a suburban school in Lancashire and were tested in the school’s library.

Materials
A wooden trick box like that in Experiment 1 and two identical postage stamps were used. One stamp was brand new, and the other was half burned.

Procedure
Participants were tested individually. There were five trials altogether: an interview trial, a demonstration trial, a prompt trial, an explanation trial, and a ‘tentative demonstration’ trial.

In the interview trial, participants were tested on two issues: (a) whether or not they understood the meaning of real magic and could distinguish real magic from magically looking tricks, and (b) whether or not they believed that real magic is possible. Children were shown two pictures of a wizard who performed the unusual events. The pictures differed only in the colour of one of the following features: a cap, buttons, shoes, or a
beard. They were then told that one of the two men was a real wizard and could do real magic, and the other only pretended that he could do real magic, but in reality, he could only show tricks that looked like magic. The children were then presented with 4 pairs of test items: creation, disappearance, destruction, and restoration of an object (i.e. 8 items in total). For each given pair of items, there was a distinct set of props (e.g. a postage stamp placed in an empty briefcase which had a secret pocket in it). Children were first told about these props and then asked to consider two different outcomes: a trick that looked like magic, and a genuine instance of magic that involved a violation of known physical principles (the ‘thought over matter’ type of magic). An example of the first outcome was presenting a postage stamp to disappear in an apparently empty briefcase after a magic spell was cast while in fact hiding it in a secret pocket, and an example of the second outcome was destroying a postage stamp in an empty briefcase with the help of a magic spell. After describing the item with the genuine instance of magic, the experimenter immediately asked two questions: a conceptual question that targeted children’s capacity to theoretically distinguish between magic and tricks (whether the outcome is a trick or an instance of real magic) and an ontological question (whether this outcome could indeed happen in the real world or it could not). When the item was presented that described a trick looking like magic, only a conceptual question was asked. The reason for this was that in a pilot study, children of all ages failed to understand the ontological question about this item due to its inherent ambiguity: A magic trick can be done in the real world, and yet what the trick is suggesting (genuine magic) cannot. To test the reliability of children’s judgments, after presenting each pair of items the child was asked, in a different form, a third conceptual and a second ontological question. These questions asked the children to identify which of the wizards was a real one and which one only pretended, and to tell whether the instance of genuine magic could happen in the real world or only in fairy tales. This was done to further decrease the possibility of children mistaking this and the subsequent trial for a game of pretence.

Specifically, in Item 1 (Disappearance) participants were told:

On the first day, the two men showed us how they can make things disappear. One of the men (with the red cap) showed us an empty briefcase that had a secret pocket in it. The man took a postage stamp, placed it in the briefcase, closed the briefcase and said some magic words. While he was saying the magic words, he shook the briefcase slightly, so that the postage stamp slipped into the secret pocket. The man then opened the briefcase and showed us that it was empty, OK? Now tell me, was this magic or was it a trick?

The other man (with the blue cap) too showed us an empty briefcase that had a secret pocket in it. The man then placed the stamp into the briefcase, closed the briefcase, and said some magic words. The magic words made the postage stamp disappear into thin air, so that the stamp vanished from the briefcase. The man then opened the briefcase, and we saw that it was empty. Now tell me, was this magic or was it a trick? Can it be done in the real world or can it not?

‘Now, please, show me, which of these two men was a real wizard, and which was only pretending that he was a wizard.’

If the child could identify the picture of a real wizard correctly, a second ontological question was asked: ‘And do you think that it is indeed possible in the real world to make things disappear into thin air with the help of the magic words, or can it only happen in fairy tales?’

To avoid an order effect, item order was randomized across subjects. The order of
presentation and questioning about magic versus trick was counterbalanced. The sequence for particular items and for pairs of items (creation, disappearance, destruction, and restoration) was also counterbalanced.

Children who passed the interview trial, participated in the demonstration trial, and those who failed the interview trial were excluded from participation in the demonstration trial. Passing the interview trial would also increase the probability that participants in all age groups understood the instructions in this and subsequent trials in a similar way.

In the demonstration trial, the children were tested on the entrenchment of their disbelief in magic. They were shown the magical causal event as in Experiment 1, except that a brand-new postage stamp became half burned after the experimenter pronounced the magic spell. Three questions were then asked: (1) ‘What do you think has happened to the postage stamp? Why has it become half burned?’, (2) ‘Do you think that it was my magic spell that made a burned stamp appear instead of a new stamp, or was it not my magic spell?’, (3) ‘Do you think what I did to the postage stamp was real magic or was it a trick?’ Like in Experiment 1, in this experiment, the aim of this trial was to examine the entrenchment of children’s disbelief in magic. This disbelief can be considered entrenched if the demonstration of the anomalous causal event that looked like an instance of real magic would not make children change their view that magic is impossible in real life.

Children who produced or accepted magical explanations in the demonstration trial participated in the prompt trial. In contrast to the previous trial in which the entrenchment of children’s scepticism (disbelief) toward magic was tested, in this trial children were tested on the entrenchment of their credulity toward (i.e. belief in) magic. They were shown the trap door in the box. They were given the following instruction:

Look, this is not an ordinary box, but a special box. It has a trap door in it. See, I can lift this door with the help of this piece of wire, and it sticks to this wall. When I close the lid of the box, this little cog on the lid pushes the trap door down, and the trap door drops down on the bottom. Can you see it?

After this, the same questions as those in the demonstration trial were asked. The aim of this trial was to examine the entrenchment of children’s magical beliefs. Belief in the reality of magic can be considered entrenched if children who accepted magical explanations of the phenomenon in the demonstration trial retain this explanation after they are given a hint that the phenomenon had, in fact, been a trick, by explaining to them the mechanism of the trick box.

Children who retained their magical explanations in the prompt trial participated in the explanation trial. In this trial, the children were tested on the depth of the entrenchment of their magical beliefs. Instead of just being shown how the trick box worked (like in the previous trial), in this trial they were shown how the trick was done. They were given the following instruction: ‘Look, now I am going to show you what really happened when I showed you how a new stamp became burned, OK? There had been a half burned stamp hidden between this trap door and the wall of the box. When you placed the new stamp on the bottom of this box and closed the lid, the trap door dropped down, it covered the new stamp and released the burned stamp instead’. The instruction was accompanied by the demonstration of all the elements of the trick. After this, the key questions were asked again. The aim of this trial was to test the entrenchment of children’s magical beliefs still further. Magical beliefs can be
qualified as deeply entrenched if children stuck to magical explanations even after the trick had been explained.

Children, who passed the demonstration trial, also participated in the ‘tentative demonstration’ trial. In this trial, the experimenter placed a half burned stamp in the box, closed it and pronounced a magic spell, which ended with the words: ‘I want this stamp to become a living rabbit’. Children were then asked the question: ‘What is in the box now: a stamp or a living rabbit?’ If a child answered that there was a living rabbit in the box, they were then asked: ‘Do you think it can run away if I open the box, or can it not run away?’ The aim of this trial was to test the stability of children’s magical beliefs. Children can be viewed as having stable magical beliefs if they are prepared to expect the postage stamp to become a living rabbit as a result of a magic spell. The children who said that there was still a stamp in the box, or that there might be a rabbit but it was either a picture or a toy and could not run away, can be qualified as those whose magical beliefs are not stable.

Results

Interview trial (testing children’s capacity to distinguish between real magic and magically looking tricks, and their belief or disbelief in magic)

In this trial, for each item, children were given a scored of 1 if they (a) correctly identified the magical outcome as an instance of real magic (maximal possible score: 4), (b) correctly identified a trick as not an instance of real magic (maximal possible score: 4), (c) correctly identified a picture of the real wizard (the third conceptual question, maximal possible score: 4), (d) claimed that the magical outcome could be achieved in real life (maximal possible score: 4), and (e) said that magic is possible in real life, and not only in fairy tales (maximal possible score: 4). For alternative answers, participants received 0 scores. The maximal score that could be achieved in response to conceptual questions was therefore 12, and the minimal score was 0. In response to the ontological questions about magical outcomes, the maximal score was 8 (strong believers in magic), and the minimal number was 0 (non-believers in magic).

In this trial, fifteen 5-year-olds, eleven 6-year-olds, and five 9-year-olds failed to pass the test for understanding the distinction between magical events and tricks that looked like magic (i.e. scored less than 10 out of 12). Nine-year-olds performed significantly better on passing this test than did 5-year-olds, \( \chi^2(1) = 6.9, p < .01 \).

Table 3. Mean numbers (standard errors) of responses to the conceptual questions in the interview trial of Experiment 2, in which the outcome (trick or magic) and the real wizard were correctly identified, and to the ontological questions in which the magical outcome was claimed to be possible in real life, as a function of age and item (maximum possible score: 4)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Conceptual questions (item)</th>
<th>Ontological questions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trick</td>
<td>Genuine magic</td>
</tr>
<tr>
<td>5</td>
<td>2.82 (.20)</td>
<td>2.74 (.19)</td>
</tr>
<tr>
<td>6</td>
<td>3.00 (.18)</td>
<td>2.77 (.20)</td>
</tr>
<tr>
<td>9</td>
<td>3.24 (.18)</td>
<td>2.88 (.20)</td>
</tr>
</tbody>
</table>
The mean scores of correct answers on conceptual questions are listed in Table 3. Two-way repeated measures ANOVA for age (3) and question (3), showed main effects, with $F(2, 76) = 3.11, p < .02$ for age and $F(2, 76) = 3.8, p < .04$ for question. Tukey’s post hoc test showed that 9-year-olds answered significantly better than 5-year-olds, and that real was wizard correctly identified significantly more often than either trick or magic outcomes. The two-tailed Pearson correlation coefficient between correct answers to ‘trick’ and ‘magic’ outcomes collapsed, and the ‘wizard’ question exceeded $r = .84$ in all age groups, which shows that children’s answers to these questions were highly reliable.

In addition, a two-way ANOVA for age (3) and outcome (trick versus real magic, 2) with children calling an outcome to be magical as a dependent measure showed only the main effect of outcome, $F(1, 76) = 124.35, p < .0001$. Children of all ages labelled the event that presented the effect as caused by the magic spell as magic significantly more often than the event that presented the effect as a result of a trick. There were no interaction effects found.

The mean numbers of positive responses to the two ontological questions about magical events are shown in Table 3. Two-tailed Pearson correlation coefficients between the scores on the two ontological questions exceeded $r = .90$ in all age groups, which shows a high degree of reliability of children’s answers to these questions.

A three-way repeated-measures ANOVA for age (3), gender (2), and question (2), with the number of positive responses being a dependent measure, showed that the only significant result was an interaction of age and gender, $F(2, 60) = 3.89, p < .02$. Three two-way repeated-measures ANOVAs for gender (2) and question (2) confirmed that in 9-year-olds, unlike in 5- and 6-year-olds, girls scored significantly higher on the possibility for genuine magical events to happen in real life than did boys.4

**Demonstration trial (testing the entrenchment of children’s disbelief in magic)**

Participants who scored at least 10 out of 12 on conceptual questions of the interview trial (i.e. answered correctly above chance level, binomial two-tailed, $p < .05$) were considered as being able to understand the difference between instances of real magic and similarly looking tricks, and those who scored 9 or less were considered as failing to understand this difference.

Children who could understand the difference between magic and tricks were then classified into two categories: believers in magic and non-believers in magic. Believers in magic were those who had a score of 5 or more (out of maximum 8) on the ontological questions about magical outcomes in the interview trial, and those who scored less than 5 were viewed as non-believers in magic. The rational for using this criterion was that, in the ontological questions, children were asked not about their understanding of magic (this understanding was secured by their passing the test on conceptual questions) but about their magical beliefs. Based on a simple majority of their responses, children were categorized as believers or non-believers. Both of these groups participated in the demonstration trial.

In this trial, a score of 1 was ascribed to participants each time if the participants (a) evoked the concept of magic in their spontaneous explanations (question 1), (b)
acknowledged that it was the magic spell that had produced the effect (question 2), and (c) said that it was an instance of real magic and not a trick (question 3). Zero scores were given if participants produced the alternative answers.

On the basis of their responses in the demonstration trial, the non-believers in magic were further divided into two subcategories: those whose disbeliefs were entrenched, and those whose disbeliefs were not entrenched. The non-believers in magic were classified as having entrenched disbelief if they scored 0 on question (c) (i.e. said it was not real magic, but a trick) in the demonstration trial; if they scored 1 on questions (b) and (c) (i.e. said that the effect was produced by the magic spell and that it was real magic, and not a trick), their disbelief in magic was considered not entrenched.

Mean scores for children’s credulity towards magic in the demonstration, prompt, and explanation trials are shown in Table 4. A one-way ANOVA for each trial showed main effects of age for the demonstration trial, $F(2, 41) = 3.53, p < .05$, and the prompt trial, $F(2, 31) = 15.51, p < .0001$. Tukey’s post hoc test confirmed that in the demonstration trial, 6- and 9-year-olds were significantly more sceptical towards magical explanations than 5-year-olds. Comparisons between numbers of children who accepted magical explanations in this trial (i.e. scored 1 on at least (b) and (c) questions) also showed a significant difference: in 9-year-olds, a significantly smaller number of children (13 out of 20) explained the effect as magical than in 5-year-olds (12 out of 12), $\chi^2(1) = 5.37, p < .02$, with 6-year-olds occupying a marginal position (12 out of 16). All children who produced or accepted magical explanations in the demonstration trial participated in the prompt trial.

### Table 4. Mean scores (standard errors) for answers invoking magic in Experiment 2, as a function of age and trial (maximum possible score: 3).

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Demonstration</th>
<th>Prompt</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2.83 (.11)</td>
<td>2.70 (.25)</td>
<td>1.54 (.39)</td>
</tr>
<tr>
<td>6</td>
<td>2.40 (.28)</td>
<td>1.23 (.34)</td>
<td>.43 (.42)</td>
</tr>
<tr>
<td>9</td>
<td>1.80 (.29)</td>
<td>.41 (.28)</td>
<td>.00 (.00)</td>
</tr>
</tbody>
</table>

Tukey’s post hoc test confirmed that in the demonstration trial, 6- and 9-year-olds were significantly more sceptical towards magical explanations than 5-year-olds. Comparisons between numbers of children who accepted magical explanations in this trial (i.e. scored 1 on at least (b) and (c) questions) also showed a significant difference: in 9-year-olds, a significantly smaller number of children (13 out of 20) explained the effect as magical than in 5-year-olds (12 out of 12), $\chi^2(1) = 5.37, p < .02$, with 6-year-olds occupying a marginal position (12 out of 16). All children who produced or accepted magical explanations in the demonstration trial participated in the prompt trial.

**Prompt trial (testing the entrenchment of children’s beliefs in magic)**

In this trial, children were scored as in the previous trial. Children who scored at least 1 on the first two questions of the prompt trial (i.e. either evoked the concept of magic in their responses to question (a), or answered ‘yes’ to the suggested magical explanation in questions (b) and said that it was real magic (question (c)) were considered as having entrenched magical beliefs, and those who scored 0 on question (c) (said that it was not magic but a trick) were considered as those whose beliefs in magic were not entrenched.

Tukey’s post hoc test also indicated that in the prompt trial, 9- and 6-year-olds showed a significantly lesser degree of credulity toward magic than did 5-year-olds ($p < .05$). In this trial, the number of children who showed entrenched magical beliefs...
was significantly larger in 5-year-olds (11 out of 12) than in 6-year-olds (4 out of 12), \( \chi^2(1) = 8.7, p < .01 \), or in 9-year-olds (2 out of 13), \( \chi^2(1) = 14.54, p < .0001 \).

**Explanation trial (testing the depth of the entrenchment of children’s belief in magic)**

Children who showed entrenched magical beliefs in the prompt trial participated in the explanation trial. In this trial, the number of children who showed deeply entrenched magical beliefs was larger in 5-year-olds (8 out of 11) than in 6-year-olds (2 out of 7), though the difference proved insignificant, and there were no children of this category among 9-year-olds (see Table 4).

**Tentative demonstration trial (testing the stability of children’s beliefs in magic)**

All children who passed the demonstration trial participated in the tentative demonstration trial. In this trial, a number of children who showed stable magical beliefs among 9-year-olds was significantly smaller (3 out of 13) than among 5-year-olds (10 out of 12), \( \chi^2(1) = 9.9, p < .001 \), with the number of such children in 6-year-olds being somewhere in between the above numbers (6 out of 12). Correlations between children’s scores of magical beliefs on the two ontological questions collapsed and on the demonstration trial were not significant.

**Table 5.** Numbers (%) of children who showed these patterns of behaviour in the demonstration and prompt trials of Experiment 2, as a function of age

<table>
<thead>
<tr>
<th>Trial</th>
<th>Demonstration (disbelief in magic)</th>
<th>Prompt (belief in magic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Entrenched</td>
<td>Not entrenched</td>
</tr>
<tr>
<td>5</td>
<td>0 (0%)</td>
<td>7 (100%)</td>
</tr>
<tr>
<td>6</td>
<td>4 (30%)</td>
<td>9 (70%)</td>
</tr>
<tr>
<td>9</td>
<td>7 (50%)</td>
<td>7 (50%)</td>
</tr>
</tbody>
</table>

**General patterns of responses**

Children’s general patterns of responses are shown in Table 5. The data in the table show that all 5-year-old children who understood the distinction between magic and tricks exhibited the ‘not entrenched’ pattern. Half of the 9-year-olds who understood the magic/trick distinction and who exhibited disbelief had the ‘entrenched’ pattern. This age difference was significant, \( \chi^2(1) = 5.25, p < .02 \). In 6-year-olds, the number of non-believers in magic with either ‘entrenched’ or ‘not-entrenched’ pattern was in between (but not significantly different from) those found for the other two groups. For children who participated in the prompt trial, most 5-year-olds exhibited ‘entrenched’ belief in magic, and most 9-year-olds exhibited ‘not-entrenched’ belief in magic. This difference was significant, \( \chi^2(1) = 14.54, p < .0001 \). In 6-year-olds, these numbers were again in the intermediate position, yet the number of believers with the ‘not-entrenched’ pattern in 6-year-olds was significantly larger than in 5-year-olds, \( \chi^2(1) = 8.7, p < .01 \).
Discussion

In the interview trial of this experiment, a significant number of children in all age groups (up to 55% in the youngest group) failed to distinguish between instances of real magic and similarly looking tricks. This confirmed our concern that in Experiment 1, part of the children may have labelled some events as magical to contrast these events with ordinary events, and not because the children viewed them as instances of real magic.

Comparisons between the general patterns of answers given by 6- and 9-year-olds in Experiments 1 and 2 showed that in 6-year-olds, the majority in both experiments were non-believers in magic with the ‘not entrenched’ pattern. In 9-year-olds, non-believers in magic with the ‘entrenched’ pattern were the majority in Experiment 1 (77% of participants), and their number dropped, though insignificantly, in Experiment 2 (50% of participants). This drop might be explained by the increase in the authenticity of the anomalous phenomena demonstrated (burning, instead of renovation, of a postage stamp). Yet, like in Experiment 1, in this experiment the number of children with this pattern among 9-year-olds significantly exceeded that among 5-year-olds. This supports the assumption that scepticism toward magic is not entrenched in children in the age of 5–6 years, and becomes entrenched in a large proportion of 9-year-olds.

Regarding the entrenchment of magical beliefs per se, not only did 9-year-olds perform significantly better than younger children in their capacity to distinguish between real and fake wizards, but they also showed a significantly higher drop in their magical explanations in the prompt trial than did 5-year-olds. A significantly larger drop in magical explanations in this trial was also evident in 6-year-olds compared with that in 5-year-olds.

The data showed that in 5-year-olds, magical beliefs are deeply entrenched and stable: Children of this age tended to retain magical explanation, even after they had been encouraged to abandon them by prompting and explaining the mechanism of the trick. In the tentative explanation trial, most of these children were prepared to believe that another type of magical event—a transformation of a non-living entity into a living creature (coming to life magic)—had occurred in front of them. In children of this age, magical beliefs appear to coexist with the belief in physical causality.

In contrast, most 6-year-olds, who also were quite impressed by the anomalous magical experience in the demonstration trial, were quick to abandon their magical explanations as soon as their physical beliefs were supported in the prompt trial. Almost all 6-year-olds dropped magical explanations after the mechanism of the trick was shown to them in the explanation trial. This unstable character of magical beliefs was even more evident in 9-year-olds, among whom only 15% of participants showed entrenched magical beliefs. These results support the earlier observations of the entrenchment of magical beliefs in very young children (DeLoache et al., 1997) and show that, under certain conditions, deeply entrenched magical beliefs can be found, even in 5-year-olds.

To summarize, the experiment confirmed the expectation that the belief in magical causal events is deeply entrenched in 5-year-olds, the entrenchment of this belief decreases in 6-year-olds, and this belief is not entrenched in 9-year-olds. The development of the scepticism toward magic (and, conversely, of the belief in the universal power of physical causality) follows the opposite route: This scepticism is not entrenched in 5- and 6-year-olds, and becomes entrenched in 9-year-olds. Yet, even many 9-year-olds were prepared to acknowledge the possibility of real magic in everyday life. The absence of significant correlations between children’s answers to
ontological questions and their tendency to accept magical explanations in the demonstration trial also testify in favour of the assumption that magical beliefs may disappear from children’s judgments, but not from their behaviour. This suggests that, under certain conditions, magical beliefs can be found in adults as well. Although, in Experiment 1, adults showed zero scores in their ontological judgments about magic and did not change their sceptical view of magic when observed as an anomalous causal event, this can be explained by the low credibility of the anomalous data.

Indeed, why should a single anomalous event have much influence on adult individuals' scepticism toward magical causality? The question arises if the adults can retain their scepticism toward magic (i.e. their belief in the universal power of physical causality) if they are repeatedly confronted with the anomalous causal phenomena that look like instances of magic. It can be expected that the increase in credibility of the anomalous data through repetition would undermine the view of adult participants that magic is impossible in real life. Experiment 3 was conducted to examine this.

EXPERIMENT 3

Method

Participants
Participants were 30 university undergraduates, 15 in each of the 2 experimental conditions. Mean ages and age ranges were 20.8, 18–30 years for Condition 1, and 20.4, 19–22 years for Condition 2.

Materials
A magic box, similar to that used in Experiment 1, and two identical postage stamps were used. The only difference in the construction of the box from that used in previous experiments was that the box used in this experiment did not have a magnet in its bottom. This allowed the experimenter to recharge the box without this being noticed by participants.

Procedure
In the interview trial, a simplified version of a questionnaire used in Experiment 2 was employed. The questionnaire included two pairs of items in which genuine magical events were contrasted with similarly looking tricks. In each of the items, a book appeared or disappeared in an apparently empty briefcase either because of the magic spell or because it fell out of (into) a secret compartment in the briefcase. Conceptual and ontological questions were asked like in Experiment 2.

In the demonstration trial, participants were individually shown 3 events in which a postage stamp appeared or disappeared in an apparently empty box after a magic spell was cast on the box by the experimenter, and one event when the box stayed empty after the magic spell was not cast. Altogether, each participant witnessed 4 subsequent events in which a change (no change) in the empty box was observed as a possible result of casting (not casting) the magic spell. The order of the events was fixed, and it followed the sequence ‘appearance–appearance–no change–disappearance’.
In Condition 1, the interview trial preceded the demonstration trial, and in Condition 2, the order was reversed. This was done to check for a priming effect that the interview trial might have on the results of the demonstration trial. It was expected that the increase in credibility of anomalous data through the repeated demonstration of the effect of the magic spell would significantly increase the participants' probability estimates that the effect they observed was an instance of real magic.

Results
For each event, a participant was asked to assess (a) the probability of change—the probability that a change occurred in the box after the magic spell was or was not cast; and (b) the probability of magic—the probability that any change that was observed after the box was opened was caused by the presence or absence of the magic spell.

In the interview trial, all participants correctly distinguished between genuine magical events and tricks that resembled these events. All participants thought that real magic could not occur in the real world.

In the demonstration trials, the mean probability that the object in the box changed after a magic spell was pronounced grew from $M = 27.17$ ($SE = 4.97$) in trial 1 to $M = 42.8$ ($SE = 4.76$) in trial 2, and then it only slightly increased. A two-way repeated-measures ANOVA for condition (2) and trial (4) showed a main effect of trial, $F(3, 28) = 4.16, p < .01$. Mean probability estimates that the effects were caused by the magic spell varied from $M = 6.46$ ($SE = 2.92$) to $M = 8.86$ ($SE = 3.76$) in Condition 1, and from $M = 6.28$ ($SE = 3.42$) to $M = 16.35$ ($SE = 7.81$) in Condition 2. A two-way repeated-measures ANOVA for condition (2) and trial (4) did not show main effects.

Discussion
The results indicated that although participants' prediction that a change would occur in the box significantly increased in the second trial, their tendency to attribute this change to the magic spell did not. Despite an increase in the 'probability of magic' in subsequent trials, this increase failed to reach a significant level. There were, however, marked individual differences observed. Four participants did increase their estimates of probability of magic up to 90%, and 11 participants gave the probability of magic a fair chance (10% or more). All these participants majored in non-scientific subjects or psychology, and all participants who majored in science (5 altogether) gave magic a probability of zero. This may suggest that science education encourages scepticism toward magical causality to a larger extent than does a humanities education—a suggestion that warrants further investigation.

In general, adult participants did not show a tendency to drop their scepticism toward magic after they were repeatedly—four times—confronted with anomalous data that challenged this scepticism. This suggests that adult participants’ disbelief in magic was deeply entrenched. The question arises as to why the adults stuck to their physical causal explanations, even after the anomalous events that looked like instances of magic were increased in credibility through repetition. A possible explanation for this is that the repetition of the anomalous data is not a sufficient condition to make these data sufficiently convincing. What is needed to make the anomalous data convincing is a plausible theory that would explain the data.
Indeed, as Chinn and Brewer (1993) suggested, one of the important characteristics of the anomalous data that encourages people to change their preinstructional theories is the availability of a plausible alternative theory. The alternative theories which could explain anomalous data like those employed in this study can vary in their plausibility, and framing the data in a magical context is, perhaps, a rather implausible way to explain the effect of the object’s change in the box. A more plausible way to explain the effect could be, for instance, to view it as an effect of the work of some unknown physical device. If this device, like the magic spell, has no physical link to the box, then the assumption that the device changed something in the box would be anomalous, because in the physical world, all causation occurs through physical contact. The effect of the device cannot also be explained as being caused by electromagnetism, as long as a piece of paper cannot be destroyed or transformed by a magnetic field. Yet, the assumption that the device is the cause of the effect is more compatible with physical explanations than the assumption that a magic spell is. Even if the effect of the device cannot be explained by the known physical forces, it can be viewed as an effect of some physical force which is yet unknown to science. In fact, it has been reported that in a similar experimental situation, participants more often acknowledged that an unknown physical device could have destroyed the object in the box than that a magic spell could have done so (Subbotsky, 2001). This effect, however, was only evident if participants’ verbal judgments were tested. In their actions, the participants showed an equal (and very small) degree of credulity to both ‘the magic’ and ‘the device’ explanations of the effect.

It can be hypothesized that if participants are shown a group of different physical events presented as a possible cause of the anomalous effect (i.e. the events that are performed one after another immediately prior to the demonstration of the unusual effect), this ‘pack of possible causes’ would seem more compelling to the participants than a single action of the device. In this case, a participant would have a choice to attribute the anomalous causal effect to any of these accompanying events or their combination. In comparison with this group of actions, the magic spell could be viewed as the least plausible alternative to the proper physical explanation. It can be assumed on this ground that, although any action (or combination of actions) from the pack still provides the anomalous effect and in this respect is not different from the magic spell, in another respect it would seem a significantly more plausible candidate for the causal explanation of the effect than would magic.

Indeed, unlike explaining the effect by the magic spell, explaining the effect by the group of non-magical actions (or any combination of those) does not involve the belief in the supernatural and can be retained within the domain of physical causality. It can be expected therefore that the increased plausibility of the explanatory context of the anomalous causal phenomena would significantly increase the participants’ credulity toward these phenomena at the level of both verbal and non-verbal processing.

Experiment 4 was conducted to examine this.

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3This type of causal judgment in which a cause is named on the basis of sheer association with the effect is often called ‘phenomenalistic’ (see Piaget, 1927; Subbotsky, 1997). A specific feature of phenomenalistic causal judgment is that it is potentially open to either scientific or magical interpretations, whichever fits better in the causal beliefs dominant in a particular cultural environment.
EXPERIMENT 4

Method

Participants
Participants in this experiment were 16 university undergraduates, men and women. The mean age was 23.3, and the age range was 18–41 years.

Materials
The same magic box as that in Experiment 1 and two identical postage stamps (one new and another cut in half were used). In addition, an unknown physical device producing light and sound effects if switched on, a square of plain paper similar in size to a postage stamp, and a ball of Play-Doh were available. Participants were also asked to have their driving licences with them.

Procedure
To allow comparison with the earlier reported results, the procedure of this experiment was the same as in Subbotsky’s (2001) study. Participants were tested individually. In the first part of the experiment (verbal processing), participants were told that the purpose of the experiment was to examine what people know about properties of physical objects and on what grounds they make a distinction between objects that exist and those that do not exist.

Next, participants were asked to pick up the postage stamp, examine it, and say whether it was new or old. They were then encouraged to examine the box, make sure it was empty, place the stamp into the box, and close the lid. After this, the experimenter said: ‘And now I am going to do some actions’. The experimenter then performed a succession of three actions meant to be associated with the oncoming effect by the participants. None of these actions had any ‘magical loading’, yet, like the magic spell, none of these actions had any direct physical contact with the box. To examine the role of the ‘associative proximity’ of the actions with the effect, two of these actions were chosen to be easily associated with the effect (the relevant actions), and the third was hard to link to the effect (the irrelevant action). The experimenter switched the device on for a few seconds and switched it off again (the relevant action, association by a possible physical impact), cut the square of paper in half with a pair of scissors (the relevant action, association by the similarity of the effect produced in this action and the effect to be explained), and rolled the Play-Doh ball into a sausage (the irrelevant action). The order of these actions was randomized.

The question that followed was: ‘Do you think that the postage stamp that you placed in the box remains the same, or changed? Why do you think so?’ Irrespective of their answers, the participants were asked to open the lid and remove the stamp. On opening the box, the participants discovered that the stamp was now cut in half. The participants were then asked whether it was the same stamp that they had placed in the box or whether it was a different stamp. If the answer was ‘different’, the participants were encouraged to search (unsuccessfully) for the original postage stamp.

After this, the participants were asked the key questions like in the previous experiments: ‘What do you think has happened to the stamp, why did it become cut in
half? ’ and ‘If I told you that the actions that I did, or some of them, had caused the destruction of this stamp, would you believe me or not?’

In the second part of the experiment (non-verbal processing), participants were asked to put their driving licences in the box and close the lid. They were then immediately encouraged to open the lid and make sure that their driving licences were in the same condition. This was done to convince the participants that a single action of closing the lid of the box, without the accompanying action performed by the experimenter, would not affect the object in the box.

Participants were then given the following instruction:

If I don’t reproduce my actions with these objects, I can promise you that your licence would be safe. If, however, I reproduce the actions, I cannot give you a guarantee that you would get your licence back in the same condition that you put it in. It is entirely your responsibility to encourage me to reproduce my accompanying actions or ask me not to reproduce them, or some of them.

Participants were then asked if they wanted the experimenter to reproduce the accompanying actions or abstain from the reproduction of these (some of these) actions.

Results

Participants’ responses to the key questions were scored as in Experiment 1, Condition 2 (destruction). If a participant, after observing the accompanying actions, said that the postage stamp remained the same, they were judged as a non-believer in the causal role of the accompanying actions. If the participant then responded to both key questions in the negative, they were classified as a non-believer whose disbelief in the causal role of the anomalous causal event was entrenched. If, however, the participant did not think that the postage stamp changed as a result of the accompanying actions but, after seeing the change, acknowledged that some of the accompanying actions may have caused this change, the participant was classified as a non-believer whose disbelief in the causal role of the anomalous causal events was not entrenched.

In response to the experimenter’s questions about whether the stamp changed after the accompanying actions were performed, all participants answered that it remained the same. After having seen that the stamp had actually changed and being asked the key questions, 5 participants received a score of 1, and 3 received a score of 2. These participants either spontaneously acknowledged that the accompanying action may have caused the destruction of the stamp, or agreed with the experimenter that it might have been the case. Seven of these participants chose the device as a possible cause of the effect, and one chose the cutting of a piece of paper. None of the participants could explain exactly how switching on the device or cutting a piece of paper in half could have affected the stamp in the box. A few explanations that were given, were suggestive: ‘There might be something in these actions’, ‘Is it ultrasonic?’, ‘If you do any of these actions, you would destroy my licence’. The number of non-believers in anomalous causality with the ‘not entrenched’ pattern in this experiment was marginally larger than that in Experiment 1, Condition 2 (8 out of 16 against 2 out of 16, $\chi^2(1) = 3.63, p = .057$) and significantly larger than in Experiment 3 (none out of 30, $\chi^2(1) = 14.44, p < .001$).

Participants’ performance at the level of non-verbal processing showed that 10
participants asked the experimenter not to reproduce all or some of the accompanying actions. Five participants chose to ban the action with the device, two chose to ban the cutting, one asked not to cut the paper and not to change the shape of the Play-Doh ball (‘There might be something in it’), and two asked to abstain from the reproduction of all actions. A comparison with the number of participants (two altogether) who asked the experimenter to abstain from repeating a magic spell in the identical experiment reported in earlier studies (Subbotsky, 2001) showed the difference to be significant, \( \chi^2(1) = 8.53, p < .01 \).

Discussion

The fact that none of the participants thought that the postage stamp had changed after the accompanying actions were performed indicated that they did not believe that the accompanying actions had any causal relation to the stamp in the box. Eight participants, however, changed their view after they saw the postage stamp destroyed. This shows that in this experiment, which did not involve a reference to the supernatural (a plausible framework), the number of non-believers in the possibility of anomalous causal events who were prepared to drop their scepticism as soon as they saw the effect (the ‘not entrenched pattern’) was larger than the number of non-believers in magic with the ‘not entrenched’ pattern in Experiments 1 and 3. In other words, the increase in the plausibility of explanation of the anomalous event (i.e. some invisible physical forces unknown to participants, like ultrasonic waves) resulted in a significant increase in the number of participants who believed that the accompanying actions could, in fact, affect their driving licences in the box. The fact that the overwhelming majority of actions identified as possible causes of the effect were relevant actions confirms that participants were guided by rational reasons in their decisions.

Yet, speaking in rational terms, the action of pronouncing a magic spell is not different from the action of switching on a device or tearing a piece of paper in half, as long as the causal effect of these actions on the object in the box is concerned. Like the magic spell, the latter actions did not have any observed physical link to the postage stamp in the box. The participants’ verbal responses prior to observing the object’s destruction indicated that none of the participants believed that any of the accompanying actions could have causally affected the object in the box. Yet, after they observed the destruction, a significantly larger number of participants abandoned their sceptical views in the ‘no magic’ theoretical framework (this experiment) than in the ‘magic’ theoretical framework (Experiments 1 and 3). How can this effect be explained?

One possible explanation is that, in contrast to other irrelevant but non-magical actions, a magic spell runs against the fundamental belief in the rational and physical structure of everyday reality. Accordingly, an anomalous causal phenomenon that looked like an instance of magic was devalued and discounted, even if it was repeated several times before the participant, whereas a similar phenomenon that looked unusual but not magical, was taken seriously and changed the participants’ original sceptical views of the possibility of these phenomena. Not only could the effect of the increased plausibility of the anomalous data be seen in participants’ verbal judgments, but it was also evident in participants’ actions (i.e. at the level of non-verbal processing when the cost of disregarding the possible causal effect was increased). At this level,
when the participants’ valuable objects were put at risk, most participants disregarded the possible undesirable effect that the magic spell might have produced on their licences (Subbotsky, 2001), yet they took the threat seriously if the equally distant and irrelevant events did not imply a belief in the supernatural (this experiment).

**GENERAL DISCUSSION**

The results of the four experiments presented in this study suggest that Chinn and Brewer’s description of factors affecting people’s reactions to anomalous scientific experience can be extended to include reactions to anomalous ontological causal events. The data also support the view that sometime in the age of 5–11 years, children undergo a fundamental ‘theory change’ in their ontological beliefs about the world (Carey, 1985; Laurendeau & Pinard, 1962; Piaget, 1927).

Indeed, in Experiment 1, 4-year-old children proved to be able to distinguish between non-magical outcomes and those that involved ‘thought over matter’ magic. At the same time, for children of this age, magical events are as real as ordinary events. For 6-year-olds, however, things are different. At this age, children come under the influence of school education with its rationalistic view of the physical world. As soon as this paradigm suggests that magic is something that can occur only in dreams and fairy tales, children develop scepticism towards magical events. In 6-year-olds, this scepticism, however, is unstable, and their belief in the universal power of physical causality is not entrenched. This follows from the data of Experiment 1, in which most children of this age were quick to retreat to their earlier magical beliefs as soon as they were shown the ‘magical’ effect of the spell. This behavioural pattern was not observed in 9-year-old children and adult participants, in whom the belief in the universal power of physical causality was entrenched and could withstand the challenge of personal experience of anomalous data.

As the results of Experiment 2 have shown, only about 45% of 5-year-olds, 59% of 6-year-olds, and 80% of 9-year-olds proved able to distinguish between anomalous causal events that invoked the supernatural from similarly looking tricks framed in a magical context. This indicates that interpreting children’s responses in which outcomes are called ‘magical’ without the preliminary testing on the discrimination between ‘real’ and ‘trick’ magic (like in Experiment 1 of this study) can be a real problem. Yet, testing the entrenchment of their scepticism toward magic in children who could make this discrimination by showing an authentically looking ‘magical event’ yielded results similar to those obtained in Experiment 1: In 5-year olds, the number of non-believers in magic with the ‘not entrenched’ pattern was significantly larger than that in 9-year-olds. Both the demonstration trial and the tentative demonstration trial elicited a significantly larger number of magical responses in 5-year-olds than in 9-year-olds, with 6-year-olds occupying the intermediate position. This again suggests that in children of 5–6 years of age, their belief in the universal power of physical causality is not entrenched.

The data on the entrenchment of magical beliefs per se were in the same direction: 5-year-olds were significantly more reluctant to part with their magical explanations in the prompt trial than were 9-year-olds. Most 5-year-olds (but not 6-year-olds) retained their magical explanations, even after the mechanism of the trick was exposed to them in the explanation trial.

Altogether, the data of Experiments 1 and 2 showed that in 4- and 5-year-olds, magical explanations have a certain advantage over physical explanations. In children
of this age, their magical beliefs are deeply entrenched; and vice versa, in those 4–5-year-olds who showed disbelief in magic (and, as a consequence, the belief in the universal power of physical causality), this disbelief (belief) proved not to be entrenched. This explains the earlier reported data, according to which, in one kind of circumstance, children of this (and younger) age can show a good grasp of physical causation (Bullock & Gelman, 1979; Kun, 1978; Schultz et al., 1986), and in other kinds of circumstances, they are prepared to explain causal events in terms of magic (Bullock, 1985; Rosengren et al., 1994). To summarize, in 4- and 5-year-olds’ causal judgments, their beliefs in physical and magical causal explanations coexist, with a certain prevalence of magical beliefs. Not only are magical events not viewed as anomalous by 4- and 5-year-olds, but also their belief in the reality of magic is deeply entrenched, whereas the belief in the universal power of physical causality, if present, is not.

This prevalence of magical explanations over physical explanations disappears in 6-year-olds. At this age, in their ontological judgments, the overwhelming majority of children denied the possibility of magic in the real world and viewed magical outcomes as anomalous events. In those 6-year-olds who did possess magical beliefs, these beliefs were no longer entrenched. Along with this relaxation of their magical view of the world, most 6-year-olds develop the belief in the universal power of physical causality. However, in 6-year-olds, as in younger children, the belief in the universal power of physical causality is not yet entrenched, and most children are quick to retreat into magical explanations if confronted with anomalous causal phenomena. In other words, in 6-year-olds, magical and physical beliefs coexist on more or less ‘equal terms’, i.e. a certain balance is achieved between children’s preparedness to go either for magical or for physical explanations.

This balance is no longer observed in 9-year-olds. Unlike in 6-year-olds, in 9-year-olds, a large proportion of children (36–62%, in different conditions) showed an entrenched belief in the universal power of physical causality. At the same time, in those 9-year-old children who still hold magical beliefs, these beliefs are no longer entrenched. This indicates that in 9-year-olds, the imbalance in relation between magical and physical causal beliefs that was observed in 4–5-year old children is reversed in favour of the prevalence of the belief in the universal power of physical causality. Not only did the majority of 9-year-olds deny the reality of magic in their ontological judgments, but a large number of children refused to accept magical causal explanations when confronted with the anomalous events. Almost all 9-year-old children who accepted or produced magical explanations abandoned these explanations as soon as their physical causal beliefs received support in the prompt trial.

Experiments 3 and 4 confirmed the expectation that in adults, the belief in the universal power of physical causality is deeply entrenched. In adults, this belief can withstand multiple demonstrations of anomalous causal events presented in a magical context. On first glance, this result contradicts the view that adults are not fundamentally different from children in their magical beliefs (Subbotsky, 1992; Woolley, 1997). However, the entrenchment of physical causal beliefs in adults was observed only at the level of verbal causal judgments. As the earlier reported data showed, at the level of non-verbal processing when participants’ ‘vested interest’ is involved in their causal explanations of events, even in adults the belief in physical causality can coexist with the belief in magical causation (Nemeroff & Rozin, 2000; Subbotsky, 2001, Subbotsky & Quinteros, 2002). Extending these data, the results of Experiment 4 indicated that, if the same anomalous phenomena are framed in the
context that does not refer to the supernatural, adults are prepared to accept the reality of the anomalous physical events at both verbal and non-verbal levels of processing.

Along with providing support for the ‘coexistence’ model of the development of ontological causal beliefs (Boyer, 1994; Shweder, 1977; Subbotsky, 1992; Zusne, 1986; Zusne & Jones, 1986), the results of Experiment 4 also highlighted a methodological problem of studying magical beliefs (and other non-physical causal events) in Western cultures. This problem concerns the possibility of ‘scientific rationalization’ of participants’ responses in experiments on magical thinking and behaviour. Indeed, it has been noted that in the contemporary Western tradition, the very concept of magic became rationalized (see Boyer, 1994). In traditional cultures, magic is viewed as a kind of participation between people and objects or between different objects. For the mind of a traditional individual, magical effects are not perceived as anomalous and do not require a logical explanation. In contrast, in Western cultures, the concept of magic was reinterpreted to include certain ‘magical powers’ or ‘magical forces’—the ideas that are more closely associated with scientific ideology than with the traditional view of magic (see Needham, 1976). In so far as many events that, in earlier centuries, were believed to be magical (transmitting auditory and visual messages remotely, flying in the air and space, etc.) became a scientific reality, this creates the possibility of interpreting anomalous causal events as scientific effects. Even psychological phenomena that lack a scientific explanation (like the ‘psi’ phenomenon) are sometimes presented as an effect of some unknown physical ‘fields’ (Bem & Honorton, 1994). Likewise, there is a strong tendency to reduce causal events that conform to the laws of magical causality (such as those that happen in the domains of dreams, feelings, symbolic communication, perceptual illusions) to physical events in the brain (Aguirre & D’Esposito, 1997; Dennett, 1991; Jackendoff, 1987).

By interpreting anomalous causal events as unknown physical events, people can rescue their belief in the universal power of physical causality and accept the anomalous data at the same time (Experiment 4 of this study). As a result, people consider causal judgments that are in fact compatible with magical thinking as scientific causal judgments. This suggests that a more cautious and critical view is needed for assessing participants’ responses in psychological experiments on magical thinking. If these responses are only verbal instances, they can be particularly vulnerable to scientific over interpretations. However, there is an equal possibility of ‘magical over interpretation’ of answers that, in fact, do not imply magical beliefs. Thus, participant’s positive answers to questions like ‘I have occasionally had the silly feeling that a TV or radio broadcaster knew I was listening to him’ or ‘I have felt that I might cause something to happen just by thinking too much about it’ do not necessarily mean that the participant believes in magical things: Assuming the latter would be confusing feelings with beliefs.

This issue highlights the importance of going beyond verbal processing in studying individuals’ ontological causal beliefs. It is only on the basis of general patterns of participant’s judgments, non-verbal responses, and their explanations of those responses that a sensible conclusion about the participant’s ontological causal beliefs can be made. As the results of this study suggest, judging from these general patterns of responses, magical beliefs persist in the modern industrialized world but are disguised to fit the dominant scientific paradigm.

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6The questions are taken from the ‘Magical ideation’ questionnaire by Eckblad and Chapman (1983).
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References


Magical thinking in judgments of causation 151


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