



## Curiosity and exploratory behaviour towards possible and impossible events in children and adults

Eugene Subbotsky\*

Psychology Department, Lancaster University, UK

In four experiments with 4-, 6-, and 9-year-old children and adults, the hypothesis was tested that, all other conditions being equal, a novel and unusual event elicits stronger curiosity and exploratory behaviour if its suggested explanation involves an element of the supernatural than if it does not (the impossible over possible effect – the I/P effect). Participants were shown an unusual phenomenon (a spontaneous disintegration of a physical object in an apparently empty box) framed in the context of either a magical (the impossible event) or scientific (the possible event) explanation.

In the verbal trial, participants showed a clear understanding of the difference between the effect of genuine magic and the effect of a trick. In the behavioural trial, both children and adults showed the I/P effect. They were more likely to run the risk of losing their valuable objects in order to explore the impossible event than the possible event. Follow-up experiments showed that the I/P effect couldn't be explained as an artifact of the different degrees of cost of exploratory behaviour in the possible and impossible conditions or as a result of misinterpreting magic as tricks. The I/P effect emerged when the cost of exploratory behaviour was moderate and disappeared when the cost was perceived as too high or too low.

Studying behavioural responses to novelty in a stimulus situation have shown that the degree of novelty of a stimulus is a major factor in eliciting exploratory behaviour (Mendel, 1965) and that the intrinsic motivational value of novelty is equivalent to that provided by material and edible rewards (Cahill-Solis & Witryol, 1994). Stimulus novelty, however, is not a sufficient factor for evoking exploratory behaviour: in order to elicit exploration, a stimulus, apart from being novel, must also be interesting and attractive (Henderson & Moore, 1980). Thus, novel foods that look unattractive or dangerous are unlikely to engage a participant in exploration (Nemeroff & Rozin, 1992; Pliner, Pelchat, & Grabski, 1993).

The assumption to be tested in this study is that one particular feature that makes a stimulus intrinsically interesting for humans is its capacity to violate fundamental

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\* Correspondence should be addressed to Dr Eugene Subbotsky, Psychology Department, University of Lancaster, Lancaster LA1 4YF, UK (e-mail: e.subbotsky@lancaster.ac.uk).

physical laws. In contrast to possible events that are compatible with the fundamental laws of nature (such as object permanence or physical causality), an impossible event is incompatible with these laws. Ghosts, witchcraft, astrology, magic, and other impossible phenomena have always attracted considerable public interest (Jahoda, 1969; Lundahl, 1993; Zusne & Jones, 1982). What remain unclear, however, are the causes of this attraction. Indeed, due to their very nature, the above phenomena are rarely observed and there is no hard evidence that they are actually real; hence, they are extremely novel. Apart from being novel, they are also impossible (i.e., cannot be explained in terms of modern science). Along with impossible events, in contemporary industrial societies there exist a number of objects and events (such as the products of technology or medicine) that are equally novel and counter-intuitive (i.e., beyond the individual's capacity to understand), yet they are considered explainable and provide the individual with little inspiration to explore. The question arises of whether impossible phenomena elicit interest and exploration simply because they are novel or because they are also impossible, i.e., they involve an element of the supernatural.

To examine this, it is necessary to provide a participant with a novel counter-intuitive stimulus that is framed either in the context of natural (physical) causality (a counter-intuitive possible event) or in a context that involves an element of the supernatural (an impossible event). If the stimulus' impossibility is an additional factor that contributes towards eliciting curiosity and exploration, then participants' tendency to engage in exploratory behaviour towards the impossible event should be stronger than towards the same but possible event. If this indeed is the case, then it can be named the 'impossible over possible' (I/P) effect. Consequently, in this paper *the I/P effect implies that, other conditions being equal, a novel and counter-intuitive event elicits stronger curiosity and exploratory behaviour in participants if its suggested explanation includes an element of the supernatural than if it does not.*

With some reservations, the beginning of the investigation of the I/P effect can be traced to studies of infancy. It has been shown, for instance, that young infants show a higher degree of exploratory behaviour towards displays that violate principles of physical causality than towards similar displays with no violation of these principles (Baillargeon, 1987; Leslie, 1982, 1984). These data suggest that infants possess sensitivity towards violation of intuitive natural causal order. The question that remains open is whether the same is the case for reflective ideas about physical causality in children and adults.

Sperber (1997) contrasted reflective beliefs that are primarily of cultural origins and intuitive beliefs that are the direct output of perceptual and spontaneous inferential processes. There is no doubt that the way older children and adults perceive the distinction between possible and impossible events is different from the way that infants perceive this distinction. Unlike infants, older children and adults possess reflective knowledge of what is possible and impossible in the physical world. The possession of language and scientific education create in children and adults the clear and conscious understanding that physical laws (such as object permanence or physical causality) are inviolate. This understanding can be symbolically represented and verbally formulated in scientific terms. As a consequence of this, one can assume that in modern industrial societies older children and adults tend to view any observable event as a possible event (i.e., as one that complies with the laws of physics). Even if a certain physical effect looks

counter-intuitive (i.e., like a violation of the fundamental laws of nature), it is still viewed as a possible effect, the causes of which are hidden from direct observation (i.e., as a magic trick).

If this assumption was true, then a demonstration of a certain novel counter-intuitive effect would elicit the same degree of curiosity and exploratory behaviour in the participants regardless of its framing in a scientific or non-scientific (i.e., magical) reflective context. Alternatively, it can be assumed that, in the modern world, older children and even adults still hold some belief in the reality of effects that violate fundamental laws of nature. Indeed, in many ways reflective ideas about magic and the supernatural are widely cultivated in modern life, in children's play and literature, in fiction, religion, and other alternative belief systems (Luhrman, 1989; Nemeroff & Rozin, 2000; Tambiah, 1990; Vyse, 1997). It is possible therefore, that modern human individuals are still attracted to the idea of supernatural forces. While explicitly denying that such events can happen in real life, implicitly people might still believe that impossible events can occur. In this case, individuals' curiosity towards (and their interest in exploring) such events will be stronger than towards the counter-intuitive but possible events (the I/P effect).<sup>1</sup>

In this study, an impossible event, which was contrasted with a counter-intuitive possible event, was an instance of 'true magic'. Independently of whether true magic exists or does not exist in the real world, it certainly exists in the area of imagination and, therefore, merits a clear definition. One can distinguish at least four classes of events that are usually viewed as truly magical: 'mind over matter' (moving or changing physical objects by sheer effort of will or thought), 'spontaneous coming to life' (a sudden acquisition of feelings or independent movements by an inanimate object), 'non permanence magic' (a physical object spontaneously changes its shape, appears from thin air or disappears without a trace), and 'participation or sympathetic magic' (the widespread belief that certain chosen objects and actions can bring luck or affect the flow of natural events) (see Boyer, 1994; Frazer, 1923; Jahoda, 1969; Needham, 1976; Tambiah, 1990). Despite the diversity of these types of events, none of them are compatible with the views of modern physics. If a person can clearly distinguish between magical events (like a piece of paper changing its shape as a result of a magic spell) and ordinary events (the piece of paper is changed as a result of a trick), then the person can be said to have an adequate concept of the difference between impossible (truly magical) and possible (physical) events.

In recent decades, the study of magical thinking and magical beliefs has been on the rise. Harris, Brown, Marriott, Whittall, and Harmer (1991) showed that preschool children endow fairy tale characters (like monsters or witches) with special capacities, and they are fearful of monsters despite the knowledge that they do not exist. Johnson and Harris (1994) demonstrated that 3- to 5-year-old children viewed magical transformations of objects to be impossible, yet in their actions they showed considerable credulity towards magic. Other studies showed the ability of preschool children to distinguish magical transformations from non-magical ones and make effective use of the concept of magic (Rosengren & Hickling, 1994; Subbotsky, 1985).

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<sup>1</sup> In contrast to the studies of infants, in the studies with older children and adults this suggestion does not involve a strong claim of the existence of precocious knowledge or 'cognitive modules', as long as in this case a strong interest towards impossible events can be elicited by verbal knowledge and understanding that these events are impossible.

Chandler and Lalonde (1994) showed to preschoolers aged 3–5 years an effect that appeared to be one solid object passing unhindered through a space already occupied by another solid object. Although about 70% of children initially labelled the event ‘magical’, on exploring the apparatus the children discovered the trap door mechanism and came to judge the effect they had seen to be ‘a trick’. In another experiment of this study 9- to 13-year-olds were exposed to a series of demonstrations that challenged their belief in the laws of conservation. These demonstrations were administered either by a magician, a psychologist, or a ‘priest’. When retested in about 10 days later, the majority of children in the magician condition recovered their earlier commitments to the laws of conservation, whereas most children in the other two conditions kept giving non-conservation responses.

Even adults show a tendency to follow the rules of contagious and sympathetic magic in making their emotional preferences (Rozin, Markwith, & Ross, 1990; Rozin, Millman, & Nemeroff, 1986) and are able to quite consciously act in a way that is concordant with a belief in magic (Subbotsky, 1997, 2001, 2005). Woolley (1997) concluded that with regard to their engagement in magical thinking, adults are not fundamentally different from children.

While considerable progress in studying magical beliefs has been made, another aspect of magical thinking – children’s and adults’ curiosity towards magic – remains largely unexplored. It must be emphasized that curiosity towards magic does not necessarily involve an explicit belief in magic and vice versa. Indeed, a person can believe in magic and yet be afraid of it and reluctant to explore this belief. Conversely, a person may treat the possibility of magic with skepticism and yet be curious towards magic and willing to explore whether magic can be a real thing. At the same time, it is also possible that individuals who express curiosity towards magic might actually hold some belief in magic. To test for the existence of the I/P effect, in Expt 1 children 4, 6 and 9 years of age were individually tested in two conditions in which they were given a choice about whether or not to place their valuable objects at risk in order to see an unusual phenomenon (a disappearance of a new postage stamp in an apparently empty box). In the ‘impossible condition’ (IC), the phenomenon was suggested to have been caused by magic, and in the ‘counter-intuitive possible condition’ (CIPC) by a trick box. Care was taken that in both conditions on exploring the trick box participants were not able to discover the trap door. This guaranteed that, unlike in Chandler and Lalonde’s (1994) experiment, in this experiment in the IC participants would be less likely to treat the effects as tricks and more likely to treat them as instances of true magic that involves an element of the supernatural (i.e., a violation of object permanence). It was predicted that if children’s exploratory behaviour were triggered by the novelty of the unusual phenomenon, then the numbers of participants encouraging the experimenter to reproduce the phenomenon would be approximately the same in both conditions. If, however, in addition to the event’s novelty, magic had an intrinsic motivational value for children, then the number of children willing to put their valuable objects at risk in the IC would be significantly larger than in the CIPC. In Expt 2, the same methodology was employed with adult participants. Expt 3 aimed to examine if the I/P effect can be explained by the slight methodological differences between conditions, in particular, by the causality vector (external in the IC and internal in the CIPC). Finally, in Expt 4, the possibility was explored that participants viewed the effect produced by a magic spell as the work of a high-tech device and not as a violation of fundamental physical principles.

## EXPERIMENT I

### Method

#### Participants

In total, 84 children who passed the pre-test interview<sup>2</sup> participated in 2 conditions of this experiment. In each condition, there were 42 children aged 4, 6, and 9 years, 14 in each age category, with equal numbers of boys and girls. For the IC, mean ages and age ranges were as follows (years, months):  $M = 4.5$ , 4.1 to 4.11;  $M = 6.6$ , 6.2 to 6.11;  $M = 9.9$ , 9.3 to 9.11. For the CIPC they were:  $M = 4.6$ , 4.2 to 4.11;  $M = 6.7$ , 6.2 to 6.10;  $M = 9.8$ , 9.1 to 9.11. The participants were taken from schools in Thessaloniki and Stavros, Greece.

#### Materials

A wooden 'trick box', two postage stamps, and a 'magic wand' were used. The box was constructed in such a way that a metal plate became detached from one of the inside walls and sank to the bottom as soon as the lid was closed. A system of magnets built into the side and the bottom of the box ensured that the box could be manipulated by the participants without the trap door being discovered.

#### Design

Condition (IC vs. CIPC) and age (4, 6, and 9 years) were between-subjects independent variables. The number of children who wanted to explore the effect using their valuable objects was the dependent variable.

#### Procedure

##### Pre-test interview

The aim of the interview was to ensure that children were capable of distinguishing between magical and ordinary transformations. They were individually asked the following questions:

- (1) Suppose I put a postage stamp into this box, close it, wave a magic wand, then open the box and see that the postage stamp is still there. Can we say that the postage stamp appeared in the box by magic, or would there not be any magic in this?
- (2) Now, suppose I take an empty box, close it, wave a magic wand and say 'stamp - appear', and then look into the box and see that the stamp appeared in it. Please, bear in mind that the stamp appeared because the magic wand made it appear, not because it was some kind of trick, OK? Now, can we say that the stamp appeared by magic or would there not be any magic in this?
- (3) And what if I take a box with a stamp in it, take the stamp out of the box, burn it to ashes, and then wave the magic wand and say 'stamp - disappear', Can we say that the stamp disappeared from the box by magic, or would there not be any magic in this?

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<sup>2</sup> Three children who did not pass the pre-test interview were excluded from further testing.

- (4) And what if I put a stamp in the box, close the lid, wave a magic wand and say 'stamp - disappear', then open the box and see that there is no stamp in it anymore. Please, bear in mind that the stamp disappeared because the magic wand made it disappear, not because it was some kind of trick, OK? Can we say that the stamp disappeared by magic, or would there not be any magic in this?

Only children who answered all four questions correctly were allowed to proceed to the main interview.

#### *Main interview*

This included two trials: the demonstration trial and the action trial, which followed the demonstration trial.

#### *Demonstration trial*

In the IC, children were individually shown a 'magic box' and a postage stamp. Next, the child was given a wooden stick and told that it was a magic wand and that he or she could check whether it worked. The child was then encouraged to place the postage stamp into the box, close the box, and wave the magic wand in order to make the stamp disappear.

After the children did this, they were asked if they thought that the stamp was still in the box or had disappeared. Whatever the answer, the child was encouraged to open the box. On opening the box, children found that it was empty.

In the CIPC, the procedure was similar, but no magic wand was given to the child. Children were encouraged to place the postage stamp in the box and close the box and were then asked whether they believed that the stamp was still there or had disappeared. Next, the children were asked to open the box and discovered that it was empty.

In both conditions, children were thanked for their answers and given an attractive postage stamp as praise.

#### *Action trial*

In the IC, the children were asked if they wanted to put their 'praise' postage stamps into the box in order to see again how the magic wand works.

In the CIPC, the instruction was the same, except that the last words were '... in order to see again how the box works'.

#### **Hypothesis**

It was expected that if children were more interested in experimenting with magic than in experimenting with the trick box, then the number of children who would encourage the experimenter to reproduce the magical action in the IC would be significantly larger than the number of children who wished to place their praise postage stamps into the box in the CIPC. If the prediction proved correct, this would provide evidence for the I/P effect. This follows from the fact that, apart from using the magic wand, the phenomenon to be seen (the disappearance of a postage stamp in an empty box) and the risks to be taken (losing the praise postage stamp) were identical in both conditions.

## Results

In the IC, all children showed surprise in the demonstration trial, and about half of the children made critical commentaries ('This is not a magic wand', 'You cannot be a magician'). In the action trial, most children wished to repeat the experience and used the magic wand on their praise stamps in the box.

In the CIPC, all children were surprised to see the stamp disappear, but only a few of them wanted to repeat the effect using their praise objects.

The percentages of children in the three age groups who agreed to proceed with the testing using their praise objects in each testing condition are shown in Table 1. In the IC, the proportions of children who agreed to the testing on their valuable objects significantly exceeded those in the CIPC, with Fisher's exact probabilities being  $p = .0007$ ,  $p = .009$ , and  $p = .0002$  for 4-, 6-, and 9-year-olds, respectively.<sup>3</sup> There were no significant age differences within conditions.

**Table 1.** Percentages of children (out of 14 total) who agreed to proceed with the testing using their valuable objects, as a function of age (4, 6, and 9 years) and condition (possible vs. impossible)

Age groups (years)	Condition	
	Impossible	Possible
4	71	7
6	64	14
9	93	21

## Discussion

The results support the hypothesis that children would show a significantly stronger tendency to experiment with the magic wand than with the trick box, thus revealing the I/P effect. In all age groups, a significantly larger number of children wanted to put their praise objects at risk in the IC than in the CIPC.

An alternative explanation of this difference might be the greater amount of risk taken in the CIPC, because it is easier to believe that a tricky box can destroy objects (CIPC) than that a magic wand can do this (IC). Indeed, in the demonstration trial of the IC, children may have thought that the postage stamp disappeared because the box made this happen while viewing the magic wand manipulation as a distracter. However, if in the IC the children viewed the box as a real cause of the postage stamp's disappearance, then in the action trial, they would be reluctant to place their praise postage stamps in the box in the IC to the same extent as in the CIPC. However, this was not the case.

There remain, however, other possibilities for alternative explanations of the above result. The first alternative explanation is that, even though in the pre-test interview all children called the impossible event magical, it was not completely clear if magic meant true magic (which involves the element of the supernatural) or stage magic (tricks). As was shown in earlier studies, children of preschool and school ages often label as

<sup>3</sup> Two-tailed assessment is used throughout.

magical the events for which they simply have no plausible scientific explanations (Chandler & Lalonde, 1994; Phelps & Woolley, 1994; Rosengren & Hickling, 1994). If, in the pre-test interview in Expt 1, children, while correctly telling magical effects from non-magical ones, viewed magical effects as magic tricks, then the statistical difference between conditions would result from the fact that children found the magic trick in the IC to be more interesting than the magic trick they observed in the CIPC.

The second alternative explanation comes from the possibility that in Expt 1 the children were not aware of the irreversibility of the postage stamp's disappearance. They may have been more willing to experiment with the magic wand (IC) than with the trick box (CIPC) on a tacit assumption that they would be able to subsequently recover the stamp with the same magic wand – a possibility that would be much less likely for a box that annihilates objects placed into it.

The third alternative explanation is that in the IC the observed effect was made to look as if it had been caused by an external factor (by waving the magic wand), whereas in the CIPC it was made to look as though it were happening inside the box. Also, own agency could play a role in the effect: the child did something to create an effect in the IC condition there, but not in the CIPC condition. This difference in the 'causality vector' (external vs. internal) and agency (doing vs. not doing something) could also contribute to the fact that children in the IC were willing to repeat the experiment with their praise objects more frequently than in the CIPC.

Finally, in Expt 1 cultural background may have influenced children's answers. In Greece, magical beliefs are widely spread among the population. For example, a survey by the Commission of the European Communities (1993) asked people to indicate what disciplines (such as biology, physics, astronomy, medicine, and others) they find scientific or not scientific. Interestingly, 30–40% of the respondents gave astrology the highest mark on the 'science' end of the scale, viewing it no less 'scientific' than physics or astronomy (Gorney, 2006). On this ground, in subsequent experiments of this study it was necessary to employ participants from other cultural backgrounds.

To examine the first and second alternative explanations, in Expt 2 mainly British adult participants were tested in the same two conditions. In contrast to children, the difference between true magic that involves an element of the supernatural and stage magic (a trick) that does not can be more clearly explained to adults. It can also be made clear to them that losing their valuable objects in either of the test conditions would be irreversible. In terms of culture, British participants scored low on their verbal magical beliefs (Subbotsky, 2000; Subbotsky & Quinteros, 2002), thus explicit beliefs in magic could not interfere with these participants' curiosity and exploratory behaviour.

## EXPERIMENT 2

### Method

#### *Participants*<sup>4</sup>

Participants were 32 university undergraduate and graduate students, 16 in each of the 2 conditions. Mean ages and age ranges for the IC and CIPC were  $M = 21.7$ , 18–42 and  $M = 21$ , 18–33, respectively. They were primarily British and Caucasian. Approximately,

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<sup>4</sup>In this study, none of the subjects participated in more than one experiment.

30% of the participants were international visiting undergraduates from continental Europe, Asia, and the USA. About half of participants were psychology students, and the other half represented disciplines other than psychology.

### **Materials**

Materials were a magic box, the same as in Expt 1, two identical postage stamps (one of them new, another cut in half), and participants' driving licenses.

### **Design**

Test condition was a between-subjects variable with two levels (IC vs. CIPC). The number of participants who wanted to test the effect on their driving licenses was the dependent variable.

### **Procedure**

The procedure of this experiment followed the procedure of Expt 1, with a few exceptions. First, in the demonstration trial, instead of the magic wand, a magic spell pronounced by an experimenter was used as a magical setup for the phenomenon. This was done in order to equate the 'own agency' factor: in both conditions, all that participants were required to do is to place their driving licenses into the box. Second, in order to prevent a direct association between the magical effects presented in the pre-test interview and the main interview, the objects employed in the pre-test interview were changed: instead of the box and the postage stamp, a briefcase and a book were used. Third, with the aim of ensuring that the participants could distinguish between true magic and stage magic, the differences between these two possibilities were explicitly spelled out in the questions with the impossible outcome (questions 2 and 4). For instance, in question 2, after the unexpected appearance of the book in the briefcase was described, the experimenter continued as follows: 'Now, consider two possibilities. Possibility 1: The book appeared in the briefcase because my magic spell made it appear from nothing; I simply thought hard about making the book appear, said my magic spell, and the book appeared from thin air. Possibility 2: There was some trap compartment in the briefcase, and the book appeared from that compartment. Which of these two possibilities is a trick, and which is an instance of true magic?'

In the *demonstration trial* of the IC, after participants were asked to put a new postage stamp in the box and close the lid, the experimenter informed them that he was going to put a magic spell on the box to destroy the stamp. The experimenter then pronounced a series of words that sounded like a magic spell. Next, participants were encouraged to open the box and discovered that the postage stamp was cut in half.

Participants were then encouraged to inspect the box and asked to explain the phenomenon. Next, the experimenter asked whether participants believed that the experimenter was in command of magic powers and that he destroyed the postage stamp by putting a magic spell on the box.

In the *action trial*, if the answer to the previous question was 'yes', the instruction was as follows: 'OK. Do you think it is worth trying to test my magic spell on your driving license right now, or do you think it is not worth trying?'

If the answer to the suggested magical explanation was 'no', the instruction was different. Indeed, if participants explicitly acknowledge that they are non-believers in magic, they might feel uncomfortable not encouraging the experimenter to proceed with the magic spell, for it would show that they actually believe in magic. As a result, the participants might be willing to reassure the experimenter in order to show that they are skeptical and encourage the experimenter to proceed with the testing. In order to minimize this possibility, the experimenter explicitly stressed that he was aware of the participants' skepticism towards magic and would not interpret their desire to repeat the experiment with their driving licenses as a concession to magical beliefs. The instruction therefore was as follows: 'I see now that you don't believe in magic, so you don't think that if I reproduced this magic spell on your driving license it would destroy your license, do you?' Next, the experimenter asked the subject if it was still worth trying the magic spell on the participant's driving license. The aim of these questions was to find out whether the participants, though skeptical towards magic, would nevertheless be curious to try it again by putting their valuable object at risk.

In addition, the question about the possibility of further experimenting with magic was asked in a neutral way (Do you think it is worth trying . . .) in order to avoid any tacit suggestion that the experimenter was interested in trying the magic spell on the participants' licenses. As a result, participants were assured that they were not viewed as believers in magic and that the experimenter himself had no specific interest in the continuation of the experiment. Under these circumstances, the only motive that could encourage participants to prompt the experimenter to proceed with the experiment is their curiosity to find out whether the magic would work again, even if this time there might be a price to pay.

In the *demonstration trial* of the CIPC, participants were simply shown the phenomenon of a postage stamp being cut in half in the box. In the *action trial* of the CIPC, the participants were asked: 'Do you think it is worth trying to test this hypothesis by closing the box with your driving license inside it, or do you think it is not worth trying?'

In both conditions, participants who agreed to place their driving licenses into the box and continue the experiment were explicitly warned that the experimenter takes no responsibility for their driving licenses' safety and that, if damaged, their licenses could not be restored. In addition, in both conditions participants who encouraged (did not encourage) the experimenter to proceed with testing were asked why they did (did not do) so. In this and the following experiments, participants' justifications in favour of testing were coded in two categories: 'curiosity' ('Because I am curious towards magic', 'If anything like that happened to my license, I'll show it to my kids', 'Even if I don't believe in magic, I am still open minded', 'It would be exciting if you did it', 'I was interested to see if you could do it, I believe in magic not in the fairy tale sense, but as a power of mind', 'Because if you could do something like this, then my skepticism about the power of spirituality would be significantly reduced', 'I wanted to see whether it would work with my license') and 'skepticism' ('Because I did not believe it could work, I wanted to prove that it did not work'). Participants' answers against testing were also coded in two categories: 'skepticism' (as above) and 'concern for safety' ('This is some kind of power, bad power. You are not doing this for any good', 'I think it is not a good idea . . . which means I have to believe in it to some extent', 'Only if you could then restore it back to its original state'). In the IC, they were also asked if they would be happy if the magic really worked. Participants' answers were coded as positive (e.g., 'Yes, I'd like to believe in magic, the world seems to be too boring, every

question seems to have answers, I'd like if it had some mystery in it', 'I'd be happy, because you can meet people with powers, and you can get this power of your own if you believe in it', 'I am a physics student, I am trying not to believe it, but there is still something in the back of my mind that makes me curious that it might work', 'Yes, it would be nice to have something that can't be explained', 'If you'd be able to prove that magic works, it would change my perspective and perception of the world') or neutral ('I really don't care')<sup>5</sup>.

### **Hypothesis**

The hypothesis in this experiment was the same as in Expt 1: it was assumed that if it was a specific interest in seeing the impossible event (and not just an amazing trick) that made the participants explore, then the number of 'curious' participants in the IC would be significantly larger than in the CIPC (the I/P effect).

### **Results**

In the pre-test interview, all of the participants showed a clear understanding of the difference between instances of true magical events and tricks that looked like magical events. Only the possibility in which a magic spell produced or destroyed the book by itself was acknowledged to be true magic.

In the demonstration trial, all participants examined the box with obvious curiosity. In the IC, two participants agreed that the postage stamp might have been cut with the magic spell. Others thought it was some kind of trick produced by the box. In the CIPC, all participants thought that the effect was a trick.

In the action trial, all participants in the IC encouraged the experimenter to try the magic spell on their licenses. In the CIPC, nine participants decided that it was worth trying the tricky box on their driving licenses, and seven participants said that it was not. The difference between conditions was significant, Fisher's exact  $p = .003$ .

The analysis of participants' answers to the follow-up question about why they encouraged the experimenter to proceed with the magic spell yielded the following results. In the IC, 15 participants justified this by curiosity, and 1 gave a skeptically based justification.

To the follow-up question of whether they would be happy or not to discover that magic was real, all but one participant answered positively. In the CIPC, out of nine participants who encouraged the experimenter to proceed with testing, four justified this by their curiosity to see how the tricky box would work, and five said they did it because they did not believe anything would happen to their driving licenses. All participants who refused to proceed with testing justified this by concern about their licenses' safety.

### **Discussion**

The results of Expt 2 confirmed the I/P effect: adult participants showed a significant preference for experimenting with a magic spell over experimenting with a trick box. This happened even though the majority of participants came from the cultural

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<sup>5</sup> Two judges did the coding, the agreement was 95%, the disagreements were resolved via a discussion.

background where explicit magical beliefs are rare, had a clear understanding that the effect they wanted to see was true magic and not a trick and that if their driving licenses were indeed damaged, this would be irreversible. This result makes the first and second alternative explanations of the result of Expt 1 unlikely.

Participants' answers to the follow-up questions showed that their reason for encouraging the experimenter to proceed with the magic spell was not to show their skepticism towards magic, but rather to satisfy their curiosity towards the possibility that it might still work. The presence of the specific motivation of curiosity towards magic was confirmed by the fact that all but one of the participants said they would be happy to discover that magic was real. Some participants were even more explicit on the topic, saying that if magic were real it would make the world a more interesting place to live.

In contrast, in the CIPC only 9 of 16 participants encouraged the experimenter to proceed with the testing, and only 4 of those justified their decisions by curiosity. As the unusual phenomenon demonstrated (cutting a postage stamp inside the box) was the same in both conditions and the only difference between the conditions was the presence or absence of the magical context, this result clearly provides evidence of the I/P effect.

There remains, however, the third alternative explanation of the participants' stronger desire to repeat the effect they observed in the IC than in the CIPC: the 'causality vector' (external in the IC vs. internal in the CIPC) explanation. In order to examine this explanation, in Expt 3 the causality vector was made external in both conditions.

Another hypothesis tested in Expt 3 was that increasing the irreversibility of the magical effect in the demonstration trial would decrease the number of participants willing to experiment with magic by using their valuable objects. This hypothesis is based on the assumption that, in the participants' view, making the magical effect more irreversible increases the probability of their valuable objects being damaged in the action trial and thus raises the cost of exploratory behaviour.

## EXPERIMENT 3

### *Participants*

In total, 34 undergraduate and graduate students, males and females, were involved in this experiment, 18 in the IC ( $M = 20.4$ , 18–22) and 16 in the CIPC ( $M = 21.4$ , 19–32). They were primarily British and Caucasian. Approximately, 25% of the participants were international visiting undergraduates from continental Europe, Asia, and the USA. About half of participants were psychology students, and the other half represented disciplines other than psychology.

### *Materials*

Materials were a magic box, the same as in Expt 1, two identical postage stamps with a picture of an insect's head (one of them new, another half burned), participants' driving licenses, and a novel physical device that produced light and sound effects when switched on.

**Design**

The design was the same as in Expt 2.

**Procedure**

The procedure was the same as in Expt 2, save three differences. First, in the demonstration trial the phenomenon shown was burning half of the stamp, not cutting it in half as in Expt 2. This was done in order to make the 'magical effect' look more irreversible. Indeed, if the driving license is cut in half, one might tape it back together, but this would be impossible to do with the license half burnt. Second, in the CIPC, after a participant put the stamp in the box and closed the lid, the experimenter switched the novel physical device on for a few seconds and then off again. This was done to acquaint the 'causality vector' factor in both conditions by making the causes of the unexplained phenomena look like external events (either the magic spell or the physical device). As in the IC, in the CIPC, after the demonstration of the effect, participants were asked if they thought that the physical device had burned the postage stamp. Third, at the end of the experiment the third (imaginative) trial was introduced. In this trial, participants were asked if they would be prepared to proceed with the testing if it were not their driving licenses but their more valuable documents - passports - involved in the experiment. The purpose of this trial was to examine if the I/P effect would remain under the condition in which the cost of exploratory behaviour was further increased.

**Hypotheses**

If the alternative explanation of the results of Expts 1 and 2 by differences in the causality vectors between conditions (external in the IC vs. internal in the CIPC) were true, then in this experiment the numbers of participants willing to experiment with their driving licenses in the IC and the CIPC would be approximately the same. If, however, the number of participants who wished to put their valuable objects at risk in the IC were significantly higher than in the CIPC, then this alternative explanation would be overruled.

It was also expected that increasing the irreversibility of the magical effect (burning the stamp instead of cutting it in half) would significantly decrease the number of participants who wished to experiment with their driving licenses in the IC as compared with the number in Expt 2.

Finally, it was expected that in the imaginary trial the I/P effect should disappear. This was expected on the grounds that, in addition to increasing the cost of exploratory behaviour via making the magical effect more irreversible in the demonstration trial, in the imaginary trial this cost will be further increased via making the 'objects at risk' more valuable (participants' passports instead of their driving licenses). With such a high cost of exploratory behaviour in the IC, participants' concerns about their valuable objects' safety will overpower their curiosity towards seeing the impossible event, and this will disguise the difference in curiosity between conditions.

**Results**

In the pre-test interview, all participants clearly distinguished between true magic and stage magic. In the demonstration trial of the main interview, four participants in the IC

agreed that the magic spell produced the phenomenon, with the rest of the participants saying that it was a magic trick. In the CIPC, 14 participants agreed that the physical device produced the effect, and 2 participants said that the box did it. The difference between the proportions of participants accepting the suggested explanations in the IC and CIPC is significant, Fisher's exact  $p = .0002$ .

A total of 12 participants in the IC (67% of the sample) and 4 participants in the CIPC (25% of the sample) agreed to proceed with the testing on their driving licenses, with the rest saying they would rather not. This difference between conditions is significant, Fisher's exact  $p = .017$ .

The reasons that participants provided for their desire to experiment with their licenses were as follows. In the IC, 11 participants justified this by their curiosity and interest to explore, and 1 said she wanted to prove that this was not magic. Participants who refused to experiment with their licenses justified this by their concern about their licenses' safety. In the CIPC, justifications for the 'yes' answer all referred to curiosity, and 'no' answers were justified by concern about the licenses' safety.

In the imaginary trial with the participants' passports, 7 participants in the IC and 2 in the CIPC said they would like to experiment with their passports, and the rest said they would not. The difference between conditions is in the same direction as in the case of the driving licenses, yet it failed to reach a significant level, Fisher's exact  $p = .08$ .

A comparison between the results of Expt 2 (cutting) and this experiment (burning) (Table 2) shows that in this experiment the proportion of participants who opted to experiment on their licenses decreased significantly for the IC, Fisher's exact  $p = .02$ , but insignificantly for the CIPC, Fisher's exact  $p = .07$ .

**Table 2.** Percentages of participants (total numbers) who opted for testing the accompanying action on their driving licenses in Expt 2 (cutting) and Expt 3 (burning), as a function of condition (IC vs. CIPC)

Condition	Experiment	
	2	3
IC	100 (16)	67 (18)
CIPC	56 (16)	25 (16)

## Discussion

The data did not support the alternative explanation of the results of Expt 1 by the difference in the causality vectors between conditions. In Expt 3, the apparent causes of the phenomenon were external in both conditions (the magic spell in the IC and the physical device in the CIPC). Yet, as in Expts 1 and 2, in this experiment a significantly larger number of participants were willing to engage in exploratory behaviour with their driving licenses in the IC than in the CIPC. This increases the plausibility of the hypothesis that an impossible event is intrinsically more interesting than an equally novel and unexplained possible event (the I/P effect).

As expected, increasing the irreversibility of the magical effect inhibited exploratory behaviour in the IC, presumably by increasing its potential cost. As in Expt 2, in this experiment in the demonstration trial of the IC most participants were skeptical towards the suggestive magical explanation, yet the number of participants who were

willing to experiment with their licenses dropped significantly as compared to Expt 2. In the CIPC the effect was in the same direction, however, as the total numbers of participants willing to experiment with their licenses in this condition were significantly smaller than in the IC, the effect did not reach a significant level.

Finally, the expectation that in the imaginary trial, the difference between the two conditions would drop to an insignificant level with the increased cost of exploratory behaviour (participants' passports) was also supported by the result. This suggests that the I/P effect can only be observed under a certain 'optimal' degree of cost, and when the cost becomes too high the I/P effect disappears. However, if the hypothesis linking the I/P effect with the 'floor and ceiling' of the cost of exploratory behaviour is valid, then in the 'low cost' trial, as in the 'high cost trial', the I/P effect should not be observed.

In addition, testing adults instead of children creates the possibility for one more - 'high-tech' - alternative explanation of the I/P effect. The problem is that most modern adults are familiar with all sorts of sophisticated devices, such as the 'clapper' (the sound-wave sensitive light switch that directly responds to someone's clapping) or cell phones and certain GPS systems (global positioning systems, such as satellite car navigators) that can be programmed to respond to voiced commands. Even though in this experiment the effect of the magic spell was presented as a case of true magic, there is no certainty as to whether participants did indeed view the effect as one that includes an element of the supernatural. Though small, the possibility exists to interpret the magic spell as an auditory signal that triggers some remote controlled device in the box, burning the object inside. If this is the case, then in this experiment, as in Expt 2, the I/P effect can still be explained by the difference in the intrinsic interest of the two possible events rather than by the difference between possible and impossible events. Although this explanation cannot be completely overruled, its likelihood could be reduced by creating an explicit clash between the 'impossible' (magical) and the high-tech possible (non-magical) explanations.

## EXPERIMENT 4

### Method

#### *Participants*

Participants were university undergraduate and graduate students, males and females, 18 in the IC ( $M = 19.7$ , 18 to 22) and 15 in the CIPC ( $M = 20.8$ , 18 to 33). They were primarily British and Caucasian. Approximately, 35% of the participants were international visiting undergraduates from continental Europe, Asia, and the USA. About half of participants were psychology students, and the other half represented disciplines other than psychology.

#### *Materials*

Materials were the same as in Expt 3, save one difference: instead of the participants' driving licenses, the experimenter's business card was on the table.

#### *Design*

The design was the same as in Expt 2.

### **Procedure**

The procedure was the same as in Expt 3, except for the following differences. First, in the action trial, instead of the participants' driving licenses, the experimenter's business card was used. This was done in order to reduce the price of exploratory behaviour to a minimum and thus further examine the hypothesis linking the I/P effect with the optimal degree of cost of exploratory behaviour.

Second, after the participants responded to the question of whether they were willing to proceed with testing using the business card, in the IC the instruction was as follows: 'It is quite clear that what happened to this postage stamp was either a high-tech trick, for example a voice-sensor device hidden in the box, or an instance of true magic, do you agree? In the beginning of this experiment you and I agreed on what true magic was and what a trick was, didn't we? So, if it was my magic spell that burned part of this stamp, then was it an instance of true magic or a high-tech trick?'

After the participants gave their answers, the instruction continued: 'OK. Now, my condition is as follows. If you are 100% sure that it was some kind of high-tech trick, then there is no point of trying my magic spell on this business card and this experiment ends. However, if you allow for the possibility that it was an instance of true magic, I will try my magic spell on this business card. As far as it concerns me, I don't care if you allow or do not allow for the possibility that it was an instance of true magic. It is for you to decide'.

'So, are you 100% sure that this was a high-tech trick, or do you allow for the possibility that it was an instance of true magic?'

In the CIPC the procedure was the same as in the IC, except that instead of 'magic spell' the words 'physical device' were used.

This was done in order to create an explicit clash between the impossible-magical and the possible-high-tech explanations by making declining the impossible-magical explanation costly. If the participants wanted to satisfy their curiosity and proceed with testing in the action trial, they had to acknowledge that the cause of the effect shown in the demonstration trial was in fact true magic and not a high-tech trick.

### **Hypotheses**

If the hypothesis that the I/P effect occurs between the 'floor and ceiling' of cost of exploratory behaviour were valid, then in this experiment the expected numbers of participants willing to experiment with the business card in both conditions would be large and approximately the same.

The second expectation was that a significantly larger number of participants would accept the possibility of the impossible-magical explanation in the IC than in the CIPC.

Indeed, if participants strongly believed that the effect shown in the demonstration trial was a trick and not true magic (CIPC), then they would stick to the non-magical explanation even at the expense of not proceeding to the action trial and having their curiosity remain unsatisfied. This was expected because saying that the effect might be true magic when it is obvious that it is not would look like intentional lying, and most participants would not like to produce the impression that they are lying. However, if the effect implied even the smallest chance of being caused by true magic (IC), then in this experiment participants should go for this explanation in order to proceed to the action trial and satisfy their curiosity.

## Results

In the pre-test interview, all participants showed a clear appreciation of the difference between tricks and true magic.

In total, 16 participants in the IC (88%) and 15 in the CIPC (100%) said they wanted to proceed and test the effect on the experimenter's business card. Compared to the results of Expt 3, in this experiment the number of participants willing to proceed to the action trial was significantly larger in both conditions, Fisher's exact  $p = .02$  for the IC and  $p < .001$  for the CIPC. There was no significant difference between the numbers of participants who wanted to proceed in the IC and the CIPC in this experiment, Fisher's exact  $p = .48$ .

In the IC, all participants acknowledged that if the magic spell produced the effect, this would be an instance of true magic (consciousness over matter type) and not a high-tech trick. In the CIPC, all participants said that if the physical device produced the effect, then this would be a trick and not true magic ('because something caused it to happen, there is a tangible reason', 'because it is explainable', 'it is some kind of electric power and could be scientifically explained, and true magic cannot be scientifically explained').

When proceeding to the action trial was conditioned by acknowledging that the effect in the demonstration trial may have been a case of true magic and not a high-tech trick, 12 participants (67% of the sample) in the IC, but none in the CIPC, acknowledged this possibility. This difference was significant, Fisher's exact  $p < .001$ .

## Discussion

The results of this experiment supported the expectation that lowering the cost of exploratory behaviour down to zero eliminated the I/P effect: 88% of participants in the IC and all participants in the CIPC said that they wanted to proceed to the action trial. These numbers were significantly larger than in the same conditions of Expt 3. The obvious explanation of this is that when there is no risk of losing their valuable objects due to their exploratory behaviour, participants' curiosity becomes a dominant motivation of their actions in both conditions. Given that in the imaginary trial of Expt 3 only a few participants in each condition expressed interest in proceeding to the action trial with their passports being at risk, the results of this experiment support the hypothesis that the I/P effect occurs only when the cost of exploratory behaviour is not too high or too low.

The fact that in the IC, but not in the CIPC, a large number of participants acknowledged that the effect in the demonstration trial might have been caused by true magic and not by a high-tech mechanism supports the second expectation. It was significantly more difficult for the participants to acknowledge the impossible-magical explanation in the CIPC than in the IC, even if by not acknowledging this possibility participants had to forfeit their ability to proceed to the action trial. This suggests that in the IC in Expts 2 and 3, participants implicitly believed that there might be an element of the supernatural (i.e., truly magical) in the effect shown in the demonstration trial, though most of them denied that. When, in this experiment, participants were positively motivated to accept the likelihood of the impossible-magical explanation, they accepted it in the IC, but not in the CIPC. This difference between conditions cannot be explained by participants' desire to meet the experimenter's expectations since the instruction was the same in both conditions. One must therefore conclude that in Expts 2 and 3, the fact that larger numbers of participants agreed to experiment

with their valuable objects in the IC is likely to have resulted from the strong curiosity of participants towards the effect that seemed impossible, rather than towards an interesting but possible high-tech trick.

## GENERAL DISCUSSION

Expts 1 and 2 showed that both 4- to 9-year-old children and adults are more likely to engage in exploratory behaviour if the target of this behaviour is an impossible event than if it is a counter-intuitive but possible event (the I/P effect). Expt 3 indicated that the I/P effect remained when the impossible phenomenon was made more irreversible (burning instead of cutting) and the causality vectors were made external in both conditions (a magic spell in the IC and an unknown physical device in the CIPC). This effect cannot be explained as an artefact of participants' mistaking the magical effect for a high-tech trick. Indeed, in Expt 4 most participants explicitly admitted that the effect shown in the IC might have involved true magic, while the effect shown in the CIPC did not. This suggests that in Expts 2 and 3 adult participants were more willing to engage in exploratory behaviour in the IC than in the CIPC because in the IC the target of exploration, apart from being novel and counter-intuitive, involved the possibility of the supernatural.

It was also found that the I/P effect is exhibited only in the conditions in which the cost of exploratory behaviour is moderate (a threat to the safety of the participants' driving licenses). If the cost is too high or too low, participants' exploratory behaviour decreases or increases to an extent that eliminates the I/P effect.

The question arises of what causes the I/P effect. Indeed, why are children and adults attracted towards phenomena that they (and their social environment) view as impossible? In children, this can be explained by the fact that adults purposefully encourage magical thinking in children by maintaining a special 'culture of magic' in the form of traditional magical characters (Santa Claus, Tooth Fairy) or using magical explanations of events (Johnson & Harris, 1994; Rosengren & Hickling, 2000; Woolley, 1997). But why would adults show the I/P effect?

One possible explanation may be that in a world dominated by science, impossible phenomena fill certain gaps that exist in the mind of the modern individual. First, they respond to the unsatisfied need to break away from the predictable and mundane world that science has created (Subbotsky, 1992; Zusne & Jones, 1982). In this respect, the interest shown towards impossible phenomena is kindred to the interest that people show towards mass entertainment or paranormal phenomena (Bem & Honorton, 1994; Boyer, 1994; Jahoda, 1969; Tambiah, 1990). Second, impossible events like magic provide hope that it is possible to gain control over events and feelings that otherwise are beyond our control (Nemeroff & Rozin, 2000; Shweder, 1977; Zusne & Jones, 1982).

Another possible explanation is that the I/P effect is a manifestation of a certain degree of belief that most people, unconsciously or consciously, have towards magic. This explanation is based on data showing that people's unconscious reactions towards food or contamination follow the laws of contagious or sympathetic magic (Nemeroff & Rozin, 1992, 1994; Rozin, Markwith, & Ross, 1990; Rozin *et al.*, 1986) and, under certain conditions, people consciously acknowledge the possibility of magic (Subbotsky, 2001; Woolley, 1997). A certain degree of credulity towards the possibility of true magic was also shown in this study. Though small, this degree of credulity was enough to facilitate exploratory behaviour in children and adults. Although incompatible with the view of

modern science, this belief still has rational grounds in some areas of everyday life (Nemeroff & Rozin, 2000).

One more way to account for the I/P effect is to view it as a manifestation of the most archaic and basic structures of the individual's mind. This view has its roots in theories that consider magical thinking to be at the origins of the modern mind (Jaynes, 1976; Tambiah, 1990). It can also be supported by data showing the increment of magical and paranormal beliefs in people with mental illnesses (Eckblad & Chapman, 1983; Thalbourne, 1994; Thalbourne & French, 1995). It will be important in future research to look more closely at magical beliefs of psychiatric patients and to involve samples of these patients in experimental studies such as those described in this paper, rather than in studies based on questionnaires. The results of such studies may shed light on the psychological roots of the I/P effect, as well as provide clinicians with a better understanding of the cognitive changes that accompany certain kinds of mental illnesses.

The I/P effect provides support for the theory that presents the development of the individual mind as a diversification and coexistence of various, even alternative, modes of making sense of reality (Boyer, 1994; Nemeroff & Rozin, 2000; Shweder, 1977; Subbotsky, 1992; Tambiah, 1990). This effect can also partially explain the popularity that fantastic characters with magical powers enjoy in the domains of entertainment, education, and commercial advertising.

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