Curiosity and exploratory behaviour toward possible and impossible events in children and adults

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Abstract

In four experiments with 4-, 6- and 9-year-old children and adults the hypothesis was tested that, with all other conditions 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 magical (the impossible event) or scientific (the possible event) explanations.

In the verbal trial, participants showed full 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 a valuable object in order to explore the impossible event than the possible event. Follow up experiments showed that the I/P effect can not 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.
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Introduction.

Interest in studying behavioural responses to novelty in stimulus situation, initiated by Pavlov’s (1927) notion of the investigative reflex, has been on the increase in developmental psychology. It resulted in studying curiosity and exploratory behaviour in animals (Butler, 1954; Harlow, 1958), children (Cantor and Cantor, 1964; Comerford and Witryol, 1993; Mendel, 1965) and adults (Berlyn, 1960; Pliner, Pelchat and Grabski, 1993). The tendency of animals and humans to engage in exploration ‘for its own sake’ became the basis for the well known ‘habituation--dishabituation’ paradigm in psychological research, particularly with infants (Bremner, 1994).

The studies showed that degree of novelty in a stimulus is a major factor in eliciting exploratory behaviour (Mendel, 1965), and the intrinsic motivational value of novelty is equivalent to that provided by material and edible rewards (Cahill-Solis and Wytryol, 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 and Moore, 1980). Thus, novel foods that look unattractive or dangerous are unlikely to engage a participant in exploration (Nemeroff and Rozin, 1992; Pliner, Pelchat and Grabski, 1993).

The assumption to be tested in this study is that one particular feature that makes a stimulus intrinsically interesting for humans is the stimulus’ capacity to violate fundamental 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, psi and other impossible phenomena have always attracted considerable public interest (Bem and Honorton, 1994; Jahoda, 1969; Lundahl, 1993; Zusne and Jones, 1982). What remains unclear, however, is the causes of this attraction. Indeed, due to their very nature, the above phenomena are rarely observed and difficult to access, hence they are extremely novel. Apart from being novel, they are also impossible, i.e. can not be explained in terms of
modern science. Along with impossible events, a contemporary western individual has to deal in his or her everyday life with a number of objects and events (such as the products of technology or medicine) that are equally novel and 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 'supernatural'?

To examine this, it is necessary to provide a participant with a novel stimulus which is framed either in the context of scientific views (a possible event) or in the context that involves an element of the supernatural (an impossible event). If the stimulus' impossibility is an additional factor that contributes toward eliciting curiosity and exploration, then participants' tendency to engage in exploratory behaviour toward the impossible event should be stronger than toward the same but possible event. If this indeed is the case, then it can be named the 'impossible over possible' (the I/P) effect.

Consequently, in this paper the I/P effect implies that, other conditions being equal, a novel and unusual 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 infancy studies. It was shown, for instance, that 5-month-old infants reveal a higher degree of exploratory behaviour if shown displays that violated principles of physical causality (such as 'launching without collision' or pulling an object up without physical contact) than when observing similar displays with no violation of these principles (Leslie, 1982; 1984). Baillargeon (1987) reported that 3 1/2- and 4 1/2 month-old infants showed surprise when they saw a solid screen go through a solid box hidden behind it (an impossible event) to a significantly larger extent than when they saw the screen stopping in a position where it was supposed to touch the box (a possible event). It was also shown that the infants were more curious about the impossible display not because they found the 180 degrees screen rotation intrinsically more interesting than the 'impeded rotation', but because they viewed it as impossible and were surprised or puzzled by seeing a screen that moved through the space occupied by the occluded box. These data suggest that for infants
stimulus' impossibility is an independent factor that evokes exploratory behaviour. The question that remains open is whether the same is the case for children and adults.

There is substantial evidence against the views of the above authors who interpret infants' behavioural patterns in terms of advanced cognitive capacities. Instead, this evidence suggests that these behavioural patterns, based on the habituation/dishabituation or preferential looking paradigms, can be fully explained by the low level perceptual mechanisms (Bogartz, Shinskey and Speaker, 1997; Haith, 1998; Munakata, McClelland, Johnson and Siegler, 1997). Without considering this discussion in detail, for the purpose of this study we simply take it for granted that the ways the difference between possible and impossible events is perceived by infants and by older participants are fundamentally different. Unlike infants, children of advanced ages and adults acquire a more distinctive 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 of that physical laws (such as object permanence or physical causality) are inviolate, and therefore, any display that looks like a violation of these laws can be nothing but a trick. This understanding can be symbolically represented and verbally formulated in scientific terms. As a consequence of this, in older participants the distinction between 'possible unexplained' and 'impossible unexplained' events can become purely theoretical, since any observable event is actually viewed as possible, i.e. as the one that complies with the laws of physics. If this is the case, then a demonstration of the same novel phenomenon framed in either scientific or supernatural contexts can only elicit the same degree of curiosity and exploratory behaviour in the participants. Alternatively, it can be assumed that older children and even adults still hold some belief in reality of impossible events. Despite the understanding that such events violate the laws of nature, at an emotional level people can still believe that impossible events can occur as exceptional cases, as a result of the intrusion of human or God's will in the flow of natural events. In this case, their interest and tendency to explore will be stronger toward the impossible novel event than toward the same but possible event (the I/P effect).  

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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 in impossible events can be elicited by verbal knowledge and understanding of these events' impossibility.
As an impossible event which was contrasted with a possible event, an instance of magical causality was taken in this study. Theoretically, at least four classes of events are usually viewed as magical: 'consciousness 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 a non-animate 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 wide spread belief that certain chosen objects and actions can bring luck or affect the flow of natural events) (see Boyer, 1994; Frazer, 1922; Jahoda, 1969; Needham, 1976; Seligman, 1948; Tambiah, 1990). Within all the diversity of these types of events, any of them is incompatible 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 result of a trick), then the person can be qualified as having an adequate concept of the difference between impossible and possible events.

Although since Piaget's (1927) famous account of the development of causal thinking in children experimental exploration into children's beliefs in magic went into a decline, the last decade has witnessed the reemergence of studies examining children's beliefs in magic and magical causality. Thus, Harris, Brown, Marriott, Whittal 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 those do not exist. In the study by Johnson and Harris (1994) it was demonstrated that 3–5 year-old children viewed magical transformations of objects to be impossible, yet in their actions they showed considerable credulity toward magic. Similar data were reported by other authors, who showed the ability of preschool children to distinguish magical transformations from non magical ones and make effective use of the concept of magic (Chandler and Lalonde, 1994; Rosengren and Hickling, 1994; Subbotsky, 1985). Adults' preparedness to follow the rules of contagious and sympathetic magic in making their emotional preferences was reported in the studies by Rozin, Millman and Nemeroff (1986) and Rozin, Markwith and Ross (1990). On the basis of these and other data Woolley (1996) concluded that with regard to their engagement in magical thinking adults are not fundamentally different from children.
Subbotsky (2000) showed that children of 6 and 9 years and adults could quite consciously act in a way which is concordant with beliefs in magic.

While in studying magical beliefs considerable progress has been made, another aspect of magical thinking -- children's and adults' curiosity toward magic -- remains largely unexplored. Indeed, a person can believe in magic and yet be afraid of it and reluctant to explore such belief. And vice versa, a person may treat the possibility of magic with skepticism and yet be curious about magic and willing to explore if it can be a real thing. In order to examine if the I/P effect can be observed in children, in Experiment 1 children of 4, 6 and 9 years 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 caused by magic, and in the 'possible condition' (PC) by a trick box. It was predicted that if children's exploratory behaviour was 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 will be significantly larger than that in the PC.

**Experiment 1.**

**Method.**

**Participants**

Eighty four children participated in two 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 PC 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 without the double bottom being discovered.

**Procedure.**

To ensure that children are capable of distinguishing between magical and ordinary transformations, in the verbal trial they were individually asked the following questions:

1. What if 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, what if 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. Can we say that the stamp appeared by magic or would there not be any magic in this? Please, bear in mind that the stamp appeared because the magic wand made it appear, not because it was some kind of trick, OK?

3. And what if I take a box with a stamp in it, take the stamp out of the box, burn it so it becomes 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?

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

In the action trial, children were tested in two conditions. In the IC, a child was given a nice postage stamp as a reward for his or her answers. The child was then shown a 'magic box' and another postage stamp, which was immediately placed into the box and the lid of the box was closed. 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 reminded that a postage stamp had been put into the box, and requested to wave the magic wand in order to make the stamp disappear.
After the child did this, he or she was asked if he or she thought that the stamp was still in the box or had disappeared. Whatever the answer, the child was asked to open the box and saw that it was empty. The child was then encouraged to examine the box and asked to explain why the stamp was not in the box. If the wand and magic were not mentioned in the child's answer, he or she was asked if he or she believed that it was the magic wand that made the stamp disappear. Next to this, the child was told 'Would you like to see again how this magic wand works with you own postage stamp, or would it be better not to?'

In the PC the procedure followed along the same line, however, no magic wand was given to the child. The stamp was put into the box and the child was asked whether he or she believed it was still there or had disappeared. Next, the child was asked to open the box and saw that it was empty. He or she was then asked to explain the phenomenon. After this the experimenter said that this box was a tricky box. It had some stuff in its bottom which destroyed the stamps so they ceased to exist. The child was then asked whether he or she would like to see again how the box worked, using his or her own stamp.

It was expected that if children were interested in experimenting with magic more strongly than in experimenting with the trick box, then they would encourage the experimenter to reproduce the action in the IC more frequently than in the PC. If the prediction proved correct, this would mean that the I/P effect occurred. 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 were identical in both conditions.

Results.

The results of this experiment are shown in Table 1.

Table 1 about here

In the verbal trial, all the children were capable of distinguishing between magical and ordinary outcomes, and many of them made additional comments showing that they were skeptical toward magic ('This is not a magic wand', 'You cannot be a magician'). Yet, in the first part of the action trial most participants in the IC showed surprise and asked the
experimenter whether they could do it again. When told that this time they had to use their
own postage stamps, most children were prepared to repeat the experience and placed their
stamps in the box without hesitation. Others showed some hesitation, and there were only a
few children who refused to proceed. In the possible condition only a few children were
prepared to put their valuable objects at risk. The differences between conditions were
significant for all age groups, with Fisher Exact Probability being $P=.0007$, $P=.009$ and
$P=.0002$, respectively. There were no significant differences within conditions.

Discussion.

The results showed that 4-, 6- and 9-year-old children did reveal a significantly
stronger tendency to experiment with the magic wand than with the trick box. This cannot be
explained by the differences in the amount of risk taken between the conditions. In the IC
children had to put their postage stamps in the box and close it before they could use a magic
wand, so they knew they had to run the risk of losing their stamps even if they believed that
it was not magic but the box itself that had destroyed the postage stamp.

The children's curiosity toward magic could also not be explained by any pragmatic
interest, like the desire to produce some material reward with the help of magic. Indeed, in
the IC children's curiosity could only be satisfied at the price of putting their valuable
objects at risk, which made the magical action pragmatically useless and even undesirable.
The fact that so many children opted for it shows that their high interest toward magic was
triggered by the fact that the event was impossible and not simply novel.

The results also showed a contrast between curiosity toward magic and magical
beliefs. Although many children were skeptical toward the possibility of magic in the verbal
trial, in the action trial they showed strong curiosity. Interestingly, children of all age
groups showed a tendency to experiment with magic to an equal extent. This demonstrates
that even if magical beliefs decrease with age (as would follow from Piaget's account,
1927), their curiosity toward magic does not.

There remains, however, the possibility for alternative interpretations of the above
results. First of all, although in the verbal trial children called the impossible event
magical and some of them commented that it was impossible, it was not completely clear if
magic meant real magic (that involves the element of supernatural) or stage magic. As was
shown in earlier studies, children of preschool and school ages often label as magical the events for which they simply have no plausible scientific explanations or which violate their expectations (Phelps and Woolley, 1994). It was true that, when shown pictures with possible and impossible transformations of objects, 4- and 5-year-olds quite selectively called impossible transformations magical (Rosengren and Hickling, 1994). Yet, the possibility still remains that they viewed the impossible transformations as tricks. This possibility was supported in the study in which 3-5-years-old children were shown an impossible event of a solid screen apparently passing through the space already occupied by another solid object (Chandler and Lalonde, 1994). Although the children labelled this event as magical, a more thorough examination revealed that they viewed it as a trick.

Secondly, it might also be assumed that in Experiment 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 than with the trick box on a tacit assumption that they would be able to subsequently recover the stamp with the same magic wand -- the assumption that would be less likely to make in the PC.

To examine these alternative interpretations, in Experiment 2 adult participants were tested in the same two conditions. In contrast to children, the difference between real magic that involves an element of supernatural and stage magic (a trick) that does not can be clearly explained to adults. It can also be made clear to them that if they lose their valuable objects in any of the conditions than this would be irreversible.

Experiment 2.

Method.

Participants.

Thirty two men and women, university undergraduates, were involved in this experiment, 16 in each of the two conditions. Mean ages and age ranges for the IC and PC were $M=21.7$, 18 to 42 and $M=21$, 18 to 33, respectively.

Materials.

A magic box, the same as in Experiment 1, two identical postage stamps (one of them new, another cut in half), and participants' driving licences.
Procedure.

The procedure of this experiment followed the procedure of Experiment 1, with a few exceptions. First, in the verbal trial, instead of the magic wand, a magic spell pronounced by an experimenter was used as a magical set up for the phenomenon. Second, in order to prevent a direct association between the verbal and the action trials, the objects in the verbal trial were changed: instead of the box and the postage stamp, a briefcase and a book were used. Third, with the aim to ensure that the participants can distinguish between real magic and stage magic, in the questions with the impossible outcome (questions 2 and 4) these two possibilities were explicitly separated. For instance, in Question 2, after the unexpected emergence 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 though hard about making the book appear, said my magic spell, and the book just 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 real magic?

In the IC, after a participant was asked to put a new postage stamp in the box and close the lid, the experimenter informed him or her that he was going to put a magic spell on the box, after which he pronounced a phrase which sounded like a spell. The participant was then encouraged to open the box and found a postage stamp in it which was cut in half.

Next, the participant was encouraged to inspect the box and asked to explain the phenomenon. The experimenter then asked whether the participant would believe if he (the experimenter) told him or her that he was in command of magic powers, and he just destroyed the postage stamp by putting a magic spell on the box. If the answer was 'Yes, I would believe you', the instruction was as follows: 'O.K. Yet, do you think that it is worth trying to test my magic spell on your licence right now, or you think that it is not worth trying?'

If the answer to the suggested magical explanation was 'No, I would not', the instruction was '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 licence it would destroy your licence, do you?', and then the question
followed if it was yet worth trying the magic spell on the participant's driving licence. The aim of these questions was to find out whether the participants, though skeptical toward magic, would nevertheless be curious to try it again.

There was only one motive, apart from curiosity toward magic, that could have prompted participants to encourage the experimenter to proceed with testing the effect on their driving licences -- this was the participants' desire to show that they did not believe in magic. Indeed, as soon as magical beliefs run against the scientific view of the world, some participants might feel uneasy if they did not encourage 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, to show that they are skeptical and because of that encourage the experimenter to proceed with the testing. In order to eliminate this possibility, the experimenter deliberately stressed that he was aware about the participants' skepticism toward magic.

In addition, the question about the possibility of further experimenting with magic was asked in a neutral form ('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' licences. As a result, the participants were assured that they were not viewed as believers in magic, and that the experimenter himself was not in any way interested in the continuation of the experiment. Therefore, the only motive that could encourage the participants to prompt the experimenter to proceed with the experiment was their curiosity to find out whether magic would work on their licences.

In the PC, participants were simply shown the phenomenon of a postage stamp being cut in half in the box. They were then told that this may have been done by the trick box. The box may have some device hidden in it that cuts objects in half when the lid is closed. The participants were then asked whether this assumption seemed plausible to them. Next, the participants were asked 'Do you think it is worth trying to test this hypothesis by closing the box with you driving licence inside it, or you think it is not worth trying?'

It was assumed that if the participants' interest toward magic in the IC was not a specific curiosity toward an impossible event but rather a desire to see once again how a trick device works, then the number of participants who would be prepared to experiment
with magic in the IC would be approximately the same as the number of those who would be willing to experiment with the trick the box in the PC. If, however, it was a specific interest to see 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 that in the PC (the I/P effect).

This follows from the fact that the amount of risk involved was the same in both conditions. Even if participants were skeptical toward the 'magical' explanation of the demonstration phenomenon in the IC, they had to explain it somehow, and the most plausible explanation was that the phenomenon had been produced by the box itself. In order to test the magic spell in the IC, as soon as the participants placed their driving licences in the box and closed the lid, they ran the risk of losing their valuable objects to the same extent as in the PC.

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 the IC they were also asked if they would be happy if magic really worked.

Results.

In the verbal trial, all the participants showed clear understanding of the difference between instances of real magic and tricks that looked like magic. Only the possibility in which a magic spell produced or destroyed the book by itself was acknowledged to be real magic.

After the phenomenon was demonstrated, all participants examined the box with obvious curiosity. In the IC, two participants agreed that the postage stamp may have been cut with the magic spell. Others thought it was some kind of trick produced by the box. In the PC, 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 licences. In the PC, 9 participants decided that it was worth trying the tricky box on their driving licences, with the rest 7 participants saying that it was not. The difference between conditions was significant, Fisher Exact, $P=0.003$.

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.
Fifteen participants justified this by being curious (i.e. '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 licence'...,), and one gave a skeptically based justification ('Because I did not believe it could work, I wanted to prove that it did not work').

To the follow-up question about whether they would be happy or not to discover that magic was real, all but one participants answered positively (i.e., 'Yes, I'd like to believe in magic, the world seems to be too boring, every question seems to have answers, I'd like 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').

In the PC, out of 9 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 licences.

Discussion.

The results of Experiment 2 confirmed the I/P effect: adult participants showed a significant preference for experimenting with a magic spell over experimenting with a trick box. One alternative possibility to explain this result is that participants were inclined to believe that the trick box had destroyed the postage stamp in the demonstration of the phenomenon, but they did not think that the magic spell did this. As a result, in the PC they were worried about their driving licences, while in the IC they did not care.

However, if it was the fear of the box that determined the exploratory behaviour, then the number of participants who were anxious to place the licences in the box and close the lid in the IC should be the same that in the PC. Indeed, in both conditions most participants explained the demonstration phenomenon (the destruction of a postage stamp in an empty box) as a trick and, therefore, in both conditions they had the same reasons to be
worried about their licences' safety.

Participants' answers to the follow-up questions showed that their reasons for encouraging the experimenter to proceed with the magic spell was not to show their skepticism toward magic but rather to satisfy their curiosity toward the possibility that it might still work. The presence of the specific motivation — curiosity toward magic — was confirmed by the fact that all but one participants said they would be happy to discover that magic was reality. 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 PC only 9 of 16 participants encouraged the experimenter to proceed with the testing, and only 4 of those justified their decisions by curiosity. As soon 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 magic, this result clearly indicates toward the I/P effect.

One more alternative explanation of the results may be that in the IC participants did not view the effect as impossible. Instead, they viewed it as a clever trick disguised to look like magic. If this were the case, then the difference between the numbers of participants willing to engage in exploratory behaviour in the two conditions might be a result of the fact that in the IC the trick was more interesting then in the PC. Indeed, in a popular view, real magic is usually associated with a specific kind of destruction, like burning or chaotic disintegration (Seligman, 1948), and not with a mechanical cut. This disharmony between the suggested explanation (magic) and the effect (a mechanical cut) may have increased the participants' skepticism toward the plausibility of a suggested explanation in the IC, which resulted in the disbelief that the phenomenon can actually be reproduced. If this is the case, then increasing the authenticity of the magical effect would reduce the skepticism and increase the cost of the exploratory behaviour. If the I/P effect was an artifact of the participants' disbelief in the possibility for the magic spell to work on their licences, then with the increased authenticity of the demonstration phenomenon the I/P effect should disappear.

In order to examine this explanation, the demonstration 'magical' phenomenon should be made look more authentic. Consequently, in Experiment 3 adult participants were shown a
phenomenon in which a brand new postage stamp appeared to be burned after it was placed in
the box.³

Experiment 3.

Participants.

Thirty four men and women, university students, were involved in this experiment, 18 in the IC (M=20.4, 18 to 22) and 16 in the PC (M=21.4, 19 to 32).

Materials.

A magic box, the same as in Experiment 1, two identical postage stamps with a picture of an insect's head (one of them new, another half burned), participants' driving licences and an unknown physical device that produced light and sound effects when switched on. The device had a socket attached to one of its external walls and directed toward the magic box.

Procedure.

The procedure was the same as an Experiment 2, save three differences. First, the demonstration phenomenon involved burning half of the stamp and not cutting it in half. This was done to make a more convincing impression that the effect was produced by the magic spell then the cutting of the stamp could make. Second, in the PC, after a participant put the stamp in the box and closed the lid, the experimenter switched the unknown physical device on for a few seconds and then off again. This was done to increase the similarity of a suggestive explanation in both conditions, by looking for a cause of the unexplained phenomenon in some external event (either the magic spell or the physical device) and not in the box itself as it was in the PC of Experiments 1 and 2. Third, in the end of the experiment participants were asked if they would be prepared to proceed with the testing if it were not their driving licences but their more valuable documents—passports—involved in the experiment. The purpose of this question was to examine if the I/P effect would remain under the condition in which the cost of exploratory behaviour was further increased.

Results.

In the verbal trial, all participants clearly distinguished between real magic and

³ This manipulation was suggested by Dr. Carol Nemeroff in her review of my previous paper.
stage magic. In the action trial, four participants in the IC accepted the experimenter's suggestion that the demonstration phenomenon had been caused by his magic spell, with the rest of the participants saying that it was a trick. In the PC, 14 participants agreed that the effect had been produced by the physical device, and two participants said it had been caused by the box. The difference between numbers of participants accepting the suggested explanations in the IC and PC is significant, Fisher Exact, \( P = .0002 \).

When asked if they would like the experimenter to test his spell (the device) on their driving licences, 6 participants in the IC (33% of the sample) and 12 in the PC (75% of the sample) said they would rather not, with the rest saying that they would. This difference between conditions is significant, Fisher Exact, \( P = .017 \).

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

In the imaginative experiment with the participants' passports, 7 participants in the IC and 2 in the PC said they would like to experiment with their passports, and the rest said they would not. The difference between conditions shows in the same direction as the one with driving licences, yet it failed to reach a significant level, Fisher Exact, \( P = .08 \).

The comparison between the results of Experiment 2 (cutting) and this experiment (burning) (Table 2) showed that in this experiment the number of participants who opted for testing the accompanying action on their licences decreased significantly for the IC, Fisher Exact, \( P = .01 \), but insignificantly for the PC, Fisher Exact, \( P = .07 \).
Discussion.

The data supported the assumption that increasing the authenticity of the impossible phenomenon inhibits exploratory behaviour by increasing its potential cost. This inhibition effect was not observed in participants judgments about the possible effect of magic, yet it was evident in the action trial. In their judgments, most participants in this experiment remained skeptical to the suggestive magical explanation in the IC, yet the number of participants who were willing to experiment with their licences dropped significantly as compared to Experiment 2. This decrement effect did not occur in the PC. A possible explanation of this can be that for the IC the change from cutting to burning was an important one to increase the phenomenon's authenticity, whereas for the PC this change did not matter that much because both cutting and burning of the postage stamp can equally likely be produced by a trick box or a physical device.

Yet, as in Experiment 2, in this experiment a significantly larger number of participants were willing to engage in exploratory behaviour with their driving licences in the IC than in the PC. This increases the probability of the hypothesis that an impossible event is intrinsically more interesting than an equally novel and unexplained possible event (the I/P effect). The fact that in the imaginative experiment with the increased cost of exploratory behaviour (participants' passports) the difference between the two conditions dropped to an insignificant level suggests that the I/P effect can only be observed under a certain 'optimal' degree of cost.

There still remains, however, the possibility for alternative explanations of the I/P effect. Firstly, although in this experiment the effect of the magic spell looked more authentic than in Experiment 2, it was not entirely clear if participants viewed the effect as one that includes an element of the supernatural. Indeed, though small, the possibility yet exists to interpret the magic spell as an auditory signal that triggers some remote controlled device in the box and thus burns the object placed in the box. If this is the case, then in this experiment, as in Experiment 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.
Another way to account for the difference in the exploratory behaviours between conditions is to assume that participants viewed the physical device to be a stronger threat to their valuable objects than the magic spell. If this is true, then the smaller number of participants willing to experiment with their driving licences in the PC as compared to the IC was an artifact of the different degrees of cost of exploratory behaviour in the conditions, and not a result of the higher degree of intrinsic interest of the impossible event as compared to the possible event.

To examine the first alternative interpretation, it is necessary to ensure that in the IC participants do indeed allow for the presence of the supernatural element. This can only be done if participants openly acknowledge this possibility while having a clear knowledge at the same time of what the supernatural element (i.e., 'real magic') involves.

The second alternative explanation can be examined by asking participants to provide their estimates of the potential destructive effects of the magic spell and the physical device. If it is indeed the case that the probability of the device to work on the licences is perceived as being higher than that of the magic spell, then this would show itself in the participants' estimates.

Experiment 4.

Method.

Participants.

There were thirty three men and women, university students, 18 in the IC (M=19.7, 18 to 22) and 15 in the PC (M=20.8, 18 to 33).

Materials.

The same as in Experiment 3, save one difference: instead of the participants' driving licences, the experimenter's business card was on the table.

Procedure.

The procedure was the same as in Experiment 3, except the following differences. First, instead of the participants' driving licences, the experimenter's business card was used. This was done to reduce the price for exploratory behaviour to the minimum and thus to encourage exploration. Second, during the experiment participants were asked to produce
the following five estimates, using the 0 --100% scale with which they all were well familiar. They were explained that if they were sure that an event had not happened, then they should give the event zero probability, if they were confident that an event had happened, they should give the event 100% probability, and if they were not sure about an event, they should ascribe the event probability between zero and 100%.

1. After the postage stamp was put in the box, the lid was closed and the accompanying action performed but, before opening the box, the experimenter asked the participants to give their estimates of the probability that the postage stamp in the box had changed.

2. After the participants saw that the postage stamp had changed, they were asked to assess the probability that the effect had been caused by the accompanying action.

3. After the participants acknowledged that they were willing to proceed with testing using the business card this time, in the IC condition the instruction was as follows:

'OK, I can try my magic spell again, but on one condition only. It is quite clear that what happened to this postage stamp was either a trick, or an instance of real magic, do you agree? OK, and in our previous conversation I agreed with you on what real magic is and what a trick is, didn’t I? So, if it was my magic spell that burned part of this stamp, and not a tricky box or something else, then was it an instance of real magic or a trick?

Now, my condition is as follows. If you are 100% sure that it was some kind of trick, then it makes no point trying my magic spell on this business card. However, if you allow for the possibility that it was an instance of real 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 real magic. It is for you to decide.

So, are you 100% sure that this was a clever trick, or do you allow for the possibility that it was an instant of real magic?'

If the participant acknowledged the possibility that this was an instance of real magic, he or she was asked to estimate the probability of that the effect was produced by the magic spell.

In the PC the instruction was: 'If it was really the device that burned part of this stamp, would this be an instance of real magic or some kind of trick?' Then the participants were asked to assess the probability of the assumption that it was a trick and not real magic.
4. After the business card was placed in the box, the lid closed and the accompanying action performed, participants again were asked to assess the probability that the card had changed.

5. After the card was discovered unchanged, participants were asked again to give their estimates of the probability that the effect with the postage stamp had actually been caused by the accompanying action.

Results.

In the verbal trial, all participants showed a clear appreciation of the difference between tricks and real magic.

Within reasonable limits, all probability estimations but Estimation 3 were normally distributed. The mean probability scores for each of the five estimations are shown in Table 3.

The difference between conditions on all estimations (except Estimation 3) was assessed by ANOVA for conditions (2) with the probability score being a dependent measure. On Estimation 3, Fisher Exact Probability non parametric test was used to assess the difference between conditions. Within conditions, ANOVA repeated measures design was used to assess the differences.

In the first estimate, a very low probability was given in both conditions to the possibility that the stamp had changed. The difference between the means on Estimation 1 was insignificant. After the participants saw the effect, all of them acknowledged that this may have been caused by the physical device and four (22% of the sample) that it may have been produced by the magic spell. The difference between the mean estimates for these possibilities (Estimation 2) was significant, $F(1,31)=32.8$, $p<.0001$.

In this experiment, in both conditions numbers of participants who expressed their interest in proceeding with testing the accompanying action (16 in the IC and 15 in the PC) exceeded those in Experiment 3. This difference was significant for the PC only, Fisher Exact, $P=.0001$. There was no a significant difference in numbers of these participants between conditions after the first offer to proceed.
In the IC, all participants acknowledged that if the magic spell produced the effect this would be an instance of real magic (consciousness over matter type) and not a trick. In the PC, all participants qualified the possibility of the physical device producing the effect as a trick, and not real 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 real magic can not be scientifically explained').

In the IC, 12 participants (67% of the sample) acknowledged that the effect may have been an instance of real magic. In the PC all participants said that it was some kind of trick and not real magic. This difference was significant, Fisher Exact, \( P = .0001 \).

After the accompanying action was repeated on the business card, the mean probabilities assigned to the possibility that the card had changed in both conditions (Estimation 4) were significantly higher than those assigned to the possibility that the postage stamp had changed in Estimation 1, with \( F(1,22) = 22.03, p < .0001 \) for the IC and \( F(1,28) = 50.4, p < .0001 \) for the PC. Nevertheless, the difference between the mean probabilities given to the possibility that the magic spell changed the business card and that the physical device changed it (Estimation 4) proved insignificant, \( F(1,25) = 3.5, p < .07 \).

After the participants discovered that the business card was unchanged, their repeated estimations of the effect of the magic spell on the postage stamp (Estimation 5) dropped to the original low level (\( M = 20.4\% \) in Estimation 5 as compared to \( M = 9\% \) in Estimation 1, the difference is insignificant). The repeated estimations of the probability that the physical device had worked on the postage stamp decreased as well, but they were still significantly higher than in Estimation 1, \( F(1,28) = 17.34, p < .0003 \). The difference between conditions on Estimation 5 was significant, with the mean score for the PC being higher than for the IC, \( F(1,25) = 7.35, p < .01 \).

**Discussion.**

The results of this experiment showed that the mean probabilities assigned in Estimations 1 and 4 to the expectations that the object in the box had been damaged by the magic spell (IC) and the physical device (PC) were about the same. Participants, therefore, viewed the potential danger of the magic spell for the object in the box being the same as the
danger of the physical device. This allows one to overrule the explanation that the I/P effect observed in Experiments 2 and 3 was an artifact of the higher degree of risk in the PC as compared to the IC.

In the IC, 12 out of 18 participants openly acknowledged the possibility that the demonstration phenomenon had been an instance of real magic. This cannot be explained as a result of pressure or encouragement on the side of the experimenter, as long as the experimenter explicitly told the participants that it was their decision to make and he did not care. The only motive that could make the participants acknowledge the possibility of the supernatural was their desire to see the effect being repeated on the business card. It is possible to assume that these participants deliberately misled the experimenter and falsely acknowledged their belief in the supernatural in order to see again what they thought was a sophisticated trick. However, if this were the case, then it was in the participants' interest to give higher estimates for the possibility of real magic. Yet, only 4 participants gave the possibility of real magic an estimate higher than 50%, with 8 other participants estimating it between 1 and 20%. Indeed, it did not make sense to acknowledge the possibility of real magic with the only aim to persuade the experimenter to retest his spell on another object and then give this possibility only a few percent of likelihood. Also, in the IC, the mean score given in Estimation 3 to the possibility that the effect was an instance of real magic and not trick magic \((M=17.4\%)\) almost coincides with the mean score given in Estimation 2 to the possibility that the effect had actually been caused by the magic spell \((M=16\%)\). This suggests that in Estimation 2 participants assessed the probability of real magic, and not of a trick. This estimation could not be influenced by the participants' interest to make the experimenter reproduce the effect, as long as Estimation 2 was done prior to the instruction in which the connection was made between the acknowledgement of magical beliefs and the subsequent retest. All this strongly suggests that in Estimation 3 the participants sincerely acknowledged that in the IC they had possibly witnessed an instance of real magic, though most of them assessed this possibility as rather unlikely. Altogether, these data create a strong case for the assumption that in this experiment, and in the previous experiments, the majority of participants viewed the impossible events as including an element of the supernatural and were not entirely convinced that these events were nothing more than
tricks.

One more result of this experiment was that approximately equal numbers of participants in both conditions engaged in the exploratory behaviour after they were shown the demonstration phenomenon, i.e., in this experiment the I/P effect was not observed. This can be explained by the fact that in this experiment the price for exploratory behaviour was reduced to zero. Indeed, the participants could not possibly be concerned about the safety of the experimenter’s business card, and this eliminated the I/P effect. This result confirms an earlier suggestion that the I/P effect can only occur if a certain optimal cost for exploratory behaviour has to be paid. If the cost is too low (the experimenter's business card) or too high (participants' passports), the participants' exploratory enthusiasm (or the absence of it) masks the I/P effect.

General Discussion

Experiments 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 the same but possible event (the I/P effect). The follow up experiments with adults indicated that the I/P effect remains in the conditions in which the impossible phenomenon was made more authentic (burning instead of cutting, Experiment 3). This effect cannot be explained as an artifact of the different degrees of cost of the exploratory behaviour, or as a result of the lack of understanding that the impossible event employed may have involved an element of the supernatural (Experiment 4).

Indeed, in Experiments 2, 3 and 4 adult participants were clearly explained the difference between genuine magical events and similar looking tricks. In Experiment 4 most participants explicitly admitted that the effect shown in the IC may have involved real magic, while the effect shown in the PC may have not. In both conditions, the participants assessed the likelihood that the accompanying action may destroy the object in the box as approximately equal. This suggests that in Experiments 2 and 3 adult participants were more willing to engage in exploratory behaviour in the IC than in the PC because in the IC the target of exploration, apart from being novel and unusual, involved the possibility of the supernatural.

It was also found that the I/P effect shows only in the conditions in which the cost of
exploratory behaviour is moderate (a threat to the safety of the participants' driving licences). If the cost is too high or too low, participants' exploratory behaviour holds on or boosts up to the extent that eliminates the I/P effect.

The question arises of what causes the I/P effect. Indeed, why children and adults are attracted to explore phenomena that they (and their social environment) view as impossible? Regarding 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 and Harris, 1994; Rosengren and Hickling, 2000; Woolley, 1997). But why would adults show the I/P effect?

One possible explanation can be that in the world dominated by science impossible phenomena fill certain gaps that appeared in the mind of a modern individual. Firstly, they respond to the unsatisfied need to break away with the predictable and mundane world that science created (Subbotsky, 1993; Zusne and Jones, 1982). In this respect, the interest toward impossible phenomena is kindred to the interest that people show toward mass entertainment or paranormal phenomena (Boyer, 1994; Jahoda, 1969; Tambiah, 1990). Secondly, impossible events like magic can give the hope to gain control over the events and feelings that otherwise are beyond our control (Nemeroff and Rozin, 2000; Shweder, 1977; Zusne and 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 toward magic. This explanation is based on the data showing that people's unconscious reactions toward food or contamination follow the laws of contagious or sympathetic magic (Nemeroff and Rozin, 1992; 1994; Rozin, Millman and Nemeroff, 1986; Rozin, Markwith and Ross, 1980) and, under certain conditions, people consciously acknowledge the possibility of magic (Subbotsky, 2000; Woolley, 1997). A certain degree of credulity to the 'possibility of impossible' was also shown in this study. Though small, this degree of credulity was enough to facilitate exploratory behaviour in children and adults. Being incompatible with the view of modern science, this belief yet has its rational ground in some areas of the everyday life (Nemeroff and Rozin, 2000).
One more way to account for the I/P effect is to view it as a manifestation of the most archaic and evolutionary early 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; Seligman, 1948; Tambiah, 1990). It can also be supported by the data showing the increment of magical and paranormal beliefs in people with mental illnesses (Eckblad and Chapman, 1983; Thalbourne, 1994; Thalbourne and French, 1995). It would 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 described in this paper, rather than in the studies based on questionnaires. The results of such studies may throw the light on the psychological roots of the I/P effect, as well as provide clinicians with better understanding of some important aspects of mental illnesses.

Testing the above explanations in future research, as well as studying the I/P effect in more detail can have important theoretical and practical implications. Theoretically, the I/P effect can help to better understand the development of the individual mind as a diversification and coexistence of various, even alternative, modes of making sense of reality, rather than presenting this development as a series of successive stages in which scientific rationality gradually replaces the early magical beliefs of childhood (Boyer, 1994; Nemeroff and Rozin, 2000; Shweder, 1977; Subbotsky, 1992; Tambiah, 1990). This effect can also partially explain the role that fantastic characters with magical powers and other magical events play in education, psychotherapy, communication, advertising, entertainment and other pragmatic areas of life.
References


Table 1. Number of children (out of 14) in various conditions who agreed to proceed with the testing using their valuable objects.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Impossible</th>
<th>Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 2. Numbers of participants (total numbers) who opted for testing the accompanying action on their driving licences in Experiment 2 (cutting) and Experiment 3 (burning)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Experiment 2</th>
<th>Experiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC</td>
<td>16 (16)</td>
<td>12 (18)</td>
</tr>
<tr>
<td>PC</td>
<td>9 (16)</td>
<td>4 (16)</td>
</tr>
</tbody>
</table>
Table 3. Mean probability scores (standard errors) given in five estimations in different conditions of Experiment 4.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Estimation</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impossible</td>
<td></td>
<td>9</td>
<td>16</td>
<td>17.4</td>
<td>47.9</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.3)</td>
<td>(6.1)</td>
<td>(6.2)</td>
<td>(7.9)</td>
<td>(6.9)</td>
</tr>
<tr>
<td>Possible</td>
<td></td>
<td>12</td>
<td>66</td>
<td>0</td>
<td>65.2</td>
<td>47.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.6)</td>
<td>(5.9)</td>
<td>(0)</td>
<td>(5.1)</td>
<td>(6.9)</td>
</tr>
</tbody>
</table>

| Significance |            | ns   | .0001| .0001| ns   | .01  |