Visual attentional capture predicts belief in a meaningful world

Paola Bressan*, Peter Kramer and Mara Germani

Dipartimento di Psicologia Generale, Università di Padova, Italy

Running head: Attentional capture predicts meaningfulness belief

*Corresponding author: Paola Bressan, Dipartimento di Psicologia Generale,
Università di Padova, Via Venezia 8, 35131 Padova, Italy
Tel: +39 049 827-6691; Fax: +39 049 827-6600
e-mail: paola.bressan@unipd.it

ABSTRACT

Here we show that the automatic, involuntary process of attentional capture is predictive of beliefs that are typically considered as much more complex and higher-level. Whereas some beliefs are well supported by evidence, others, such as the belief that coincidences occur for a reason, are not. We argue that the tendency to assign meaning to coincidences is a byproduct of an adaptive system that creates and maintains cognitive schemata, and automatically directs attention to violations of a currently active schema. Earlier studies have shown that, within subjects, attentional capture increases with schema strength. Yet, between-subjects effects could exist too: whereas each of us has schemata of various strengths, most likely different individuals are differently inclined to maintain strong or weak ones. Since schemata can be interpreted as beliefs, we predict more attentional capture for subjects with stronger beliefs than for subjects with weaker ones. We measured visual attentional capture in a reaction time experiment, and correlated it with scores on questionnaires about religious and other beliefs and about meaningfulness and surprisingness of coincidences. We found that visual attentional capture predicts a belief in meaningfulness of coincidences, and that this belief mediates a relationship between visual attentional capture and religiosity. Remarkably, strong believers were more disturbed by schema violations than weak believers, and yet appeared less aware of the disrupting events. We conclude that (a) religious people have a stronger belief in meaningfulness of coincidences, indicative of a more general tendency to maintain strong schemata, and that (b) this belief leads them to suppress, ignore, or forget information that has demonstrably captured their attention, but happens to be inconsistent with their schemata.

Key words: attentional capture, surprise, religiosity, paranormal belief, coincidences

1. Introduction

The high prevalence of various paranormal (Gallup and Newport, 1991) and religious beliefs suggests that there could be an important reason for their existence. Some of these beliefs are accompanied by the conviction that coincidences occur for a reason (Brugger, 1995; Bressan, 2002). In the current article, we hypothesize that the tendency to assign meaning to coincidences is the byproduct of an adaptive system that is responsible for the efficient processing and memorization of information, and for guiding our attention away from what is already known, and toward what is new and relevant. We will show that the automatic, involuntary process of attentional capture is predictive of beliefs that are typically considered as much more complex and higher-level.

Our hypothesis is based on Bartlett's (1932) notion of *schemata* and on what Schützwohl (1998) calls the *psychoevolutionary model of surprise*, that we, for brevity, will call the *schema model* (e.g., Horstmann, 2006; Meyer et al., 1991; Reisenzein, 2000; Schützwohl, 1998). Although the notion of schema is inconsistently defined by different researchers, there is agreement that a schema is an abstract representation in memory that is built up by concrete past actions or experience (e.g., Bartlett, 1932; Rumelhart, 1984; Schützwohl, 1998). This representation includes variables for aspects of repeated events that change over time, and constraints to encode the regularity of changes. For example, if a dot is repeatedly shown above or below fixation, but never to the right or left of it, then a schema is created for these events with a variable for the location of the dot, and the constraint that this location can only be either above or below fixation, and not to the right or the left of it.

The purpose of having schemata is to relate present events to past ones, and to process them with greater efficiency and speed, in order to leave more processing resources available for what is new and unexpected (e.g., Bartlett, 1932; Bower et al., 1979; Minsky, 1975; Shank and Abelson, 1977; Thorndyke and Hayes-Roth, 1979). For example, a schema that has been created for dots that repeatedly appear either above or below fixation helps to process the appearance of a new dot, if it is similar to the previous ones. In this case, the dot activates the schema, and only few resources need to be spent on processing the information about its size, color, or contrast with the background, whereas more resources can be devoted to the detection of whether it appeared above or below fixation.

According to the schema model, violations of a currently active schema elicit surprise and automatically and involuntarily capture attention, which subsequently allows the stimulus to be encoded into memory (e.g. Schützwohl, 1998). The schema model follows the so-called *contingent capture of attention* hypothesis (e.g., Folk et al., 1992; 1993; 2002). This hypothesis is a rival of an earlier conjecture, according to which the sudden appearance of novel objects captures attention in a bottom-up, rather than top-down, fashion (Yantis and Jonides, 1990). According to the contingent-capture hypothesis, attentional capture is indeed bottom-up but nevertheless contingent on a top-down attentional set that is determined by one's earlier experience and current goal. Whereas the experiments in support of the contingent-capture hypothesis focus on stimulus properties (a distractor, for example, has been shown to capture attention if it shares some feature with a target), the experiments in support of the schema model emphasize the role of violations of expectations (e.g., Reisenzein, 2000; Schützwohl and Borgstedt, 2005; cf. Gendolla and Koller, 2001; Teigen and Keren, 2003).

The schema model links the study of attention to the one of memory (in which schemata are used to explain why memories appear to be actively, and often inaccurately, reconstructed rather than merely retained), and also connects it to social and personality psychology, in which the notion of schemata is also quite common. (For a social-psychological review of religiosity in which the related concepts of "scripts" and "cognitive structures" play an important role, see Batson et al., 1993; for neuropsychological evidence of the involvement of the prefrontal cortex in scripts, see Wood et al., 2005.) Little is known about the causes of paranormal and religious belief, and the latter has been associated with rather many different brain areas (e.g., Azari et al., 2001; Saver and Rabin, 1997). Yet, it is the aspect of the schema model that links different areas of psychology to each other that allows us to

connect something as relatively basic and simple as attention to something as apparently complex as the belief that coincidences are meaningful or that divine beings exist.

Figure 1 shows the stimuli that have been used to test the schema model (e.g., Niepel et al., 1994) and that we also adopted in the present study. Each subject is presented with a sequence of 33 trials containing a pair of words (one above and one below fixation). After a Stimulus Onset Asynchrony (SOA) a dot is added, either above or below the word pair, and the subject's task is to press, as fast as possible, the left key if the dot appeared above the upper word, and the right key if the dot appeared below the lower word. In all trials, except the last one, the words are white on a black background. The characteristics of the words and their meaning are irrelevant to the task but, in the last trial, one of the words is not white-on-black, but instead black-on-white. The last trial is similar to the others and activates the same cognitive schema that has been built up in the previous 32 trials. However, the deviant word violates this schema and therefore, according to Schützwohl (1998), it captures attention and is experienced as surprising.

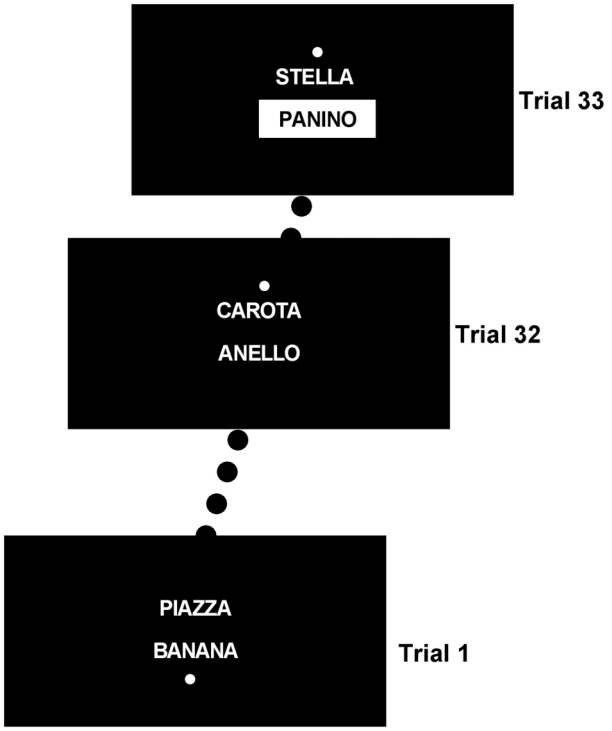

Figure 1. Sequence of trials in Experiment 1 (not to scale). In each trial two words are presented and, after a variable SOA, a dot (the target) appears. In Trial 33, after 32 trials in which the words were always white-on-black, one of the two words is unexpectedly presented in black-on-white.

The strength of a schema increases with the number of its activations (e.g., Mandler, 1984; Thorndyke and Hayes-Roth, 1979), and decreases with the variance of the events that activate it (e.g., Mandler, 1984). The schema model predicts more surprise and more attentional capture when an event violates a strong schema than when it violates a weak one. Corroborating the model, Schützwohl (1998) found that surprise and attentional capture did indeed increase with the number of similar trials leading up to the final deviant one, and decreased with variance in the font of the words.

According to the schema model, the adequacy of schemata is continuously and automatically monitored, but can only be updated in case attention is engaged (Schützwohl, 1998; see also Mandler, 1984; Rescorla, 1988); the engagement of attention, in turn, depends on schema strength. Schemata can

be seen as conscious or unconscious beliefs. Hence, another way of phrasing the same idea is that our attention is captured the most by falsifications of our strongest beliefs.

The originators of the schema model focus on within-subjects factors that affect attentional capture and surprise, but it seems likely that there could be between-subjects factors too. Whereas a single subject can have both strong, unchangeable and weak, flexible beliefs, different subjects may have different tendencies to maintain strong or weak beliefs in general. Such general tendencies could be the result of genetic dispositions, developmental processes, mental illness, drug use, or moods and experiences that have a broad effect on mental processes rather than a specific one (Batson et al., 1993). Schemata provide order and, by relating present to past events, also meaning. Schemata that are too strong provide too much order and meaning, to the point that even coincidences might be considered nonaccidental. If so, one would expect that the more people tend to maintain strong beliefs, the more they will be inclined to believe that coincidences have meaning (henceforth *meaningfulness belief*), and the more their attention will be captured by unexpected events.

We can take the argument a step further still. According to various religious doctrines (e.g., the Catholic one), God controls all, and with a definite purpose. Effectively, therefore, these doctrines contain a belief that coincidences are not just random but meaningful. In addition, the literature suggests that, on average, people who are very religious have stronger beliefs than people who are less religious. More religious people tend to be more dogmatic and are more inclined to maintain a "relatively unchangeable, unjustified certainty" (Altemeyer, 2002, p. 713) than less religious people. More religious people are also less inclined to change their core set of beliefs than less religious ones, have a stronger preference to avoid challenges to their beliefs in general, and have a stronger aversion of ambiguity (e.g., Kilpatrick et al., 1970; Saroglou, 2002). In sum, more religious people appear to have stronger beliefs than less religious ones and, at least for the Catholics among them, those beliefs include a meaningfulness belief. Hence, we predict that the more religious individuals are, the more they will be susceptible to attentional capture.

On the basis of these considerations, we tested whether there is a positive relationship between attentional capture and belief in meaningfulness of coincidences on the one hand, religious belief on the other.

2. Methods

We performed an experiment that was similar to Niepel et al.'s (1994) Experiment 2, and measured the amount of attentional capture experienced by different subjects. With the help of four questions, presented immediately after the experiment, we measured whether a discrepant event had been noticed or not, and the extent to which it had been experienced as surprising. Right after these questions, we gave subjects four additional questionnaires to measure their general tendency to be surprised, and their religious and paranormal beliefs.

2.1 Participants

The 135 Italian subjects that participated in the present study were 62 men and 73 women, between 18 and 67 years of age, with an average of 28 years; 60% of them were university students, whereas the remaining 40% had various occupations. All subjects were naïve about the purpose of the study, and were recruited with the question whether they would like to take part in a visual perception experiment; the real purpose of the study was revealed only in a final debriefing.

2.2 Materials and Procedure

2.2.1 Visual Attentional Capture Experiment

Stimuli were similar to those shown in Figure 1, presented on a Compaq Armada laptop, and viewed from a distance of 50 cm. Before each of the 33 trials of the experiment (and 4 initial practice trials whose data were not recorded), a fixation point was displayed for 1400 msec, followed by two words presented for 3000 msec, one centered above and one centered below fixation. After a variable SOA, a white dot appeared for the duration of 100 msec, centered 4 mm above the upper word or below the lower word. The task was to press on the keyboard, as fast as possible, a left key if the dot appeared above the upper word, and a right key if the dot appeared below the lower word. Reaction times were recorded on-line, with millisecond precision. A blank screen was presented for 900 msec after the subject's response, or after 3000 msec in case the subject failed to respond.

The meaning and characteristics of the words were task-irrelevant. The words consisted of six-letter Italian names of concrete everyday objects, and were exactly the same for all subjects and presented in the same order. The two words in each of the first 32 trials were both white-on-black. However, in Trial 33, the last trial, one of the words was black-on-white (i.e., was black on a white-filled rectangle). For half of the subjects, it was the upper word in Trial 33 that was black-on-white, and for the other half it was the lower word.

The variable SOA after which the target dot appeared could be either 0, 500, 1000, or 2000 msec long. In Trials 4, 7, 10, 13, 20, 23, 26, and 29 the SOA was the same as in Trial 33, and was equally likely to be any one of the four different SOAs. The other three SOAs were randomly distributed across the 24 remaining trials, in such a way that each SOA was used exactly eight times. Variance in SOA increases the unpredictability of the target dot and thereby prevents premature response preparation (e.g., Niepel et al., 1994). In total, the experiment contained 16 conditions (4 different SOAs for Trial 33 x 2 different combinations of fore- and background colors for Trial 33 x 2 dot positions, i.e., top or bottom), to which the subjects were randomly assigned.

2.2.2 Surprise and Religiosity Questionnaires

At the end of the experiment subjects were asked to fill out, without time pressure, four different questionnaires (all in Italian), in the order presented below.

2.2.2.1. QUESTIONNAIRE REGARDING THE EXPERIMENT. Immediately after the experiment, following Meyer et al. (1991), we presented the following four questions: (1) "In the last word pair, did the dot appear in the top or in the bottom position? *(top, bottom, don't know)*; (2) "Do you remember one or both of the words in the last word pair? If yes, please write it down"; (3) "Did anything unexpected occur, you think, during the presentations on the screen? If yes, what was it?"; (4) "How surprising was the unexpected event for you?" (on a 9-point rating scale going from 1 for "very little" to 9 for "very much").

2.2.2.2. COINCIDENCE SURPRISINGNESS QUESTIONNAIRE. This questionnaire consisted of the descriptions of the 5 coincidences that, out of a total of 24 (Fadda, 1998), best discriminated people with strong beliefs from those with weak ones (as measured by the paranormal belief scale of Bressan, 2002). The subjects were told that these coincidences had actually occurred in real life, and were asked to read each of them carefully. Next they were asked to state, for each coincidence, how surprising they thought it was (on a 7-point scale, from 1 for "not at all surprising" to 7 for "very surprising").

2.2.2.3. COINCIDENCE FREQUENCY QUESTIONNAIRE. This questionnaire (for details see Bressan, 2002) inquired about the frequency with which subjects had experienced coincidences of a general nature, and coincidences of specific types. In the final part of the questionnaire, a number of possible causes of coincidences were listed and subjects had to indicate whether they believed them or not.

2.2.2.4. MEANINGFULNESS BELIEF AND RELIGIOSITY QUESTIONNAIRE. This questionnaire contained 30 items, designed to measure meaningfulness belief, paranormal belief, and various aspects of religiosity. We distinguished between (a) religiosity based on personal experience, (b) religiosity not based on experience, and (c) belief in paranormal aspects of religion (e.g., the devil, angels, miracles). We predicted that only the first kind of religiosity, which we assumed to involve deeply felt beliefs rather than mere traditions, would be predictive of attentional capture.

With an 11-item version of the paranormal belief scale of Bressan (2002), we measured meaningfulness belief (2 items: "Certain premonitions and presentiments come true in such detail that they cannot be due to chance" and "Premonitory dreams exist and are not simple coincidences"), belief in paranormal aspects of religion (5 items, for example: "Each of us is protected by an angel"), and belief in telepathy and divination (4 items, for example, respectively: "The direct communication between minds is possible" and "Through card reading, a good fortune-teller is able to predict future events"). Each item required a response on a 7-point scale ranging from 1 for "I do not believe it", through a midpoint of 4 for "I don't know", to 7 for "I believe it". Religiosity based on personal experience was measured with 3 items that required a "yes" or "no" response: (1) "I have directly experienced the existence of God", (2) "I did not use to be a believer, but experience made me change my mind", and (3) "The beauty of the world tells me that there must be a creator". Religiosity not based on personal experience was measured with 12 items that required a "yes" or "no" response, for example: "I was raised in a family of believers, therefore I am a believer" and "Death is the end of everything". Two items, finally, were questions of a more general nature: (1) "Do you consider yourself a believer?", with a 5-point rating scale going from 1 for "not at all" to 5 for "very much", and (2) "How often do you attend church?". We hypothesized that both meaningfulness belief and religiosity based on personal experience would correlate with attentional capture, whereas other forms of religious and paranormal belief would not.

3. Results

Three participants whose average RT was more than 2 standard deviations above the mean were excluded from the analyses as outliers, leaving 132 subjects in the final sample.

3.1 Visual Attentional Capture

We followed Niepel et al. (1994) in our evaluation of the effect of the unexpected event in critical Trial 33, in which a word was shown with its fore- and background colors opposite to those of all other words presented. First, we computed the mean RT for each subject across those two trials of Trials 25-32 that had the same SOA as the critical Trial 33 (*baseline RT*). Next, we subtracted this baseline RT from the RT of the critical trial to obtain the *RT increase* that is regarded as a measure of surprise and attentional capture. The average RT increase across SOAs was significantly larger than zero, $t(131) = 9.1$, $p < .0001$. The mean RT increases on the critical trial for the SOAs of 0, 500, 1000, and 2000 msec were, respectively, 223, 232, 233, and 152 msec, indicating that surprise and attentional capture were observed at all SOAs.

Seventy percent of the subjects reported the unexpected event. For the SOAs of 0, 500, and 1000 msec the reporting probability was virtually the same (62%, 65%, and 62% respectively), but for the SOA of 2000 msec it increased to 91%, leading to an effect of SOA ($F(3, 128) = 3.29$, $p = .023$). The obvious explanation for this effect is that the long interval of 2000 msec favored the processing of the display more than the shorter ones, and therefore increased the likelihood that the unexpected event would be noticed. The position of the target dot was recalled correctly by 52% of the participants, incorrectly by 19% of them, and reported as forgotten by the remaining 29%. Only 16% of the subjects remembered one

of the two words of the critical trial, and nobody remembered both of them. For the 92 subjects who had noticed the unexpected event, the mean reported surprisingness of it was 4.96 on a scale from 1 to 9, and did not correlate with RT increase.

3.2 Visual Attentional Capture, Surprisingness, and Religiosity

We performed both zero-order and partial correlations to investigate the relationship between visual attentional capture, surprisingness, and religiosity. Because many of our scales were ordinal in nature, all correlations reported below, with the exception of the partial ones, were Spearman correlations (the Pearson ones were very similar in all cases). Items that were conceptually related and correlated significantly with each other were combined.

The two particular items that reflected meaningfulness belief (which were highly correlated: $r(132) = .63$, $p < .0001$) completely dominated the results. The stronger the meaningfulness belief was, the larger the RT increase was for the trial with the unexpected event ($r(132) = .32$, $p < .0001$). Remarkably, however, although the above correlation indicates that unexpected events had a larger impact on believers than on nonbelievers, believers were apparently less aware of such events (Figure 2): that is, meaningfulness belief was negatively correlated with the probability of noticing the unexpected event ($r(132) = -.22$, $p = .01$).

Incidentally, women scored higher on meaningfulness belief than men (independent-samples $t(130)=3.42$, $p=.001$), but the correlation between this belief and RT increase remained virtually unchanged after partialling out gender. Age-related neuronal loss in the prefrontal cortex can lead to difficulties filtering out irrelevant stimuli and, consequently, to increased attentional capture (Andrés et al., 2006). In our sample, however, age did not correlate with RT increase (and did not correlate with surprisingness of coincidences either, both $r(132)=.05$, $p>.1$).

Meaningfulness belief not only correlated with RT increase and (negatively) with probability of noticing, but also with (a) surprisingness of coincidences ($r(132) = .22$, $p = .01$), (b) estimated frequency of coincidences ($r(132) = .37$, $p < .0001$), and (c) religiosity based on personal experience ($r(131) = .45$, $p < .0001$). The latter index was a combination of the three items described in the method section, which were significantly intercorrelated (all ps $< .03$). Like meaningfulness belief, religiosity based on experience correlated positively with RT increase ($r(131) = .25$, $p = .004$), whereas religiosity not based on experience did not ($r(132)=.01$, $p>.8$). Belief in paranormal aspects of religiosity (such as miracles, angels, and the devil) correlated positively and marginally significantly with RT increase ($r(132)=.16$, $p=.07$), but this correlation totally disappeared when religiosity based on personal experience was partialled out ($r(128)=-.02$, $p>.8$). Belief in telepathy and divination did not correlate with RT increase (respectively, $r(132)=.13$ and $r(132)=-.01$, ps$>.1$) and neither did self-reported religious conviction or church attendance (respectively, $r(132)=.12$ and $r(132)=.02$, ps$>.1$).

Whereas the correlations of meaningfulness belief with each of the factors of (a) RT increase, (b) probability of noticing, (c) surprisingness of coincidences, (d) frequency of coincidences, and (e) religiosity based on experience remained significant when all of the others were partialled out (in combination), the reverse was not the case. None of the significant correlations between the five factors themselves remained significant after meaningfulness belief was partialled out. In fact, most of the correlations virtually disappeared, suggesting that they were entirely due to its mediating role (in all cases $r(129)<|.1|$, ps$>.1$). Most notably, although visual attentional capture (as indicated by an increase in RT) was predictive of religiosity based on experience, this effect was also entirely due to the mediating effect of the belief that coincidences are meaningful ($r(128)=.07$, $p>.1$, after partialling out meaningfulness belief).

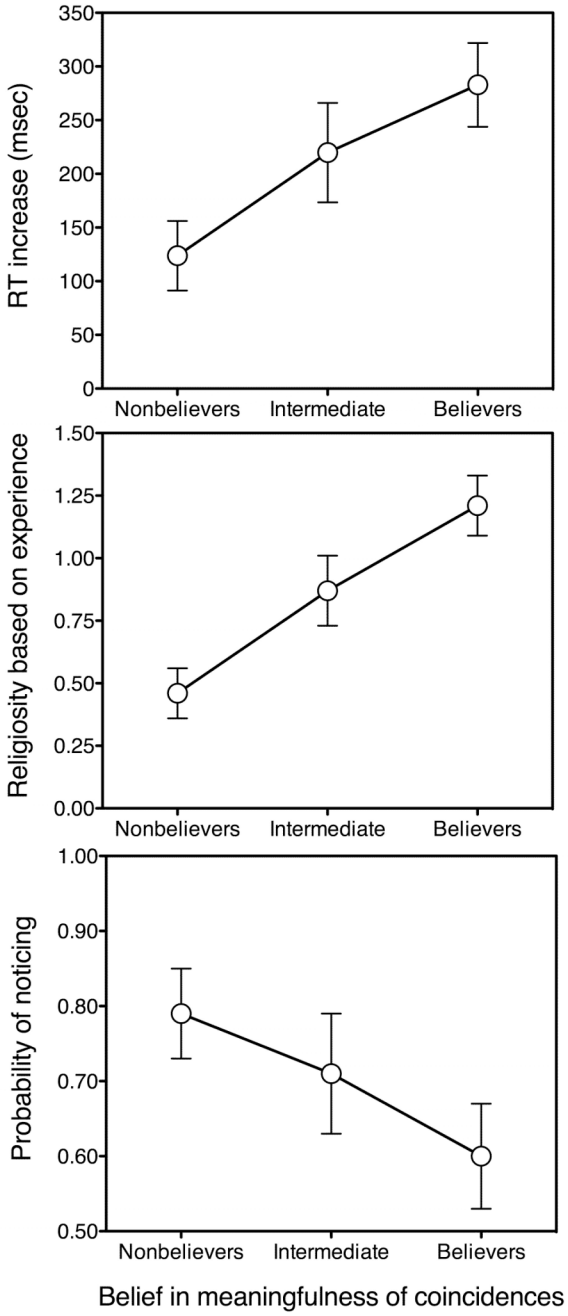

Figure 2. Belief in meaningfulness of coincidences (a) is positively related to the increase in reaction time (RT) following the unexpected event, (b) is positively related to religiosity based on personal experience, and (c) is negatively related to the probability of noticing the unexpected event. Shown here are the 48 nonbelievers (scores corresponding to the 33.3rd percentile and lower), the 53 believers (scores corresponding to the 66.7th percentile and higher), and the 31 subjects with an intermediate belief strength.

As mentioned earlier, meaningfulness belief led both to a larger RT increase (suggesting that the unexpected event captured attention) and to a lower probability of noticing. It is possible that some form of suppression played a role. Because more motivated subjects may try harder to ignore disrupting events than less motivated ones, we wondered whether the probability of noticing would decrease with motivation. Assuming that higher motivation leads to shorter reaction times, our results did indeed support this conjecture. We found a negative correlation between the probability of noticing and baseline

RT ($r(132) = -.18$, $p = .039$), which remained marginally significant ($r(129) = -.17$, $p = .055$) after partialling out meaningfulness belief. Thus, more motivated subjects fail to notice or recall irrelevant, task-disrupting information more than less motivated subjects. Motivation (i.e., baseline RT) did not affect the RT increase for the unexpected event ($r(132) = -.10$, $p = .23$), nor the correlation between meaningfulness belief and RT increase (which remained virtually unchanged after partialling out motivation: $r(129) = .30$, $p < .0001$). The negative correlation between meaningfulness belief and probability of noticing slightly increased even ($r(129) = -.23$, $p = .009$) when motivation was partialled out.

4. Discussion

Schemata are representations in memory, built up by past experience, that help process new information and link it to what is already known (e.g., Bartlett, 1932; Rumelhart, 1984). According to the schema model, schemata play an important role not only in the formation of memories, but also in generating surprise and guiding our attention towards unexpected events. More specifically, the model predicts that attentional capture increases with schema strength. This prediction has been corroborated in a large number of experiments (e.g., Horstmann, 2006; Meyer et al., 1991; Reisenzein, 2000; Schützwohl, 1998).

In a schema, the aspects of events that vary over time are represented as variables. The stronger the schema, the tighter the constraints on these variables and the less variance the schema can accommodate. We hypothesized that, as a result, the schema-producing mechanism yields the byproduct of a view of the world as highly predictable and orderly, with little space for chance events: that is, a belief in meaningfulness of coincidences (which Brugger, 1995, and Bressan, 2002, found to be related to paranormal belief). We predicted that the strong schemata associated with this meaningfulness belief should be positively related to attentional capture by unexpected events. Our results support this prediction, and also indicate that the stronger the meaningfulness belief is, the more one tends to come across coincidences in real life (see also Brugger et al., 1990, and Bressan, 2002) and be surprised by reports of them. In addition, we found that although religiosity also predicts attentional capture, its effect is entirely mediated by meaningfulness belief. Paradoxically, however, although unexpected events grab the attention of staunch believers more than that of nonbelievers, the former report these events less often. Apparently, believers either ignore, suppress, or forget schema-discrepant events that captured their attention.

Memory storage and the proper guidance of attention are obvious benefits of a schema-producing mechanism. Sticking to one's beliefs (i.e., schemata) in the face of conflicting evidence could potentially diminish that adaptive value. There are at least four reasons, though, why such dogmatism may not necessarily be evolutionarily disadvantageous. First, if the beliefs involved are shared with one's social environment, dogmatism may help to maintain good social relations and avoid cognitive dissonance (Batson et al., 1993). Second, evidence is not always reliable (not even when in plain sight, as visual illusions demonstrate). Third, schemata have been shown to facilitate information processing, and occasional violations of a schema may not render it useless. In fact, according to Kuhn (e.g., 1977), even science benefits from a certain amount of dogmatism, and celebrated theories that are inconsistent with some evidence are not abandoned until this evidence has accumulated enough to cause a *paradigm shift*. Fourth, according to Mandler (1984) and Schützwohl (1998), schemata can be monitored for accuracy in an unconscious and automatic fashion, but require attentional resources to be updated during learning. In fact, Kamin (1969) showed that even simple Pavlovian learning in rats requires attention. Thus, constant updating of schemata could go at the expense of other important activities. For example, in case of danger, it is probably better to pay full attention to the situation and leave schema updating for later.

The schema model is consistent with the partly top-down contingent-capture-of-attention hypothesis of Folk et al. (1992; 1993; 2002) rather than with the completely bottom-up capture-of-attention

hypothesis of Yantis and Jonides (1990). Recently, Barceló et al. (2002; 2006) have shown that familiar, but unpredictable, prompts to switch tasks can cause the same event-related P300 potentials on the scalp as sudden novel stimulus events. Contrary to the completely bottom-up capture-of-attention hypothesis, this suggests that the novelty of stimulus events may not be critical to the mechanisms of attentional capture. In an fMRI study, Kincade et al. (2005) found that the right temporoparietal junction, which is involved in attentional capture (Serences et al., 2005), was modulated during shifts of attention, but only if the target stimulus was behaviorally relevant. This result also supports the ideas of Folk et al. (and thereby of the schema model) of a top-down set gating attentional capture. In another fMRI study, Michelon et al. (2003) found that the ventral and dorsal visual pathways, the frontal cortex along the inferior frontal gyrus, the parietal areas, the supplementary motor area, and the thalamus were all more recruited by incongruous than by congruous stimuli, even when these were frequent rather than infrequent. These results corroborate the prediction by both Folk et al. and the schema model that stimulus events do not need to be novel in order to capture attention.

Task switching involves a frontoparietal network that includes the temporal parietal junction (for a brief review see Easton et al., 2008, this issue). As mentioned above, this junction has also been implicated in attentional capture. Interestingly, Easton et al. connect this same temporoparietal junction to out-of-body experiences (OBE). The subjects in their study continuously switched between two tasks that involved different egocentric reference frames, and subjects who had had OBE in the past were worse at task switching than those who had not. Easton et al. suggest that both tasks targeted the same "body schema". If so, then subjects with OBE may have trouble updating their body schema when a task switch requires it. A future experiment could test this hypothesis by performing a similar experiment to the one that has been performed here, and contrasting subjects with and without OBE. The attention of the former should be more easily captured than the attention of the latter.

P300 (or more specifically P3a) potentials increase in response to novel, or expectation-violating, events (Kirino et al., 2000; Knight, 1996; Knight and Nakada, 1998; Knight and Scabini, 1998; McCarthy et al., 1997; Strange et al., 2000). On the basis of the schema model, one would expect these responses to be mediated by schema strength. That is, within subjects, one would expect a P3a potential in response to an unexpected event to increase with the number of repetitive events that lead up to the unexpected one. Between subjects, one would expect the potential to increase with the strength of the beliefs (hence, schemata) of the subject. Thus, on the basis of the present study, we predict that there should be a positive correlation between meaningfulness belief and the magnitude of P300 potentials. Likewise, we predict that, in fMRI, meaningfulness belief should be positively correlated with blood oxygenation levels in areas associated with attentional capture.

From our current research, for now, we derive three conclusions. First, the automatic, involuntary process of visual attentional capture is predictive of beliefs that are typically considered as much more complex and higher-level. Second, visual attentional capture predicts belief in meaningfulness of coincidences and, indirectly, religiosity because of a common dependency on schema strength. Third, believers tend to ignore, suppress, or forget schema-discrepant events that they have not only seen with their own eyes, but attended as well.

Acknowledgements

Part of this research was submitted as an undergraduate thesis by Mara Germani to the Department of General Psychology of the University of Padua, under the supervision of Paola Bressan. We thank Luigi Garlaschelli for material and discussion. We are grateful to editors Christine Mohr and Peter Brugger, to Pascal Boyer, and to an anonymous reviewer for very helpful comments.

REFERENCES

Altemeyer B. Dogmatic behavior among students: testing a new measure of dogmatism. *The Journal of Social Psychology*, 142: 713-721, 2002.

Andrés P, Parmentier FBR, and Escera C. The effect of age on involuntary capture of attention by irrelevant sounds: a test of the frontal hypothesis of aging. *Neuropsychologia*, 44: 2564-2568, 2006.

Azari NP, Nickel J, Wunderlich G, Niedeggen M, Hefter H, Tellmann L, Herzog H, Stoerig P, Birnbacher D, and Seitz RJ. Neural correlates of religious experience. *European Journal of Neuroscience*, 13: 1649-1652, 2001.

Barceló F, Periáñez J, and Knight RT. Think differently: a brain orienting response to task novelty. *Neuroreport*, 13: 1887-1892, 2002.

Barceló F, Escera C, Corral MJ, and Periáñez JA. Task switching and novelty processing activate a common neural network for cognitive control. *Journal of Cognitive Neuroscience*, 18: 1734-1748, 2006.

Bartlett FC. *Remembering: a study in experimental and social psychology*. Cambridge, England: Cambridge University Press, 1932.

Batson CD, Shoenrade P, and Ventis WL. *Religion and the individual: a social-psychological perspective.* New York: Oxford University Press, 1993.

Bower GH, Black JB, and Turner TJ. Scripts in memory for text. *Cognitive Psychology*, 11: 177-220, 1979.

Bressan P. The connection between random sequences, everyday coincidences, and belief in the paranormal. *Applied Cognitive Psychology*, 16: 17-34, 2002.

Brugger P. The roots of meaningful coincidence. *The Lancet*, 345: 1306-1307, 1995.

Brugger P, Landis T, and Regard M. A 'sheep-goat effect' in repetition avoidance: Extra-sensory perception as an effect of subjective probability? *British Journal of Psychology*, 81: 455-468, 1990.

Easton S, Blanke O, and Mohr C. A putative implication for fronto-parietal connectivity in out-of-body experiences. *Cortex*, 2008, this issue.

Fadda C. *Psicologia delle Coincidenze*. Contributo sperimentale allo studio delle credenze nel paranormale. Unpublished master's thesis, University of Padua, Padova, Italy, 1998.

Folk CL, Leber AB, and Egeth HE. Made you blink! Contigent attentional capture produces a spatial blink. *Perception & Psychophysics*, 64: 741-753, 2002.

Folk CL, Remington RW, and Johnston JC. Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance*, 18: 1030-1044, 1992.

Folk CL, Remington RW, and Johnston JC. Contingent attentional capture: a reply to Yantis (1993). *Journal of Experimental Psychology: Human Perception and Performance*, 19: 682-685, 1993

Gendolla GHE and Koller M. Surprise and motivation of causal search: how are they affected by outcome valence and importance? *Motivation and Emotion*, 25: 327-349, 2001.

Gallup GH and Newport F. Belief in paranormal phenomena among adult Americans. *Skeptical Inquirer*, 15: 137-146, 1991.

Horstmann G. Latency and duration of the action interruption in surprise. *Cognition and Emotion*, 20: 242-273, 2006.

Kamin LJ. Predictability, surprise, attention, and conditioning. In Campbell BA and Church RM (Eds), *Punishment and Aversive Behavior*. New York: Appleton-Century-Crofts, 1969, pp 279-296.

Kincade JM, Abrams RA, Astafiev SV, Shulman GL, and Corbetta M. An event-related functional magnetic resonance imaging study of voluntary and stimulus-driven orienting of attention. *Journal of Neuroscience*, 25: 4593-4604, 2005.

Kilpatrick DG, Sutker LW, and Sutker PB. Dogmatism, religion, and religiosity: a review and re-evaluation. *Psychological Reports*, 26: 15-22, 1970.

Kirino E, Belger A, Goldman-Rakic P, and McCarthy G. Prefrontal activation provoked by infrequent target and novel stimuli in a visual target detection task: an event-related functional magnetic resonance imaging study. *Journal of Neuroscience*, 20: 6612-6618, 2000

Knight RT. Contribution of human hippocampal region to novelty detection. *Nature*, 383: 256-259, 1996.

Knight RT and Nakada T. Cortico-limbic circuits and novelty: a review of EEG and blood flow data. *Review of Neuroscience*, 9: 57-70, 1998.

Knight RT and Scabini D. Anatomical basis of event-related potentials and their relationship to novelty detection in humans. *Journal of Clinical Neurophysiology*, 15: 3-13, 1998.

Kuhn TS. *The essential tension*. Chicago & London: University of Chicago Press, 1977.

Mandler, G. (1984). *Mind and body*. New York: Norton.

McCarthy G, Luby M, Gore J, and Goldman-Rakic P. Infrequent events transiently activate human prefrontal and parietal cortex as measured by functional MRI. *Journal of Neurophysiology*, 77: 1630-1634, 1997

Meyer W-U, Niepel M, Rudolph U, and Schützwohl A. An experimental analysis of surprise. *Cognition and Emotion, 5*: 295-311, 1991.

Michelon P, Snyder AZ, Buckner RL, McAvoy M, and Zacks JM. Neural correlates of incongruous visual information: an event-related fMRI study. Neuroimage, 19: 1612-1626, 2003.

Minsky M. A framework for representing knowledge. In Winston PH (Ed), *The psychology of computer vision.* New York: McGraw-Hill, 1975.

Niepel M, Rudolph U, Schützwohl A, and Meyer W-U. Temporal characteristics of the surprise reaction induced by schema-discrepant visual and auditory events. *Cognition and Emotion*, 8: 433-452, 1994.

Reisenzein R. Exploring the strength of association between the components of emotion syndromes: the case of surprise. *Cognition and Emotion*, 14: 1-38, 2000.

Rescorla RA. Pavlovian conditioning: It's not what you think it is. *American Psychologist*, 43: 151-160, 1988.

Rumelhart DE. Schemata and the cognitive system. In Wyer RS and Srull TK (Eds), *Handbook of social cognition.* Hillsdale, NJ: Erlbaum, 1984, Vol. 1, pp 161-188.

Saroglou V. Beyond dogmatism: the need for closure as related to religion. *Mental Health, Religion & Culture*, 5: 183-194, 2002.

Saver JL and Rabin J. The neural substrates of religious experience. *Journal of Neuropsychiatry and Clinical Neurosciences, 9*: 498-510, 1997.

Serences JT, Shomstein S, Leber AB, Golay X, Egeth HE and, Yantis S. Coordination of voluntary and stimulus-driven attentional control in human cortex. *Psychological Science*, 16: 114-122, 2005.

Shank R. and Abelson R. *Scripts, Plans, Goals and Understanding*. Hillsdale, NJ: Erlbaum, 1977.

Schützwohl A. Surprise and schema strength. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 24: 1182-1199, 1998.

Schützwohl A and Borgstedt K. The processing of affectively valenced stimuli: the role of surprise. *Cognition and Emotion*, 19: 583-600, 2005.

Strange BA, Henson RNA, Friston KJ, and Dolan, RJ. Brain mechanisms for detecting perceptual, semantic and emotional deviance. *Neuroimage*, 12: 425-433, 2000.

Teigen KH and Keren G. Surprises: low probabilities or high contrasts? *Cognition*, 87: 55-71, 2003.

Thorndyke PW and Hayes-Roth B. The use of schemata in the acquisition and transfer of knowledge. *Cognitive Psychology*, 11: 82-106, 1979.
Wood J, Tierney M, Bidwell LA, and Grafman J. Neural correlates of script event knowledge: a neuropsychological study following prefrontal injury. Cortex, 41: 796-804, 2005.
Yantis S and Jonides J. Abrupt visual onsets and selective attention: voluntary versus automatic allocation. *Journal of Experimental Psychology: Human Perception and Performance*, 16: 121-134, 1990.