\a\Where is the ball? Behavioral and neural responses elicited by a magic trick

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\e**Abstract**

We present results from two experiments, in which subjects watched continuous videos of a professional magician repeatedly performing a maneuver in which a ball could "magically" appear under a cup. In all cases, subjects were asked to predict whether the ball would appear under the cup or not, while scalp EEG recordings were performed. Both experiments elicited strong and consistent behavioral and neural responses. In the first experiment, we used two blocks of videos with different probabilities of the ball appearing in the cup and found that, first, based on the behavioral responses, the subjects could track this probability change; and second, the different probabilities modulated the neural responses. In the second experiment, we introduced a control condition in which the magician performed the maneuver under the table, out of subjects' view. Comparing the two conditions (i.e., performing the maneuver within or out of the subjects' view), we found that, first, the magic trick dramatically biased the subjects' behavioral responses; and second, the two conditions led to differential neural responses, in spite of the fact that the stimulus triggering the evoked responses (seeing the ball in the cup) was exactly the same. Altogether, our results show how new insights into sensory and cognitive processing can be obtained using adapted magic tricks. Moreover, the approach of analyzing responses to continuous video presentations offers a more ecological setting compared to classic evoked potential paradigms, which are typically based on presenting static images flashed at the center of the screen.

Descriptors: Evoked potentials, Perception, Magic

It has long been recognized that, from relatively limited, noisy, and ambiguous information, perception relies on unconscious inferences based on previous experiences (Gregory, 1973; Helmholtz, 1878a, 1878b). For thousands of years, magicians have been aware of this fact and have learnt how to manipulate perception by breaking these assumptions at will. Although the scientific interest in magic is not new (Binet & Nichols, 1896; Jastrow, 1897; Triplett, 1900), in the last decade there has been an increasing interest in setting up parallels between magic theory and cognitive neuroscience, in some cases leading to the adaptation of magic tricks into new experimental paradigms (Cui, Otero-Millan, Macknik, King, & Martinez-Conde, 2011; Johansson, Hall, Sikstrom, & Olsson, 2005; Kuhn, Caffaratti, Teszka, & Rensink, 2014; Kuhn & Findlay, 2010; Kuhn & Land, 2006; Lamont & Wiseman, 2005; Macknik, King, Randi, & Robbins, 2008; Martinez-Conde & Macknik, 2008; Olson, Amlani, & Rensink, 2012; Otero-Millan, Macknik, Robbins, & Martinez-Conde, 2011; Parris, Kuhn, Mizon, Benattayallah, & Hodgson, 2009; Quian Quiroga, 2016; Rieiro, Martinez-Conde, & Macknik, 2013; Shalom et al., 2013). Most of these experiments have focused on the subjects' behavioral and oculomotor responses while they watched magic tricks. However, only very few studies have dealt with brain responses elicited by magic tricks, using fMRI recordings to localize areas that contrasted responses upon different conditions (Danek, Öllinger, Fraps, Grothe, & Flanagin, 2015; Parris et al., 2009). It is within this context that we set out to study whether the observation of a magic trick might trigger specific patterns of brain activations, as measured with scalp EEG. To address this question, we recorded EEG signals of subjects watching videos showing an adaptation of a famous magic trick, the Chop Cup (Wilson & Nelson, 1979), in which a ball taken from a cup may "magically" reappear inside it (a similar type of trick has been used in Riero et al., 2013). We hypothesized that the unexpected appearance of the ball in the cup—compared to trials where the ball does not appear in the cup—will trigger a P3 response similar to the one observed during oddball

paradigms. In such cases, an unexpected stimulus (the target stimulus triggering the P3 response) is presented randomly and sporadically among a sequence of nontarget stimuli (Sutton, Braren, Zubin, & John, 1965). In other words, we used the classic P3 response as a marker of the subjects' reactions upon observing the ball magically appearing (or not appearing) inside the cup. The main reason for choosing this trick is that it can be repeated many times without the subjects noticing how it is done, thus allowing us to calculate ensemble averages of several trials to obtain reliable neural responses. Furthermore, given that subjects were presented with videos showing continuous repetitions of the magician performing (or not) the trick, this experiment allowed us to characterize brain responses obtained in a much more natural condition (i.e., freely gazing at a video presentation) compared to the classic evoked potential paradigms implemented by flashing images, which require subjects to keep their fixation at the center of the screen (Freeman & Quian Quiroga, 2012; Luck & Kappenman, 2011).

Given the sequence of trials presented in the video, we further hypothesized that the strength of this P3-like response should be modulated by the probability of appearance of the infrequent stimulus (ball in the cup), as described with classic oddball paradigms (Polich, 2007).

To test these hypotheses, in a first experiment (Experiment 1), subjects saw two blocks of videos with sequential trials, in which the manipulation of the ball and the cup was performed under the subjects' view (direct load condition, see Method). The probability of the ball appearing in the cup was 50% in the first block and 30% in the second block. The rationale for using a 50/50 probability was to test if, even with equal probability, the appearance of the ball in the cup would still give a P3-like response due to the fact that this "magical" event is unexpected. In a second experiment (Experiment 2), we introduced a control condition (indirect load condition, see Method), in which the movement of removing

the ball from the cup (or not) was performed under the table, out of the subjects' view. The aim of introducing this condition, in which the eventual appearance of the ball in the cup (or not) cannot be attributed to the performance of a magic trick, was to test the hypothesis that the same stimulus (ball in the cup) may trigger different brain responses when appearing as a result of a magic effect (direct load) or no magic effect (indirect load). More generally, our goal was to explore the possibility of adapting a magic trick into a new paradigm in cognitive neuroscience that gives differential brain responses from exactly the same stimulus, as has been described with binocular rivalry, flash suppression, background masking, or the morphing of the stimuli, among others (Blake & Logothetis, 2002; Kanwisher, 2001; Logothetis, 1998; Navajas, Ahmadi, & Quian Quiroga, 2013; Quian Quiroga, Kraskov, Mormann, Fried, & Koch, 2014; Quian Quiroga, Mukamel, Isham, Malach, & Fried, 2008).

Altogether, we found that the video presentations of the magic trick elicited strong evoked potentials, similar to the ones described in classic oddball paradigms. These evoked potentials, as well as the behavioral responses by the subjects, were modulated both by the probability of the stimuli and by the performance of the magic trick.

Method

Subjects

A total of 35 participants (24 females; 26 right-handed; mean age 25.6; range 19–40 years old) volunteered for this study. All of them had normal or corrected-to-normal vision and no history of neurological disorders. Ten subjects participated in Experiment 1 and the remaining 25 participated in Experiment 2. Data from five other participants were rejected due to an excessive number of artifacts in the EEG recordings.

Materials

Participants observed videos projected on a CRT monitor. The screen resolution was 1,024 × 768 pixels, the refresh rate 100 Hz and the viewing distance was approximately 55 cm. The

stimuli consisted of videos of a professional magician (HC) repeatedly performing a magic

trick (see Paradigm for details). Videos were filmed using a standard video camera mounted

on a tripod with a sampling frequency of 25 frames/second. The presentation of the videos

(without sound) was controlled and synchronized to the EEG recording system using

MATLAB (Mathworks, Natick, MA) and the Psychophysics toolbox (Brainard, 1997).

\2**Paradigm**

Each video comprised a subblock of 50 consecutive trials, in which an adapted version of the

Chop Cup magic trick was repeatedly shown (Wilson & Nelson, 1979). On each trial, the

magician inserted a red ball into a metal cup, turned the cup upside down while covering its

mouth with the other hand, and then executed a movement that pretended to remove the ball

from the cup. Immediately after this movement, the cup was maintained upside down in the

air for few seconds before being placed on the table (thus, it would be very surprising that the

ball could be inside the cup). We call this sequence of movements *direct load* (see Figure

1A\f1\ and online supporting information Movie 1). Once the cup is on the table, the video

was automatically paused and the subjects were instructed to guess whether the ball was in

the cup or in the magician's hand, using the left and right arrow keys, respectively. After a

short delay following the subjects' responses (see below), the video was restarted, showing

either that the ball was not there (i.e., it was retained in the magician's hand, as one would

expect), or that it magically appeared under the cup. For each trial, we considered the

stimulus onset to be the first video frame at which the experimenter started to tilt the cup to

show its content.

In Experiment 1, participants underwent two consecutive direct load blocks,

consisting of 250 trials each (i.e., five subblocks of 50 trials). In the first block, the

probability of the ball magically appearing inside the cup was 50%, whereas in the second

block this probability was 30%. The two blocks were separated by a 5–10 min break. For this

experiment, the video was always restarted 500 ms after the subjects' decisions, at a point that was exactly 12 frames (480 ms) before the stimulus onset. These delays were introduced in order to avoid contaminations of the EEG responses due to hand movements in the first case, and the restarting of the video in the latter case. The total duration of the experiment was approximately 90 min.

Experiment 2 consisted of 400 trials presented in eight subblocks of 50 trials each. Throughout this experiment, the probability of the ball appearing inside the cup was 30%. Half of the trials were conducted as in Experiment 1 (direct load condition), and in the other half of the trials the magician manipulated the ball and the cup under the table, out of subjects' view. We refer to this sequence of movements as *indirect load* (see Figure 1B). This way, the appearance of the ball in the cup was not related to a magical effect but rather to the regular movement of putting (or not putting) the ball inside the cup under the table (see Movie 2 in the supporting information). Altogether, we had four conditions:

- cup_direct-load: The magician placed the ball inside the cup and directly manipulated the cup, under subjects' view, clearly pretending to remove the ball. The ball, however, magically appeared in the cup. Note that this is the unique condition that we considered to be a magic effect.

- hand_direct-load: The magician repeated the same maneuver but the cup appeared empty, as expected, given that the ball was retained in the magician's hand.

- cup_indirect-load: The magician placed the ball inside the cup, indirectly manipulated the ball and cup under the table, and finally showed that the ball was in the cup.

- hand_indirect-load: The magician performed the same indirect load under the table, but then showed that the cup was empty.

In Experiment 2, trials corresponding to the direct load and indirect load conditions were randomly interleaved and presented with equal probability (see Movie 2). Due to the

fact that in Experiment 1 we observed an EEG response elicited by the restart of the video (see Results), in Experiment 2 we randomized the time at which the video was paused (between 280 ms and 680 ms before stimulus onset, corresponding to seven and 17 frames, respectively). The total duration of the experiment was approximately 70 min.

EEG Recordings

EEG data were recorded with 64 scalp electrodes mounted in an elastic cap (10/20 system), using a BioSemi ActiveTwo System with a sampling frequency of 256 Hz and a data acquisition band-pass filter between 0.001–100 Hz to avoid aliasing. The linked bilateral mastoids were used as reference, and electrode impedances were kept below 5 KΩ. For each electrode, 2,000-ms epochs were extracted from the continuous EEG data, 1,000 ms before and 1,000 ms after stimulus onset. Epochs were linearly de-trended and baseline-corrected. Trials with eyeblinks, eye movements, and other artifacts were removed by visual inspection of electrooculogram (EOG) channels. We report results for the midline electrodes Fz, Cz, Pz, and Oz.

Data Analysis

We focused on the analysis of the P3 responses across different conditions. For a better identification of the single subject's P3 peak amplitudes and latencies, the average evoked potentials for each subject (and in each condition) were denoised as in previous works (Ahmadi & Quian Quiroga, 2013; Quian Quiroga, 2000). This was achieved by doing a wavelet transform of the signal, selecting a number of wavelet coefficients that were correlated with the evoked responses, and then reconstructing the signal (using the inverse wavelet transform) but only from the selected coefficients. For each subject, the set of wavelet coefficients chosen for denoising was the same for all conditions. From the denoised traces, the P3 peak amplitude and latency were identified as the maximum in the poststimulus time window (250–750 ms).

Statistical comparisons were performed using paired nonparametric sign tests, with a Bonferroni correction for multiple comparisons.

<h1 style="text-align:center">\1\Results</h1>

\2\Behavior

In Experiment 1, we assessed how the behavioral choice was influenced by the percentage of trials in which the ball appeared in the cup (50% in the first block and 30% in the second block). The left panel of Figure 2\f2\ shows the average percentage (across subjects) of "cup responses" in each block. This proportion was smaller in the second block compared to the first block, suggesting that subjects could track the change in the proportion of cup_direct-load trials (i.e., with the ball appearing inside the cup), although this difference did not reach statistical significance ($p = .17$; sign test). Moreover, considering each block separately, the mean percentage of cup responses in the first block (42.8%) was significantly smaller than the actual proportion of cup_direct-load trials shown (50%; $p < .05$; sign test). This lower proportion of cup responses could be attributed to the unexpected (magic) effect of seeing the ball in the cup. The number of cup responses in the second block, 31.9%, was slightly larger, though not statistically different from the actual percentage of cup responses shown (30%; $p = .58$; sign test). The slight increase in the number of cup responses (rather than a decrease, as in the first block) is likely due to the fact that, during the second block, subjects were still adapting their response pattern from the higher percentage of cup_direct-load trials shown in the first block.

The right panel of Figure 2 shows the percentage of cup responses in Experiment 2. Even though the probability of the ball appearing in the cup was 30% for both the direct load and indirect load conditions, the percentage of cup responses was significantly lower for the direct load trials ($p < 10^{-5}$; sign test). As before, the percentage of cup responses was lower than the actual proportion of cup_direct-load trials (30%; $p < .001$; sign test), but when the

movement was done under the table (the indirect load condition), the subjects were equally likely to answer either way. In this case, the percentage of cup responses was no different from 50% (sign test) and it was significantly larger than 30% ($p < 10^{-7}$; sign test).

Summarizing the behavioral results of both experiments, subjects were able to track changes of the probability of the ball appearing in the cup. In trials where the magic trick was performed (cup_direct-load), subjects had a strong bias toward predicting that the ball was not in the cup, as would be naturally expected, in spite of the fact that they saw the same manipulation performed hundreds of times. In contrast, for the indirect-load condition, the subjects' responses were 50/50, although the proportion of cup_indirect-load trials was 30%, as in the direct load condition. We argue that, since both types of trials (direct load and indirect load) were interleaved, subjects did not keep track of the proportion of trials in each condition and compensated downward in one case (percentage of cup responses in the direct load condition) and upward in the other (percentage of cup responses in the indirect load condition).

\2**Neural Responses for Experiment 1**

Figure 3\f3\ shows the grand-averaged neural responses in the midline electrodes for the two blocks of Experiment 1. We first observe that the video presentations elicited strong evoked responses in all conditions. In particular, we observe a slow negative shift preceding stimulus onset, most pronounced in the central-parietal electrodes. This corresponds to the contingent negative variation (CNV), which has been largely studied in classic evoked potential paradigms and reflects the expectation produced by the anticipation of the stimulus (in our case, the revelation of whether the ball was in the cup or not; Walter, Cooper, Aldridge, McCallum, & Winter, 1964). Given that we did not observe differences in the CNV responses across conditions, we did not analyze this response any further. Approximately 200 ms prior to stimulus onset, a positive deflection is also observed in all conditions, which is

due to resuming the video after the pause (this response disappeared when introducing a variable restart time in Experiment 2).

After stimulus onset, all conditions triggered a large positive response, resembling the P3 evoked potential described in classic oddball paradigms (Picton, 1992; Polich, 2007; Sutton et al., 1965). In particular, in Block 2, this response was larger for the less frequent cup_direct-load trials (30%), compared to the hand_direct-load trials (70%). Moreover, the amplitude difference between the cup and hand responses was larger in Block 2 compared to Block 1, where the proportion of cup and hand trials were both 50% (for all electrodes $p <$ .05, except Oz with $p = $ .08; sign test). In addition, and in line with previous evidence (Picton, 1992; Polich, 2007; Sutton et al., 1965), the P3 response to the infrequent cup_direct-load trials in Block 2 was preceded by a negative N2 deflection. Finally, there was an earlier response onset for cup_direct-load compared to hand_direct-load trials, something that we studied further in Experiment 2 with a larger number of subjects.

\2**Neural Responses for Experiment 2**

In Experiment 2, we generated a different set of videos, where in half of the trials (interleaved) the magician manipulated the cup's content under the table—indirect load condition (see Method). The rationale for introducing this condition was to compare responses to the exact same stimulus eliciting the electrophysiological responses (ball in the cup) but dissociating between the direct load and indirect load conditions (see Method). Figure 4A\f4\ shows the grand-averaged responses. As before, we observe a slow negative (CNV) deflection preceding stimulus onset, but, in this case, the prestimulus responses to the restarting of the video were absent due to the randomization of the restart time (see Method).

After stimulus onset, we again observe a clear positive deflection, which was significantly larger (for all electrodes, $p < $ .005; sign test) and earlier (for all electrodes $p <$ .05, except Pz with $p = $ .17; sign test) for the cup trials compared to the hand trials. The

amplitude difference can be attributed to the less likely outcome of finding the ball under the cup (30% of the trials), and the earlier responses for the cup trials could be due to a better-defined onset of seeing the ball compared to noticing its absence.

Next, we focused on comparing the direct load and indirect load conditions. For the hand trials, no significant differences were found between these two conditions, either in the amplitude or in the latency of the P3. This was expected given that the magic effect took place only when the ball appeared in the cup (in the direct load condition). For the cup trials, there were no significant differences in the amplitude of the P3 response between direct load and indirect load conditions ($p = n.s.$ for all the electrodes; sign test). However, there was a significant delay (of about 50 ms) in the latency of the cup responses under the direct load condition (for all electrodes $p < 10^{-5}$; sign test).

The latency difference between the direct load and indirect load conditions for the cup trials cannot be attributed to the different retinal stimulation, because in this case the visual stimulus (i.e., the red ball appearing in the cup) was the same. However, this difference could in principle be attributed to the different number of correct responses in the direct load and indirect load conditions, considering that (a) on average, correct responses elicited a significantly earlier response onset compared to incorrect responses (for all electrodes, $p < .05$; sign test); and (b) for the cup trials, subjects had a larger number of correct responses in the indirect load condition (59%) compared to the direct load condition (17%), given their tendency to answer "cup" more frequently in the first case (see Figure 2B). To rule out this potential confound, we performed a two-way analysis of variance (ANOVA) of the P3 latency of the cup trials, with factors condition (two levels: direct load and indirect load) and response (two levels: correct and incorrect). Latency differences were significant for factors condition ($p < .05$; in all electrodes except Oz) and response ($p < .05$; in all electrodes except Fz). The interaction between factors was not significant in any of the electrodes, thus

showing that these were two independent effects. To further ensure this was the case (i.e., that the latency differences between the direct load and indirect load conditions were not due to a different number of correct trials), we evaluated the latencies for each response type separately (Figure 4B). The P3 peak latencies for the cup trials occurred significantly later in the direct load condition compared to the indirect load condition, both when considering only the correct responses (in all cases, $p < .01$, except Oz with $p = .13$; sign test) and when considering only the incorrect responses (in all cases, $p < .05$; sign test). Overall, these results indicate that the perception of the magic action delayed the neural response onset, regardless of whether the trial was correct or incorrect.

\1Discussion

In the last few years, several works have made parallels between synergetic theories developed by magicians and neuroscientists (Cui et al., 2011; Kuhn, Amlani, & Rensink, 2008; Lamont & Henderson, 2009; Macknik et al., 2008; Otero-Millan et al., 2011; Quian Quiroga, 2016; Rieiro et al., 2013). Along this line, a handful of studies have started to show insights into how magic tricks can be translated into novel neuroscience paradigms (Cui et al., 2011; Johansson et al., 2005; Kuhn, Kourkoulou, & Leekam, 2010; Kuhn & Land, 2006; Macknik et al., 2008; Martinez-Conde & Macknik, 2008; Olson et al., 2012; Otero-Millan et al., 2011; Parris et al., 2009; Raz & Zigman, 2001; Rieiro et al., 2013; Shalom et al., 2013), in a late revival of pioneering studies performed at the end of the nineteenth century (Binet & Nichols, 1896; Jastrow, 1897; Triplett, 1900). Within this context, we adapted a known magic trick—the Chop Cup trick, in which after a magic movement a ball may or may not appear in a cup—to study behavioral decisions made by the subjects and their brain evoked responses. Of particular relevance was the fact that the trick was repeatedly shown in a nonedited video, so that subjects could perform a meaningful estimation of the probability of finding the ball in the cup. Related to our approach, videos showing the repeated execution of

a similar trick involving cups and balls under different conditions were used to study behavioral and oculomotor responses in a recent study (Rieiro et al., 2013).

The study of behavioral and evoked responses generated by the observation of the Chop Cup magic trick allowed us to establish three main points. First, we showed that electrophysiological responses could be obtained while subjects freely gazed at a sequence of events shown in a continuous unedited video, in contrast to standard paradigms using images flashed at the center of the screen (where the subjects are asked to maintain fixation). Second, we showed that behavioral and neural responses were biased according to the particular sequence of events shown in the videos (i.e., the probability of observing the ball in the cup following direct and indirect loads). Third, we found that the same stimulus (seeing the ball in the cup) gave differential responses depending on whether it was the result of a magic trick being performed, or simply the natural outcome of a manipulation performed outside the subjects' view. With regard to this latter point, we propose that the comparison between these two conditions contributes to the interesting literature in cognitive neuroscience separating sensory processing and subjective perception, which is typically done by describing differential neural responses to presentations of the same stimuli (Blake & Logothetis, 2002; Kanwisher, 2001; Logothetis, 1998; Navajas et al., 2013; Quian Quiroga et al., 2008, 2014).

In two separate experiments, we found clear behavioral and electrophysiological responses. With respect to behavior, in the first experiment, we observed that the subjects could track a change in the proportion of cup trials (i.e., trials in which the ball appeared in the cup) between two different blocks. Moreover, in the first block, the percentage of cup responses was significantly lower than the presented rate (50%), a bias that can be attributed to the unexpected effect of seeing the ball in the cup (due to the performance of the magic trick in cup_direct load). In the second block, the number of cup responses was slightly higher, though not significantly different, than the presented rate of cup trials (30%), an effect

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that is likely due to an adaptation from the higher proportion of cup trials in the previous block.

The most interesting behavioral results were observed in Experiment 2, where we introduced a control indirect load condition, in which the movement of taking the ball out of the cup (or not) was performed under the table. In this case, the number of cup responses was significantly lower for the direct load compared to the indirect load condition, even though the number of times the ball appeared under the cup was exactly the same in both cases. Altogether, the behavioral results show that, first, the subjects were able to track changes in the rate of presentation of the different stimuli, and second, the performance of the magic trick (in spite of being repeated hundreds of times) was effective in biasing their responses.

With the electrophysiology recordings, we observed a slow negative deflection preceding the stimulus onset (the time of showing the content of cup), which corresponds to the CNV observed in classic evoked potential tasks (Walter et al., 1964) and reflects the expectation of an impending stimulus. After stimulus onset, we also observed large evoked responses that resemble the N2-P3 complex elicited with standard oddball paradigms. This response varied as the stimulus became more infrequent, which has been described in previous works (Picton, 1992; Polich, 2007).

In Experiment 2, when comparing the direct load and indirect load conditions, we observed delayed neuronal responses upon performance of the magic trick, in spite of the fact that the visual stimulus triggering the responses (seeing the ball in the cup) was exactly the same. We also showed that this difference was not due to the different number of correct responses in each condition but could instead be attributed to the fact that subjects needed more time to process the unexpected outcome of seeing the ball in the cup after the performance of the magic trick, considering that the expected outcome is that the ball remains in the hand (otherwise it would have fallen out when turning the cup upside down).

It could in principle be argued that the differential evoked responses we observed upon the performance of the magic trick are just due to surprise or novelty (irrespective of any specific effect elicited by the magic trick) due to the low probability of occurrence of these trials. In fact, surprise has been a main factor described to modulate the P3 responses in oddball paradigms (Donchin, 1981; Polich, 2007). We can, however, rule out the novelty confound given that in Experiment 2 subjects saw the trick (cup_direct-load trials) being performed a total of 60 times. Moreover, the probability of the ball appearing in the cup in the direct load condition (cup_direct load trials) was exactly the same as in the indirect load condition (cup_indirect load trials), so the stimulus was equally infrequent in both conditions. Therefore, in spite of the fact that subjects saw the trick several times, breaking natural inferences (by means of the magic trick) still led to differential brain responses.

The study of responses to video presentations shows interesting new insights compared to classic evoked potential paradigms (Freeman & Quian Quiroga, 2012; Luck & Kappenman, 2011). Clearly, we see objects continuously moving in our environment, and the standard study of responses to presented images is a limited proxy of how our visual system works under natural conditions. In this respect, our study provides interesting evidence that is in line with recent works showing evoked responses to freely gazed complex stimuli (Graupner, Velichkovsky, Pannasch, & Marx, 2007; Kamienkowski, Ison, Quian Quiroga, & Sigman, 2012; Kaunitz et al., 2014; Luo, Parra, & Sajda, 2009; Ossandon, Helo, Montefusco-Siegmund, & Maldonado, 2010). In addition, it paves the way for new studies and experimental paradigms dealing with visual responses and cognitive processes in more ecological conditions, using magic tricks and responses to freely gazed videos.

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Figure Legends

\fl**Figure 1.** General structure of a trial. A: Direct load: The ball was placed inside the cup (1). The cup was turned upside down but covered with the right hand (2). The cup remained shortly in the air, upside down, while the magician removed the right hand, apparently taking the ball (because if the ball had stayed in the cup, it would have fallen) (3). The cup was placed on the table (4). The video was then paused, waiting for the subject's response (guessing whether the ball was in the cup or in the hand). After a short delay following the subject's response (orange line), the video was restarted, revealing the content of the cup (5 and 5'). The magician reintroduced the ball in the cup starting a new trial. B: In Experiment 2, direct load trials were interleaved with indirect load trials, in which the movement of taking the ball in the hand (2, 3) was performed under the table.

\fl**Figure 2.** Behavioral results. Average percentage of predictions that the ball remained in the cup (cup responses) for Experiment 1 (left) and Experiment 2 (right). In Experiment 1, the number of cup responses was not significantly different between Block 1 and Block 2. In Experiment 2, the percentage of cup responses was significantly different depending on whether there was a direct load performed (movement done on top of the table) or indirect load (movement done under the table).

\fl**Figure 3.** Grand-averaged evoked responses for Experiment 1. In Block 1, the ball appeared in the cup (cup_direct-load trials) in half the trials and was retained in the hand (hand_direct-load trials) in the other half, whereas in Block 2 the proportion of cup/hand trials was 30%/70%. In all conditions, there was a slow negative shift preceding stimulus onset (CNV) reflecting expectation, and a P3 response that was larger and immediately

preceded by an N2 response for the infrequent cup_direct-load trials in Block 2. Time zero corresponds to stimulus onset (the time where the content of the cup was revealed). Shaded areas around mean values show *SEM*.

\fl**Figure 4.**   A: Grand-averaged evoked responses for Experiment 2. Responses are separated according to the type of trial (ball appearing in the cup or retained in the hand) and condition—direct load (DL) and indirect load (IL). Cup trials in the direct load and indirect load conditions elicited larger and earlier responses compared to the hand trials. For the cup trials, the responses had a later onset under the direct load condition. Notations are the same as in the previous figure. (B) Grand average of the P3 peak latencies for the cup responses of Experiment 2, separated according to the condition (DL, IL) and type of trial (correct, incorrect). Both for the correct and incorrect trials, the cup responses appeared later for the direct load condition. *Statistically significant differences.