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Article *in* Psychologia: an international journal of psychology in the Orient · June 2008

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FROM CHANGE BLINDNESS TO CHOICE BLINDNESS

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The phenomenon of change blindness has received a great deal of attention during the last decade, but very few experiments have examined the effects of the subjective importance of the visual stimuli under study. We have addressed this question in a series of studies by introducing choice as a critical variable in change detection (see Johansson, Hall, Sikström, & Olsson, 2005, Johansson, Hall, Sikström, & Tärning, 2006). In the present study, participants were asked to choose which of two pictures they found more attractive. For stimuli we used both pairs of abstract patterns and female faces. Sometimes the pictures were switched during to choice procedure, leading to a reversal of the initial choice of the participants. Surprisingly, the subjects seldom noticed the switch, and in a post-test memory task, they also often remembered the manipulated choice as being their own. In combination with our previous findings, this result indicates that we often fail to notice changes in the world even if they have later consequences for our own actions.

Key words: Choice Blindness, Change Blindness, Intention, Decision, Action

Even if naïve participants often express bewilderment and disbelief during change blindness experiments, the results of these experiments no longer surprise scientists working in the field. In the last decade, a mass of empirical studies of change blindness have been published in the journals of cognitive science and vision research (for overviews, see Rensink 2000a; Rensink 2002; Simons & Rensink 2005), and change blindness now serves as a standard example in cognitive science, on a par with the Stroop effect and the Kaniza triangle.

The common denominator in experiments on change blindness is that participants fail to detect changes in a scene when the change is accompanied by some other visual disturbance. If the same changes had occurred in plain sight, with no interruptions in the visual stream, they would have been detected instantaneously. While the mechanisms behind this effect has not yet been universally agreed upon (Simons, 2000), experiments

The authors thank Ronald Rensink and an anonymous reviewer for helpful comments and suggestions. Petter Johansson thanks the Japan Society for the Promotion of Science, Lars Hall thanks the Swedish Research Council and the Erik-Philip Sörensen Foundation, and Sverker Sikström thanks The Swedish Research Council for financial support.

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on change blindness has been put to great use in mapping out the fine-grained properties of attention, and has lead to a deepened understanding of the various stages of visual processing (Rensink, 2000b; Tse, Sheinberg & Logothetis, 2003). More controversially, change blindness has also served as a focal point in the debate about the nature of visual consciousness (the so called *Grand Illusion Debate*, see Noë, 2002), where a proposal have been made that change blindness shows that we all have a drastically false conception of our own visual experiences (e.g. Blackmore, 2002). A less radical conclusion to draw from these experiments is that we represent the world in much less detail than what was previously thought. Instead, when we need to be informed, we just direct our attention toward those features of the visual environment that is of current importance (as Brooks 1991, and later O'Regan and Noë 2002, put it: "allowing the world to be its own best model"). Thus, in this process, we rely on the stability of the world, and we implicitly assume that it does not change in undetectable ways.

While the study of change blindness has proliferated into various sub-fields, both with respect to the theoretical outlook (Mitroff, Simons, & Franconeri, 2002; Rensink, 2002), and to the techniques used (Grimes, 1996; O'Regan, Rensink, & Clark, 1999; Smilek, Eastwood, & Merikle, 2000) there has been surprisingly little research aimed at investigating our ability to detect changes when the stability of the world is of particular importance to us—i.e. when changes in the visual environment have effects in relation to our *intentions* and *actions*. As Rensink (2002) writes:

> The study of change detection has evolved over many years, proceeding through phases that have emphasized different types of stimuli and different types of tasks. *All studies, however, rely on the same basic design*. An observer is initially shown a stimulus ... a change of some kind is made to this stimulus ... and the response of the observer is then measured.
>
> (p. 251, our emphasis)

Research on change blindness has occasionally contained elements of interaction (most notably, the real-person interactions in Simons & Levin, 1998, and Levin, Simons, Angelone, & Chabris, 2002), and at least one task in which the actions of the participants have functional relevance has been investigated (Triesch, Ballard, Hayhoe, & Sullivan, 2003), but the full potential of change blindness as a tool for studying the human mind is far from realized. Why should change blindness be used only to study *perceptual* aspects of cognition?

In a series of studies, we have modified the basic design of change blindness experiments to incorporate other non-perceptual elements of cognition. The result is a novel research tool we call *choice blindness*, in which we surreptitiously manipulate the relationship between the choice and outcome that our participants experience (Hall, Johansson, Tärning, Sikström, & Deutgen, submitted; Johansson et al., 2005; Johansson et al., 2006). In particular, we have been interested in the relationship between intention, choice, and introspection. For example, in Johansson et al. (2005), the participants were shown pairs of pictures of female faces, and were instructed to point at the face they found most attractive. After pointing, the chosen picture was given to the participants, and they were asked to explain why they preferred the picture they now held in their hand.

Unknown to the participants, on certain trials, a double-card ploy was used to covertly exchange one face for the other. Thus, on these trials, the outcome of the choice became the opposite of what they intended.

The number of manipulated trials detected by the participants was surprisingly low. Even when they were given unlimited time to deliberate upon their choice no more than 30% of all manipulated trials were detected. But not only were the participants often blind to the manipulation of their choices, they also offered introspectively derived reasons for preferring the alternative they were given instead. In addition to this, manipulated and non-manipulated reports were compared on a number of different dimensions, such as the level of emotionality, specificity and certainty expressed, but no substantial differences were found (see Johansson et al., 2006). Choice blindness also extends to other modalities than vision. In a recent consumer choice study we have demonstrated the effect for the taste of jam and the smell of tea. Even for such remarkably different jams as spicy cinnamon apple vs bitter grapefruit, or for the smell of teas like sweet mango vs liquorice pernod, were no more than half of the manipulated trials detected (see Hall et al., submitted).

In change blindness experiments participants are usually more likely to notice changes when they concern features of particular relevance to the scene, or if they are of central interest to the participants, or if the participants are particularly knowledgeable about them (Rensink, 2002; Triesch et al., 2003). For choices it would almost seem to be a defining feature that they concern properties of high relevance and interest, or things we are very knowledgeable about. But in our experiments, in the great majority of trials, our participants were blind to the mismatch between choice and outcome. While intending to choose X (a central-interest, non-peripheral, valenced stimuli), they failed to take notice when ending up with Y. This is a result that ought to be surprising even to the most seasoned change blindness researcher.

Before implementing the card-based paradigm of Johansson et al. (2005) we ran a series of studies exploring the phenomenon of choice blindness. These studies are hitherto unpublished, but importantly add to the evidential base for choice blindness by demonstrating the effect in a different medium, with a different design, with different types of stimuli, and with additional post-test controls to guarantee that the manipulated images have been adequately processed by the participants[1]. We will here present this work in greater detail, and relate it to our previously published results.

In these studies, the participants had to choose which one of two abstract patterns they found most appealing (Experiment 1) and which one of two female faces they found most attractive (Experiment 2 and 3). The alternatives were presented on a computer screen, and the participants had to indicate their choice by moving the cursor to the chosen picture. Each experiment consisted of 15 trials, three of which were manipulated (i.e. after the choice was indicated the participants were presented with the non-chosen alternative instead). When all the choice trials were completed, an unannounced memory test was introduced. The participants had to look at all the pairs again, presented in a

[1] These experiments have previously only been reported in summary form in the *Supporting Online Material* for Johansson et al. (2005).

randomized order and without time-constraint, and try to remember which face or pattern they previously preferred.

EXPERIMENT 1

METHOD

Participants. Twenty undergraduate students (12 female) at Lund University participated in the study. They received a cinema ticket for their participation. The experiment was described as a test of rapid, intuitive judgment of aesthetic beauty. All participants were naïve about the actual purpose of the experiment.

Material. As stimulus material we used abstract patterns collected from various websites containing "artistic" computer wallpaper for non-commercial use. The pictures were organized in pairs, roughly matched for similarity and attractiveness, covering a range from "similar" to "not so similar". The matching was performed by the authors. The presentation size on the screen was around 5.0° × 5.0° visual angle (non-fixated viewing distance around 60 cm with a picture size of 5 × 5 cm)

Procedure. Experiment 1 consisted of a simple binary choice task, where participants had to choose which one of two abstract patterns presented on a computer screen they found most aesthetically appealing (see Figure 1). Each trial began when the participants clicked on a left-aligned start-icon that made two patterns appear on the right side of the screen. Participants were given 1500 ms to consider their choice, then a beep was played, and they had to move the cursor to the preferred pattern. In addition, the cursor trajectory had to pass through one of two small, color-coded, intermediate squares corresponding to either the upper or the lower pattern on the right. These two squares only became visible after the sound was played, and to prevent learning-effects the vertical position of the squares was randomized within their half of the screen. The upper square was always red and the lower square was always blue, and when the participants passed through one of these squares, the entire screen flashed in matching color for 50 ms. The intermediate square and the screen flash were explained to the participants as a way to help them keep the "pace" of the experiment.

After the participants completed their choice, the indicated pattern was framed in the same color as the prior intermediate box, and the non-chosen picture was removed from the screen. The chosen picture remained on the screen for an additional 1500 ms after the choice was completed. If the participants had not yet managed to complete a choice 1500 ms after the sound alert, the trial ended, and was categorized as a mistrial. The full experiment consisted of 15 trials[2].

For each participant, on 3 of these trials a change manipulation was introduced (see Figure 1c). On a manipulation trial, the attention-grabbing properties of the midway square and the 50 ms screen flash were used to conceal the fact that the two choice alternatives switched places while the participants were moving the cursor across the screen. The manipulation always occurred on trial 7, 10 and 14, but the presentation order of the pairs was randomized.

After all 15 trials had been completed, the participants were given an unannounced memory test. The same pairs of patterns were once again presented, and the participants were asked to indicate which one of the two patterns they had previously found most appealing. In this phase, no time constraints were imposed.

Before the experiment started, the participants were given 10 practice trials. After the experiment all participants were debriefed, and asked whether they consented to have the data from their trials included in the analysis.

A trial was classified as detected if participants showed signs of detection concurrent with the switch (such as explicitly reporting that the patterns had been switched, or that something went wrong with their

[2] 149 of 900 trials (16.5%) in the three experiments were classified as mistrials and were removed from further analyses. There were no differences between manipulated and non-manipulated trials in the number of mistrials.

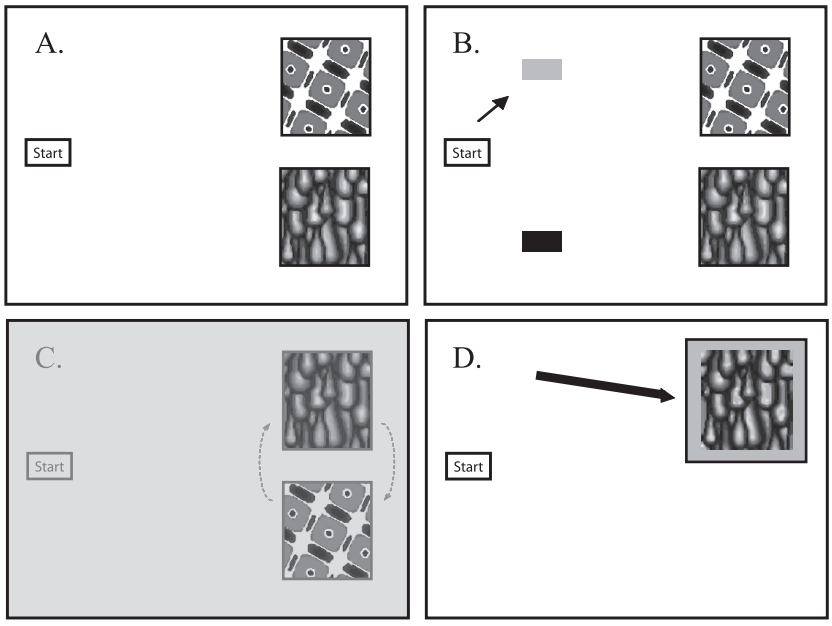

Fig. 1. Step-by-step progression of a manipulated trial. **A.** The participants press the start icon and the two pictures appear on the right hand side. **B.** After 1500 ms a beep is played, and the participants moves the cursor to the midway square corresponding to the chosen picture. **C.** When the cursor hits the square the screen is occluded for 50 ms. **D.** The participants continue the movement to the chosen (but now altered) picture, and when it is reached the non-chosen alternative is removed from the screen. The chosen picture is then framed and remains visible for 1500 ms. Note, for purposes of illustration the pictures are here somewhat magnified compared to their size in the experiment.

choice, or by showing signs of confusion and surprise), or if they later in post-experiment interviews claimed to have detected a switch or sensed that something went wrong. For participants that did not show any concurrent signs of detection, a series of increasingly specific questions were asked to make sure their responses were not misclassified as non-detected: "What did you think about the experiment?", "Did you find anything odd with the experiment?" and "Did you notice anything strange with the stimuli presented in the experiment?". At this point, if the participants still revealed no sign of having noticed anything odd with the experiment, they were told that we planned a follow-up study in which the patterns presented sometimes would switch place in mid-trial (i.e. an actual description of the current experiment), and asked if they believed that *they* would have noticed such a switch. Finally, participants were asked if they had noticed anything in the current experiment resembling the hypothetical switches that we had just described. If they answered no to this question, we concluded that they did not consciously notice any of the manipulations made during the experiment.

Previously, we have made a distinction between *concurrent* and *retrospective* detection of the manipulation, i.e. if the participants indicated that they detected a manipulation during the experiment or in the post-test interview. As we did not verbally interact with the participants during the present experiments, the category of concurrent detection is not as reliable as in our previous work. Therefore, in the current article, we report detection as a single measure based on an overall interpretation of the participant's immediate reactions and their answers in the post-test interview.

The post-test memory task was included to measure if a (non-detected) manipulation would influence what the participants remembered as their "own" choice, i.e. if the original choice or the manipulated outcome would be remembered as the picture preferred. The memory task also served as an independent measure that the pictures were processed after the manipulation was performed. If we were to find no

differences between the manipulated and the non-manipulated trials on the memory task, it might mean that the pictures were not fully processed after the switch.

Results. In Experiment 1, only 19% of the manipulated trials were categorized as detected (see Figure 3). One participant detected all of the switches, three participants detected two of the switches, one participant detected one switch, and 15 of the participant did not detect any of the switches. Of the 15 participants that did not detect any of the switches, 12 believed themselves to be able to do so, had any manipulations been made. Of the non-manipulated choices, 86% were remembered correctly in the post-test memory task. For the manipulated trials, the original choice was remembered in 61% of the trials (see Figure 4). The distribution differs significantly between non-manipulated and manipulated trials (Chi square (1, $N = 20$) = 6.95, $p < 0.0084$), showing that the manipulation influenced what the participants remembered as being their own choice.

EXPERIMENT 2

In the post-test interviews in Experiment 1, most participants described the choice task as being both "real" and meaningful. Nevertheless, it could still be argued that there is something slightly artificial about evaluating abstract patterns, as it is something most people have very little experience of[3]. To provide a more critical test of our approach, we therefore chose to use human faces as the stimuli in Experiment 2. In contrast to abstract patterns, most people have had a lot of practice in evaluating faces, and they often have strong opinions about attractiveness. Given this, it seems likely that we would be better at detecting manipulations of faces than most other stimuli.

METHOD

Participants. Twenty undergraduate students (11 female), at Lund University participated in the study. They were given a cinema ticket for their participation. The experiment was described as a test of rapid, intuitive judgment of attractiveness. All participants were naïve about the actual purpose of the experiment.

Material. Experiment 2 used gray-scale pictures of female faces (taken from the University of Stirling database (PICS), see Figure 2). The pictures were organized in pairs, roughly matched for similarity and attractiveness. The matching was performed by the authors. The presentation size on the screen was around 5.0° × 5.0° visual angle (non-fixated viewing distance around 60 cm with a picture size of 5 × 5 cm)

Procedure. As in Experiment 1, participants were given the task to choose the picture they preferred the most. However, the exact wording of the instructions was changed from "choose the pattern you find most aesthetically appealing" to "choose the face you find most attractive". The procedure employed was the same as that in Experiment 1, using 15 trials, three of which were manipulated.

Results. In Experiment 2, the detection rate for the manipulated trials was 12% (see

[3] But this is not true for all participants. For instance, an architect student had very strong views on the use of symmetry and what colours could be mixed without unbalancing the picture etc. When the actual procedure was revealed she simply refused to believe that something like that could have taken place.

Fig. 2. Examples of pairs of pictures used.

Figure 3). This detection rate does not differ statistically from Experiment 1. Two participants detected two of the switches, two participants detected one switch, and 16 of the participants did not detect any of the switches. Of the 16 participants that did not detect any of the switches, 14 believed themselves to be able to do so, had any manipulations been made. The participants remembered their choices in 87% of the trials in the post-test memory task. For the manipulated trials, the participants indicated their "original" choice as being what they chose for 76% of the trials (see Figure 4). This number does not differ significantly from the results of the non-manipulated trials.

EXPERIMENT 3

At the outset, it seemed likely to us that the change of stimulus material would lead to a difference in detection rate between Experiment 1 and Experiment 2. However, this was not the case. One possible explanation is that there are other factors than the nature of the stimuli that are more important in determining the detection rate. For instance, it may be the case that the relative "distance" between the items paired are not equivalent in the two experiments (e.g. that the face pairs differed less in similarity or attractiveness compared to the pairs of patterns used in Experiment 1[4]). Another possible explanation is that the participants did not fully process the faces after the switch in Experiment 2. In Experiment 1 we found a difference between the manipulated and non-manipulated trials

[4] The use of two sorts of stimuli should be seen more as a further test of the general phenomenon of choice blindness with this presentation technique rather than a thorough comparison between the likelihood of detection for patterns and faces.

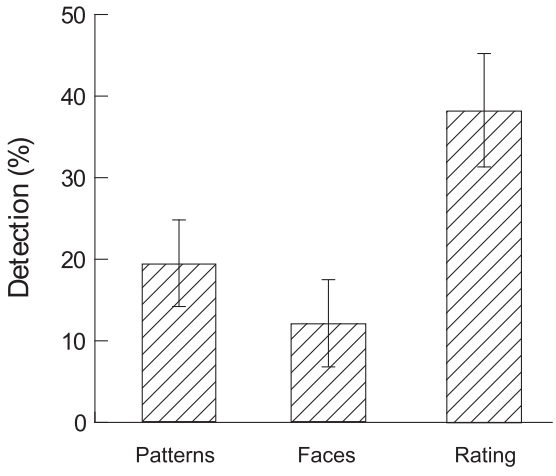

Fig. 3. Detection frequency in the three experiments.

in the post-test memory task. The only candidate explanation for this result is the manipulation itself—i.e. it can be assumed that the participants did in fact look at the pictures after the switch, but did not realize they had been switched, and then later remembered the altered alternative as the one they preferred. But in Experiment 2 there were no differences in the memory test, and therefore we have no independent measure that the participants actually attended to the faces after the switch. And if this was not the case, then it is unsurprising that very few manipulation trials were reported as detected. Thus, to make sure that the manipulated item was fully processed after the manipulation, in Experiment 3, we included a rating task of the chosen and non-chosen faces directly after the choice was completed. Now the pictures stayed visible on the screen until they were rated for attractiveness.

METHOD

Participants. Twenty undergraduate students (10 female) at Lund University participated in the study. They received a cinema ticket for their participation. The experiment was described as a test of rapid, intuitive judgment of attractiveness. All participants were naïve of the actual purpose of the experiment.

Material. Experiment 3 used the same set of female faces as in Experiment 2.

Procedure. The procedure was the same as Experiment 2, with the following exceptions. After the choice had been indicated on the screen, the chosen picture stayed visible and the participants were asked to rate the face on scale for attractiveness from 1 to 9. The picture remained on the screen until the participants had typed their numerical rating in a box next to the picture. After the chosen picture was rated it was removed, and the non-chosen picture appeared, and the participants were asked to rate this alternative as well. After the participants had done so, the next trial began. As in the previous experiments, the full set consisted of 15 trials, three of which where manipulated.

Results. The detection rate in Experiment 3 was 39%. This is a significantly higher level of detection compared to Experiment 2 (Chi Square (1, $N = 20$) = 8.75, $p < 0.0031$).

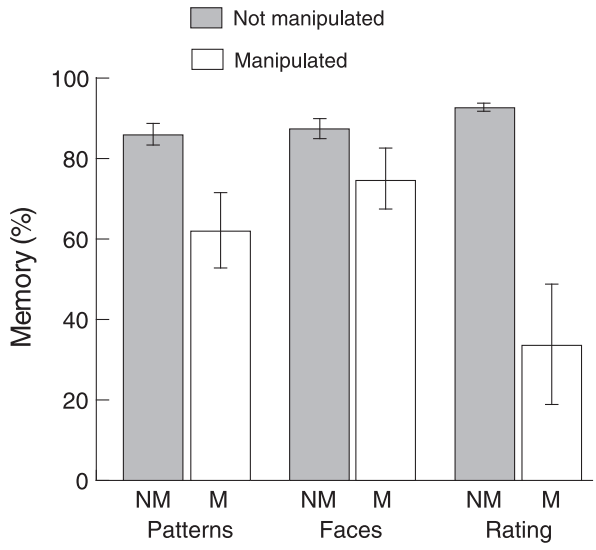

Fig. 4. Memory of original choice.

Four participants detected all of the switches, two participants detected two of the switches, three participants detected one switch, and 11 of the participant did not detect any of the switches. Of the 11 participants that did not detect any of the switches, 9 believed themselves to be able to do so, had any manipulations been made.

The result on the memory test differed markedly when comparing non-detected manipulated and non-manipulated trials. In the non-manipulated trials, the participants remembered their original choice in 92% of the trials. But for the manipulated trials, only 33% of the originally chosen pictures were later remembered as being what the participants preferred initially. The difference between manipulated and non-manipulated trials is significant, (Chi Square (1, $N = 20$) = 69.62, $p < 0.00001$).

We also analyzed the attractiveness rating task. In the rating phase, when the faces were presented again, the participants "knew" that the first face to be rated was the face they originally chose. This means that the participants ought to rate the first face higher, as that was the alternative they thought was the more attractive just a few seconds ago. This is also what we found. In 89% of the non-manipulated trials, the ratings of the participants were consistent with their initial choice. The same was true for the manipulated trials. In 67% of the manipulated trials the participants rated the first picture higher, even though this picture was not the one originally chosen.

DISCUSSION

We have described three experiments involving a simple choice task in combination with a covert manipulation of the outcome of the choices made. The participants in our

experiments often failed to notice that the outcome of their choice became the opposite of what they intended, thereby demonstrating the effect we have termed choice blindness. In the experiments presented we varied both the stimuli used and the choice procedure. The first experiment used abstract patterns, and in the second and third experiment we used pictures of female faces. In all three experiments, the majority of the manipulations remained undetected, indicating that choice blindness is a robust phenomenon. In relation to our previously published studies, we have shown that it is possible to generate similar results on a computerized test as with a real-world magic trick. This result demonstrates that the prevalence of choice blindness is not strongly tied to the prior "believability" of the switch (i.e. a card-based magic trick is generally perceived to be "impossible", while almost anything can happen in the virtual world of computer presentation). By using abstract patterns we have also demonstrated the effect for a new type of stimuli. Finally, by adding a memory test we have obtained a clear indication both that the participants attend to the pictures after the switch, and that they tend to remember the manipulated choice as being the alternative they choose themselves.

But given the counter-intuitive nature of the result, we need to carefully consider some objections and alternative interpretations.

To be certain that the pictures were attended to after the switch, we amended the procedure somewhat in the final study. In Experiment 3, we left the faces on the screen until an attractiveness rating was made by the participants. It is very difficult to imagine that the participants did not look at the pictures when performing this task.

A similar question is how can we know that 1500 ms is enough to form an opinion about aesthetic preference. According to recent research we are remarkably fast at forming opinions about the appearance of faces (Todorov, Mandisodza, Goren, & Hall, 2005). For example, it has been shown that an attractiveness evaluation of a face made after as short exposure as 100 ms correlates highly with judgments made after free viewing time (Willis & Todorov, 2006). This indicates that 1500 ms is sufficient time to decide at least which of two faces are the more attractive.

But the most obvious objection to the results is that perhaps the participants actually did notice all the manipulations, but for some reason they just did not tell us. We find this to be quite unlikely. As was described in the procedure section of the first experiment, the debriefing after the experiment involved asking the participants a series of questions, the last one being if they thought they would have noticed if a switch had been made during a "similar" experiment. Of the participants that did not notice any manipulations during the experiment, 85% believed that they would have detected such a switch if it had been performed. When the actual purpose of the experiment was finally revealed, the participants showed considerable surprise, and sometimes even questioned our claim that we *had* switched the pictures. This type of strong reaction is very difficult to reconcile with participants actually knowing about the manipulations but not telling us about it. By answering yes to the meta-question about whether they think they *would* have noticed a manipulation, the participants in a sense also set the norm for what should be expected of them. To answer yes to the first question and then deliberately "lie" when asked whether they detected any manipulations seems a very strange thing to do. This also has an

interesting parallel in the change blindness literature, in that people tend to overestimate their ability to detect visual changes (the so called change blindness blindness effect, see Levin, Momen, Drivdahl, & Simons, 2000).

In comparison with change blindness experiments, it is also important to point out that even though the current experiment involves an element of cognitive load and a limited exposure time of the stimuli, this is not a prerequisite to obtain the choice blindness effect. In Johansson et al. (2005) the choice alternatives were presented for 2 s, 4 s, or for as long as the participants wanted, and even in the free viewing time condition a large majority of the manipulations remained undetected. The memory test in the current experiment also shows that for the non-manipulated trials, the initial exposure (pre- and post-choice presentation) is enough time to form a relatively stable memory of which alternative was preferred when the choice was made.

But to what extent is choice blindness something new and different in comparison with change blindness? Given that neither the current nor our previous studies were designed to address the neuro-cognitive underpinnings of choice and change blindness, it would be premature to offer any speculations whether the actual mechanisms are identical or not. However, as we see it, our methodology is perfectly positioned to bridge the disconnected research areas of choice/intentionality and change blindness, and to create some productive friction between the two. This can be seen clearly by a brief exposition of what intentional choice is supposed to entail. Sirigu Daprati, Ciancia, Giraux, Nighoghossian, Posada, & Haggard (2004) state: "voluntary action implies a subjective experience of the decision and the intention to act/.../For willed action to be a functional behavior, the brain must have a mechanism for matching the consequences of the motor act against the prior intention" (p. 80, our emphasis, see also Ullsperger & Cramon, 2004; Ridderinkhof, van den Wildenberg, Segalowitz, & Carter, 2004; Haggard, 2005). But if this is the case, how can it be that the participants in our studies so often fail to detect the glaring discrepancy between the prior intention and the outcome of their choice? Pairing this question with the most common explanations for change blindness offered in the literature does not seem to produce any satisfactory answers. In fact, in our view, given the almost complete lack of reference to mechanisms of decision making and intentionality in the change blindness literature, choice blindness would be an even more remarkable phenomenon if it turned out to be qualitatively identical to change blindness. For example, the prevalence of choice blindness in our experiment might be due to a failure to sufficiently encode the choice alternatives during the deliberation phase (O'Regan & Noe, 2002). But from the perspective of a decision researcher it would amount to a strangely maladaptive decision process not to encode the features that are supposed to be *the very basis* of the choice (such as the gross identity of the two alternatives). Another option is that the intentions simply are forgotten during the brief occlusion time. But intentions are not supposed to be instantly forgotten. As Sirigu et al. (2004) contend, they are supposed to be the guiding structures behind our actions (and phenomenologically speaking, this is what many people claim them to be), which makes this option equally unattractive to decision theorists. Similar things can be said for the other common explanations for change blindness: that initial representations might be

disrupted or overwritten by the feedback (Beck & Levin, 2003), that change blindness results from a failure to compare pre- and post-change information (Mitroff, Simons, & Levin, 2004; Hollingworth, 2003), or that explicit change detection is impossible because the representations are in a format inaccessible to consciousness (Simons & Silverman, 2004). They are all viable candidates to explain choice blindness, but also more or less incompatible with popular theories of choice and intentionality. If our task can be seen as a good example of willed action, involving perfectly standard intentions and choices (and currently we can see no reason why this should not be the case), but the outcome of the experiment could be fully explained by the conceptual apparatus of change blindness research, then something would seem to be seriously amiss in current theories of decision making and cognitive control.

There are a large number of possible future experiments to make to further examine the relationship between change and choice blindness. For example, the choice task as can be altered in several different ways to examine what effect intention has on retention and change detection. One dimension is the concreteness of the choice task, e.g. the participants can be asked to select the larger of the two patterns, or decide which of two faces is the roundest, or which person is older, or has highest education. Another is the consequences of the choice, e.g. which of the two persons the participants will pick as partner in a subsequent problem solving task, or which to go with on an afternoon date at the campus café. From a common sense perspective, it seems like these factors would influence both detection rate and memory of initial choice, but it remains to be empirically decided.

Another aspect with parallels in change blindness research is to search for implicit measures of detection, like GSR or ERP (Eimer & Mazza, 2005), gaze duration (Hollingworth, Williams, & Henderson, 2001), or a "sense" of something being wrong occurring independent of explicit change detection (Rensink, 2004).

In comparison with standard change blindness studies, another novel use of the choice blindness methodology is to examine what happens *after* the choice (what Dennett, 1991 calls The Hard Question: *And then what happens*?). In the present study, the memory test used after the completion of the choice experiment showed that for the manipulated trials, the participants were much more likely to remember the originally non-preferred face as being their actual choice. In addition, in Experiment 3, the participants tended to rate the originally non-chosen picture as being the more attractive. The question is what becomes of the participants preferences and attitudes; what would for instance happen if they had to do the same choice again, would they pick the alternative they initially thought was better or the mismatched option they ended up with? We have recently begun to explore this question. In Hall, Johansson, Tärning & Sikström (in preparation), the participants had to choose between two faces, pick the one they preferred, and give either a short or a long verbal report explaining their choice. But in addition to this, their later preferences were also probed in several different ways. All participants were presented with the pairs a second time and had to choose the picture preferred once again. In one condition, the participants also had to rate on a numerical scale how attractive they thought both pictures were directly after having given their

verbal reports. The results showed that the participants were clearly influenced by the manipulations made, as they were significantly more likely to pick the originally non-preferred face the second time they had to evaluate a pair. But perhaps even more interestingly, this tendency was correlated with the participants "involvement" in the choice, i.e. if they had given short or long reports, and if they had numerically rated the pictures after the first choice.

We think this is a very interesting avenue of exploration. What will happen with these "induced" preferences over time? Will they transfer to more general attributes (like preferring brunettes to blondes)? Will they be modulated by other choices? In a sense, choice blindness can be used as an instrument to measure how much we influence *ourselves* by the choices we make.

In summary, we have made an argument that the choice blindness paradigm can be seen as a general research tool to study decision making, intentional action, introspection, and the dynamics of preference formation and change. As such, it extends prior research on change blindness, which has primarily been focused on the properties of vision and attention. The question of the exact relation between the mechanisms of choice and changes blindness remains to be determined. In our view this is a topic that could serve as a critical catalyst for further connecting the research fields of decision making and vision science.

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(*Manuscript received December 31, 2007; Revision accepted April 28, 2008*)