

# Using choice blindness to study decision making and introspection

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## 1. From Change Blindness to Choice Blindness

Even if naïve participants often express bewilderment and disbelief at the phenomenon of change blindness, 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, 2002; Simons & Rensink, 2005), and change blindness now serves as a standard example in introductory cognitive science courses.

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 on change blindness have been put to great use in mapping out the fine-grained properties of attention, and have led to a deeper understanding of the various stages of visual processing (Rensink, 2000). More controversially, change blindness has also served as a focal point in the debate about the nature of visual consciousness (known as the *Grand Illusion Debate*, see Noë, 2002), where it has been suggested 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

268 draw from these experiments is that we represent the world in much less detail than was previously thought. Instead, when we need to be informed, we just direct our attention toward those features of the visual environment that are 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.

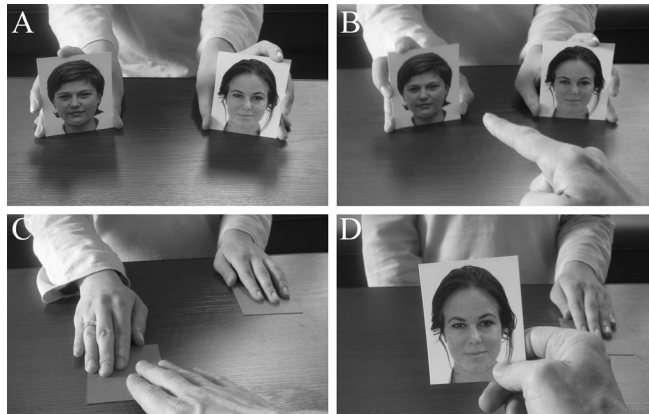
While the study of change blindness has proliferated into various sub-fields, with respect to both the theoretical outlook (Rensink, 2002), and the techniques used (Grimes, 1996; O'Regan, Rensink & Clark, 1999) there has been surprisingly little research aimed at investigating our ability to detect changes 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 et al., 2002), and at least one task in which the actions of the participants have functional relevance has been investigated (Triesch et al., 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 (Johansson et al., 2005;

Johansson et al., 2006; Johansson et al., in press; Hall et al., submitted.), 269  
In particular, we have been interested in the relationship between intention, choice, and self-knowledge. For example, in Johansson et al. (2005), participants were shown pairs of pictures of female faces, and were given the task of choosing which face in each pair they found most attractive. In addition, on some trials, immediately after the choice, they were asked to verbally describe the reasons for choosing the way they did. 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 was the opposite of what they intended (see figure 1).



*Figure 1. A snapshot sequence of the choice-procedure during a manipulation trial. A. Participants are shown two pictures of female faces and asked to choose which one they find most attractive. Unknown to the participants, a second card depicting the opposite face is concealed behind the visible alternatives. B. Participants indicate their choice by pointing at the face they prefer the most. C. The experimenter flips down the pictures and slides the hidden picture over to the participants, covering the previously shown picture with the sleeve of his moving arm. D. Participants pick up the picture, and are immediately asked to explain why they chose the way they did.*

Each of the 120 participants performed 15 choice trials, of which three were manipulated. The time given to make a choice and the similarity of the face-pairs were varied. For time, three choice conditions were included: one with two seconds of deliberation time, one with five, and a final condition where participants could take as much time as they liked. For similarity, a high and a low similarity set of target faces was used. A trial was classified as detected if participants showed any signs of detection in immediate relation to the switch (such as explicitly reporting that the faces had been switched, or indicating that something went wrong with their choice), or if the participants voiced any suspicion in the debriefing session after the experiment. 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.<sup>1</sup>

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

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1. Interestingly, while the techniques of our experiments are imported from the domain of close-up card magic, the purpose of the studies is more or less the opposite of what magicians usually want to achieve. In card magic, the performer must take great pains to ensure that the participants and the members of the audience are able to remember which card was initially chosen. Otherwise, when the act reaches its finale, they would simply be unable to notice that anything magical had taken place. But in our experiments the whole point is the participants not noticing the change.

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 notice when they ended up with Y. This is a result that ought to be surprising even to the most seasoned change blindness researcher.

However, the strongest evidence that choice blindness is a genuinely contra-intuitive phenomenon comes from the responses of the participants themselves. In the debriefing session after the experiment described above (see Johansson et al., 2005, Supporting Online Material) all participants were asked a series of increasingly specific questions to investigate whether they suspected in any way that something had gone wrong. Participants who revealed no signs of detection were then presented with a hypothetical scenario describing an experiment in which the faces they choose between are secretly switched (i.e. the very experiment they had just participated in), and asked whether they thought they would have noticed such a change. The result shows that, of the participants who failed to notice any of the manipulations, 84% believed that they *would* have been able to do so. Accordingly, many participants also showed considerable surprise, even disbelief at times, when we debriefed them about the true nature of the design. We call this effect *choice blindness blindness*; i.e. the overconfidence in our own ability to detect choice-manipulations (for a similar meta-cognitive error in relation to change blindness, see Levin et al., 2000).

## 2. Choice blindness for naturalistic decisions

Processing of faces is of great importance in everyday life (Rhodes, 2006; Bruce & Young, 1998). This suggests to us that choice blindness will generalize widely to other visual stimuli, and even across modalities. But we cannot rule out the possibility that there is something about the hypothesized “holistic” processing of human faces (e.g. Tanaka & Farah, 1993) that prevented our participants from properly categorizing and verbalizing the mismatch between their original choice and the manipu-

lated outcome. Moreover, while it is clear that lasting judgements of attractiveness for human faces can be made within a split second (Olson & Marshuetz, 2005; Willis & Todorov, 2006), it is possible that a less constrained procedure would have generated a different result.

For these reasons we were interested in investigating whether the phenomenon of choice blindness would extend to choices made in more naturalistic settings. The modern marketplace is an arena where the tug of explicit and implicit influences on the behaviour and opinions of consumers is played out in a particularly fierce manner (see Chartrand, 2005). As we see it, consumer choice is a perfect domain in which to test the choice blindness paradigm.

Recently, we have conducted two studies to begin to elucidate the phenomenon of choice blindness in this domain. In the first study we set up a sample stand at a local supermarket, where we invited customers to participate in a blind test of two paired varieties of jam and tea, and where we secretly reversed the choices when the participants made a second taste of their preferred alternative (Hall et al. submitted). In order to create a convincing covert exchange of the chosen samples, we created two sets of 'magical' jars, lidded at both ends, and with a divider inside. These jars thus looked like normal containers, but were designed to hold one variety of jam or tea at each end, and could easily be flipped over to execute a switch.

The results showed that no more than a third of all manipulation trials were detected by the participants. Even for such remarkably different tastes as spicy Cinnamon-Apple and bitter Grapefruit, or for the sweet smell of Mango and the pungent Pernod was less than half of all manipulation trials detected. In this study we also attempted to measure more indirect memory effects, but we found no differences in the rated difficulty to discriminate between the two samples in the non-detected manipulated trials as compared to the non-manipulated trials, and we found no effect of the undetected manipulated trials on the expressed confidence of the participants in their choice. In our view, it is a surprising and noteworthy finding that choice blindness seems to leave

so little implicit residue after the mismatched outcome has been presented 273

Secondly, we wanted to know whether choice blindness could be found for choices involving easily identifiable semantic attributes. In this study participants made hypothetical choices between two different apartments or mobile phones (Johansson et al., in preparation). The alternatives were presented two at a time on a PowerPoint slide, each represented by a simple drawing and 12 choice attributes, six of which were positive and six negative (e.g. for laptops: low price, short battery-life, etc ). After the participants had indicated their choice they now had to rate how important they thought each attribute had been for their decision. However, on some of the trials, a manipulation was introduced. When the choice slide was presented the second time for the rating task, two of the most important attributes were switched between the alternatives (i.e. if the first laptop originally had low price and short battery-life it now had high price and long battery-life). Remarkably, the great majority of these manipulations remained undetected. In addition, the rating task was strongly affected by the manipulation, showing that the post-choice rating of the influence of an attribute is determined by the perceived positive or negative value of that attribute *after* the choice, rather than an accurate introspective awareness of the actual importance of the attribute when the decision was made

An experimental finding like choice blindness is naturally bound at the limits by choices we know to be of great importance in everyday life. While it lies close at hand to speculate about couples at the altar solemnly affirming their choice of partner, and then (after the minister pulls some unearthly sleight-of-hand!) bringing home a complete stranger, no one would fail to notice such a change (and this, we hope, includes even those involved in the most hasty of Las Vegas marriages). Yet, there is ample of territory to explore between these small-scale consumer surveys and the preposterous idea of covert spouse swapping. It remains to be determined in future studies whether choice blindness extends to domains of more personal significance, such as moral decision judgement

274 and political opinions, where reasons more commonly are couched in a verbal format (e.g. Moore & Haggard, 2006, commenting on Johansson et al. 2006; see also the response by Hall et al., 2006).

### 3. Choice blindness and decision making research

To what extent is choice blindness something new and different in comparison with change blindness? Given that none of the studies described above were designed to address the neuro-cognitive underpinnings of choice and change blindness, it would be premature to offer any speculations as to 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 et al. (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; see also 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 & Noë, 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 (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 everyday choice, involving perfectly standard intentions (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 muddled in current theories of decision making and cognitive control. A conclusion to draw from this is that the relationship between intention and outcome may sometimes be far looser than current theorizing has suggested. As such, choice blindness warns of the dangers of aligning the technical concept of intention too closely with common sense.

Another key aspect of decision making research is the idea that people have stable and identifiable preferences that guide their choices between alternative outcomes. In all their variations and formulations, neoclassic economic theory, rational choice theory and expected utility theory share this view (Elster, 1986). To investigate this assumption we have recently utilized our choice blindness methodology to examine what happens

276 *after* the mismatched choice. In Hall et al. (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.

This result indicates that the perceived outcome of the choice (whether desired or not) enters prominently into the dynamics of preference formation, a finding that puts substantial pressure on expected utility models (see chapter 15) and rational choice theory (see also Ariely & Norton, 2008; Weber & Johnson, 2006). A further interesting point is that it might be the most quintessential features of economic choices that create the most troublesome dynamic effects. As Ariely (2008) have argued in his theory of coherent arbitrariness, when participants are influenced by arbitrary factors in their assessment of the utility of different goods (such as when participants are told to write down the last two digits of their social security number, and this then leads them to make wildly different anchors for how much they are willing to pay for a bottle of wine, see Ariely, Loewenstein, & Prelec, 2003), it might be the quantification *as such* that leads them to form further coherent preferences in the same domain of choice. In line with this, the results of Hall et al. (in preparation) showed that it was the concrete numerical judgement, where participants created a single salient rating to distinguish between the alternatives, that created the strongest preference change.

During the course of a normal day humans make countless choices: some slow and deliberate, some rapid and intuitive, some that carry only minor significance, and some that impact greatly on our lives. But for all the intimate familiarity we have with everyday decision making, it is very difficult to probe the representations underlying this process, or to determine what we can know about them from the “inside”, by reflection and introspection (Nisbett & Wilson, 1977; Jack & Roepstorff, 2004). Decades of work on human decision making, variably stressing either rational or irrational aspects of choice behaviour (Krueger & Funder, 2004), have yet to find a compelling method for studying the relationship between choice and introspection.

In Johansson et al. (2005), to solicit the introspective reasoning of the participants, we simply asked them to state why they chose the way they did. As Nisbett and Wilson (1977) remarked in their classic article on introspection: “In our daily life we answer many such questions about the cognitive processes underlying our choices, evaluations, judgments and behavior” (p. 231). Thus, for the non-manipulated trials we expected straightforward answers in reply. For the manipulated trials, on the other hand, the situation was very different. Here, we asked the participants to describe the reasons behind a choice they did not in fact make. Intuitively, it is difficult to envisage how one would respond to such an anomaly (i.e., we simply do not know what it is like to say why we prefer a particular picture, when we in fact we chose the opposite one). But based on common sense alone, one would suspect that the reports given for non-manipulated and manipulated trials would differ in many ways.

The two classes of reports were analysed on a number of different dimensions, such as the level of emotionality, specificity, and certainty expressed, but no substantial differences between manipulated and non-manipulated reports were found. In Johansson et al. (2006) we extended this methodology to include two additional forms of contrastive analysis:

278 relative word frequency and latent semantic analysis (see Kallionen & Sikström, chapter 11 in this book). Based on relevant research, such as automatic lie detection and language development, a large number of variables were compared for the manipulated and non-manipulated reports (examples include; filled and unfilled pauses, words marking uncertainty, specific and non-specific nouns, positive and negative adjectives, lexical density and diversity). Of the total 30 variables measured for the reports, only two variables registered as statistically different between the manipulated and non-manipulated reports. In latent semantic analyses, by analysing the contextual usage of words in a large corpus (i.e. a collection of text), a “semantic space” is constructed representing the relative distance between the words in the corpus. This space can in turn be used to calculate the difference between two other corpora. In our analyses, we found no difference between manipulated and non-manipulated reports. In contrast, large discrepancies were found between our male and female participants, both with latent semantic analyses and with several of the linguistic frequency variables. This shows that it is possible to detect differences in our corpus with the methods we have used, which gives strength to the overall conclusion that very few differences are to be found between manipulated and non-manipulated reports. As we see it, the lack of differentiation between the manipulated and non-manipulated reports casts doubt on the origin of the non-manipulated reports as well; confabulation could be seen to be the norm and truthful reporting something that needs to be argued for.

The analysis of Johansson et al. (2005) also established the extent to which a report could be matched to the picture originally chosen or to the manipulated outcome received – i.e. if the participants talked about the face they thought more attractive first or the one they ended up with after the switch was performed. The analysis of the verbal reports showed that that the participants sometimes referred to unique properties of the initially non-preferred face. This allowed us to show, unequivocally, that normal participants may produce confabulatory reports when asked to describe the reasons behind their choices (something previously only

demonstrated for clinical populations, or in retrospective memory paradigms, see Schnider 2003; Loftus 2003). But more importantly, this result contains a seed of systematicity for the study of choice and subjective report. The possibility of detailing the properties of confabulation that choice blindness affords, gives us an increased toehold in the quest to understand all possible forms of report. Without the benefit of good contrast cases to work from, discussions of the possibility of confabulatory *or* truthful reporting in normal human populations become incredibly difficult to conduct. We are all familiar with cases in which people make elaborate justifications for their decisions, but we have good reason to believe this is not what actually drives their actions. They might genuinely believe that the rationales given are what made them act the way they did, but for onlooker it is not hard to see that something is wrong. But to provide enough evidence for such a person to *change their mind* is an entirely different matter.

However, using the methodology of choice blindness we are now in a position to confront our participants with the plain and clear mismatch between their statements and their original choice, and use this as a springboard to re-evaluate their metacognitive belief about their own habits of choice and reasoning (as we indeed have done in an informal manner in the post-test interviews of our previous studies). In addition, using this methodology, we can target what might be called the “micro-culture” of introspection. In a conversation there are always a great number of tacit rules that influence what is being said: the relative social status of participants, the formality of the situation, concerns about the relevance of what is being said, etc. (Brown & Yule, 1983; Sperber & Wilson, 1995). By varying stimulus dimensions like these within the body of statements, large-scale systematic comparisons between reports will become possible (both hypothesis-based and of a more data-driven nature). It is our belief that this will allow us to find patterns of reporting that will enable us to say something about the general properties of introspective reports, something no other current method is able to reveal.

## 5. Conclusion

We have made an argument that the choice blindness paradigm can be seen as a general research tool to study decision making and introspection. 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 change 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. As a general method of investigation choice blindness elevates inert hypothetical statements to powerful covert counterfactuals (i.e. from what we think would have happened if we had chosen otherwise, to what actually happens when we get what we did not choose). Instead of just focusing on various influences leading up to the point of decision or post-processing of satisfaction, choice blindness targets the goals and desires themselves. In our view, this “wedge” between decision and outcome affords a unique way to estimate the representational and introspective detail of the choices people make.

### REFERENCES

- Ariely, D. (2008). *Predictably irrational: The hidden forces that shape our decisions*. New York: Harper Collins.
- Ariely, D., Loewenstein, G., & Prelec, D. (2003). Coherent arbitrariness: Stable demand curves without stable preferences. *Quarterly Journal of Economics*, 118, 73–105.
- Ariely, D., & Norton, M. (2008). How actions create – not just reveal – preferences. *Trends in Cognitive Sciences*, 10(1), 13–16.
- Beck, M. R. & Levin, D. T. (2003). The role of representational volatility in recognizing pre- and postchange objects. *Perception and Psychophysics*, 65(3), 458–468.
- Blackmore, S. (2002). There is no stream of consciousness. *Journal of Consciousness Studies*, 9, 17–28.
- Brooks, R. A. (1991). Intelligence without representation. *Artificial Intelligence*, 47,139–159.

- Brown, G. & Yule, G. (1983). *Discourse analysis*. Cambridge: Cambridge University Press. 281
- Bruce, V., & Young, A. (1998). *In the eye of the beholder: The science of face perception*. Oxford: Oxford University Press.
- Chartrand, T. L. (2005). The role of conscious awareness in consumer behavior. *Journal of Consumer Psychology*, 15(3), 203–210.
- Elster, J. (ed.) (1986). *Rational Choice*. Washington Square, NY: New York University Press.
- Grimes, J. (1996). On the failure to detect changes in scenes across saccades. In K. Akins (Ed.), *Vancouver Studies in Cognitive Science: Perception* (Vol. 2, pp. 89–110). New York: Oxford University Press.
- Haggard, P. (2005). Conscious intention and motor control. *Trends in Cognitive Sciences*, 9, 290–295.
- Hall, L., Johansson, P., Sikström, S., Tärning, B. & Lind, A. (2006). How something can be said about Telling More Than We Can Know: Reply to Moore and Haggard. *Consciousness and Cognition*, 15(4), 697–699.
- Hall, L., Johansson, P., Tärning, B., & Sikström, S. (in preparation). *Choice Blindness and Preference Change*.
- Hall, L., Johansson, P., Tärning, B., & Sikström, S. (in preparation). *Preference Change Through Choice*
- Hall, L., Johansson, P., Tärning, B., Sikström, S., & Deutgen, T. (submitted). *Magic at the Marketplace: Choice blindness for the taste of jam and the smell of tea*.
- Hollingworth, A. (2003). Failures of retrieval and comparison constrain change detection in natural scenes. *Journal of Experimental Psychology: Human Perception and Performance*, 29, 388–403.
- Jack A. I., & Roepstorff, A. (2004). Trusting the subject II. *Journal of Consciousness Studies*, 11, 7–8.
- Johansson, P., Hall, L., & Sikström, S. (in press). From change blindness to choice blindness. *Psychologia*.
- Johansson, P., Hall, L., Sikström, S., & Olsson, A. (2005). Failure to Detect Mismatches Between Intention and Outcome in a Simple Decision Task. *Science*, 310, 116–119.
- Johansson, P., Hall, L., Sikström, S., Tärning, B. & Lind, A. (2006). How something can be said about Telling More Than We Can Know, *Consciousness and Cognition*, 15(4), 673–692.
- Johansson, P., Hall, L., Yamaguchi, Y. Ogawa, H., Watanabe, K. (in preparation). *The ambiguity of introspection: Choice blindness and consumer decision making*

- 282 Krueger, J. I., & Funder, D. C. (2004). Towards a balanced social psychology: Causes, consequences and cures for the problem-seeking approach to social behaviour and cognition. *Behavioral and Brain Sciences*, 27, 313–376.
- Levin, D. T., Momen, N., Drivdahl, S. B., & Simons, D. J. (2000). Change blindness blindness: The metacognitive error of overestimating change-detection ability. *Visual Cognition*, 7, 397–412.
- Levin, D. T., Simons, D. J., Angelone, B. L., & Chabris, C. F. (2002). Memory for centrally attended changing objects in an incidental real-world change detection paradigm. *British Journal of Psychology*, 93, 289–302.
- Loftus, E. (2003). Our changeable memories: Legal and practical implications. *Nature Reviews Neuroscience*, 4, 231–234.
- Moore, J. W., & Haggard, P. (2006). Commentary on “How Something Can Be Said About Telling More Than We Can Know: On Choice Blindness and Introspection”. *Consciousness and Cognition*, 15(4), 693–696.
- Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, 84, 231–259.
- Noë, A. (Ed.). (2002). *Is the visual world a grand illusion?* Thorverton: Imprint Academic.
- Olsson, I. R., & Marshuetz, C. (2005). Facial attractiveness is appraised in a glance. *Emotion*, 5(4), 498–502.
- O’Regan, J. K., & Noë, A. (2002). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences*, 24(5), 939–1011.
- O’Regan, J. K., Rensink, R. A. & Clark, J. J. (1999). Change-blindness as a result of “mudsplashes”. *Nature*, 398, 34.
- Rensink, R. A. (2000). Visual search for change: A probe into the nature of attentional processing. *Visual Cognition*, 7, 345–376.
- Rensink, R. A. (2002). Change detection. *Annual Review of Psychology*, 53, 245–277.
- Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annual Review of Psychology*, 57, 199–226.
- Schnider, A. (2003). Spontaneous confabulation and the adaptation of thought to ongoing reality. *Nature Reviews Neuroscience*, 4, 662–671.
- Simons, D. J. 2000. Current approaches to change blindness. *Visual Cognition*, 7, 1–15.
- Simons, D. J., & Rensink, R. A. (2005). Change blindness: Past, present and future. *Trends in Cognitive Sciences*, 9, 16–20.
- Simons, D. J., & Silverman, M. (2004). Neural and behavioral measures of

- change detection. In L. M. Chalupa & J. S. Werner (Eds.), *The Visual Neurosciences* (pp. 1524–1537). Cambridge, MA: MIT Press.
- Simons, D. J., & Levin, D. T. (1998). Failure to detect changes to people during a real-world interaction. *Psychonomic Bulletin and Review*, 5, 644–649.
- Sirigu, A., Daprati, E., Ciancia, S., Giraux, P., Nighoghossian, N., Posada, A., & Haggard, P. 2004. Altered awareness of voluntary action after damage to the parietal cortex. *Nature Neuroscience*, 7, 80–84.
- Sperber, D., & Wilson, D. (1995). *Relevance: Communication and cognition* (2nd ed.) Oxford: Blackwell.
- Tanaka, J. W., & Farah, M. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology*, 46, 225–245.
- Triesch, J., Ballard, D., Hayhoe, M., & Sullivan, B. (2003). What you see is what you need. *Journal of Vision*, 3, 86–94.
- Weber, E. U. & Johnson, E. J. (2006). Constructing preferences from memory. In P. Slovic, & S. Lichtenstein (Eds.). *The Construction of Preference* (pp. 397–410). New York, NY: Cambridge University Press.
- Willis, J., & Todorov, A. (2006). First impressions: Making up your mind after a 100-ms exposure to a face. *Psychological Science*, 17(7), 592–598.