Psychological Science OnlineFirst, published on January 6, 2015 as doi:10.1177/0956797614560648

Research Article

Psychological Science
1–8

DOI: 10.1177/0956797614560648
pss.sagepub.com

Amnesia for Object Attributes: Failure to Report Attended Information That Had Just Reached Conscious Awareness

Hui Chen and Brad Wyble
The Pennsylvania State University

Abstract

People intuitively believe that when they become consciously aware of a visual stimulus, they will be able to remember it and immediately report it. The present study provides a series of striking demonstrations of behavior that is inconsistent with such an intuition. Four experiments showed that in certain conditions, participants could not report an attribute (e.g., letter identity) of a stimulus even when that attribute had been attended and had reached a full state of conscious awareness just prior to being questioned about it. We term this effect *attribute amnesia*, and it occurs when participants repeatedly locate a target using one attribute and are then unexpectedly asked to report that attribute. This discovery suggests that attention to and awareness of a stimulus attribute are insufficient to ensure its immediate reportability. These results imply that when attention is configured by using an attribute for target selection, that attribute will not necessarily be remembered.

Keywords

attribute amnesia, awareness, attention, working memory, open data

Received 4/18/14; Revision accepted 10/28/14

Although people experience a rich, detailed visual world, the memory traces that they form are quite fragmented, as shown by two striking phenomena: *inattentional blindness* and *change blindness*. Inattentional blindness occurs when neurologically normal people are incapable of detecting an unexpected, clearly visible stimulus that appears in the visual field (e.g., Mack & Rock, 1998; Most, Scholl, Clifford, & Simons, 2005; Most et al., 2001; Neisser & Becklen, 1975; Scholl, Noles, Pasheva, & Sussman, 2003; Simons & Chabris, 1999). For instance, in one study, many participants failed to notice that a person wearing a gorilla suit unexpectedly walked across the scene in a short video (Simons & Chabris, 1999). Change blindness refers to findings that people are poor at detecting large changes in a visual image or a scenario, such as a real-life conversation (e.g., Mitroff, Simons, & Levin, 2004; Rensink, O'Regan, & Clark, 1997; Scholl, 2000; Simons & Levin, 1998; Simons & Rensink, 2005).

These effects indicate a failure to notice something (an unexpected stimulus or a change) that should otherwise be easy to perceive. They are of critical importance, not only because they violate people's intuitions about memory (Simons & Chabris, 2011), but also because they have fundamentally changed researchers' understanding of how the mind interacts with the world.

The Distinction Between Blindness and Amnesia

These effects are described as "blindness" (i.e., a failure to perceive; Mack & Rock, 1998) and set the stage for examining the distinction between what is visible to the eye and what is stored in memory. For example, researchers have explored the possibility that stimuli may be consciously perceived at one moment yet fail to produce a memory trace that can be reported. This putative phenomenon has been described as amnesia (Moore & Egeth, 1997; Wolfe, 1999),[1] but no evidence has yet directly confirmed this amnesia hypothesis, despite some

Corresponding Author:
Hui Chen, Department of Psychology, The Pennsylvania State University, University Park, PA 16802
E-mail: psychenhui@gmail.com

observations that indirectly support it. For example, Moore and Egeth (1997) found that unreportable stimuli influence perception, but it is not clear that participants were aware of those stimuli.

In the present study, we attempted a more direct demonstration of such amnesia by investigating whether people can fail to report even an attribute of a stimulus that had reached awareness. We define an attribute as any aspect (e.g., color, identity) of a stimulus, as suggested by Kanwisher and Driver (1992). We begin by differentiating two levels of conscious awareness (see Block, 1996; Lamme, 2004): *phenomenal awareness*, in which some stimuli are perceived in the background without being the focus of attention, and *access awareness*, in which stimuli that are perceived are the focus of attention.

It is easily demonstrated that participants may not be able to report individual stimuli that reach only phenomenal awareness, as exemplified in classic experiments involving iconic memory and rapid presentation. Specifically, when the visual system is overloaded with information, participants have phenomenal awareness of many stimuli but have difficulty recognizing or reporting them in a subsequent test (Coltheart, 1980; Potter, 1976; Sperling, 1960).

Conversely, information that is attended and reaches an access level of awareness is assumed to be reportable (e.g., Lamme, 2004). However, whether this assumption must be true remains unknown. In other words, if a person becomes aware of an attended attribute of a visible stimulus, will he or she necessarily be able to report that attribute immediately? A finding that participants were unable to immediately report a stimulus that had reached access awareness would constitute evidence of amnesia. This logic leads to our present study. Henceforth, we use the terms *awareness* and *conscious perception* interchangeably to refer to access awareness.

The Present Study

We have discovered a method to reliably induce neurologically normal participants to be aware of a stimulus attribute (e.g., color) and yet unable immediately afterward to report it in a surprise memory test, similar to the tests used in studies of inattentional blindness (e.g., Rock, Linnett, Grant, & Mack, 1992). In four experiments, participants were required to report the location of the target (e.g., a letter) among a set of three distractors (e.g., numbers) during multiple presurprise trials. The critical attribute used to locate the target varied across the experiments (i.e., a letter among numbers in Experiments 1a, 1b, and 4, an even number among odd numbers or vice versa in Experiment 2, and a colored letter among black letters in Experiment 3). Then, on one surprise trial, respondents were unexpectedly asked to report the critical attribute of the target (e.g., identity in Experiment 1a) and a task-irrelevant attribute of the target (e.g., color in Experiment 1a; note that there was no task-irrelevant attribute in Experiment 3) by choosing the target attribute from among distractor attributes in forced-choice arrays. Respondents' inability to recognize the critical attribute would suggest that they had been aware of it but could not remember it—*attribute amnesia*. Note that this paradigm allows only one surprise trial per participant, because once a participant has experienced a surprise test trial, he or she is much more likely to remember all attributes of the target. We demonstrated this by including in our paradigm four additional control trials (after the surprise trial) in which participants were again asked to report the same attributes that had been queried in the surprise trial. Using this method, we demonstrated that participants could select a target from a set of three distractors and yet be unable to report all of its attributes, including even the critical attribute that they had just used to find the target less than a second before.

For all experiments, we used a predetermined sample size of 20 participants. This sample size was based on pilot work that indicated the magnitude of the effect that could be expected. A different set of participants was used for each experiment. Participants were all Pennsylvania State University undergraduates and received course credit in exchange for participation. All of them reported normal or corrected-to-normal visual acuity. No participants were excluded or replaced in any of these experiments.

Experiment 1a

In the first experiment, using a modification of the surprise test used by Rock et al. (1992), we investigated whether participants could report the attributes of a consciously perceived object.

Method

Apparatus. Stimuli were presented on a 17-in. CRT computer monitor with screen dimensions of 1,024 × 768 pixels. Participants viewed the screen from approximately 50 cm away and entered responses via a computer keyboard. The experiment was programmed by using MATLAB (The MathWorks, Natick, MA) with the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997).

Stimuli and procedure. As shown in Figure 1, each trial began with a black fixation cross (0.62° of visual angle in size) centered among four black placeholder circles (0.62°) on a medium-gray background. The four placeholders were located at the four corners of an

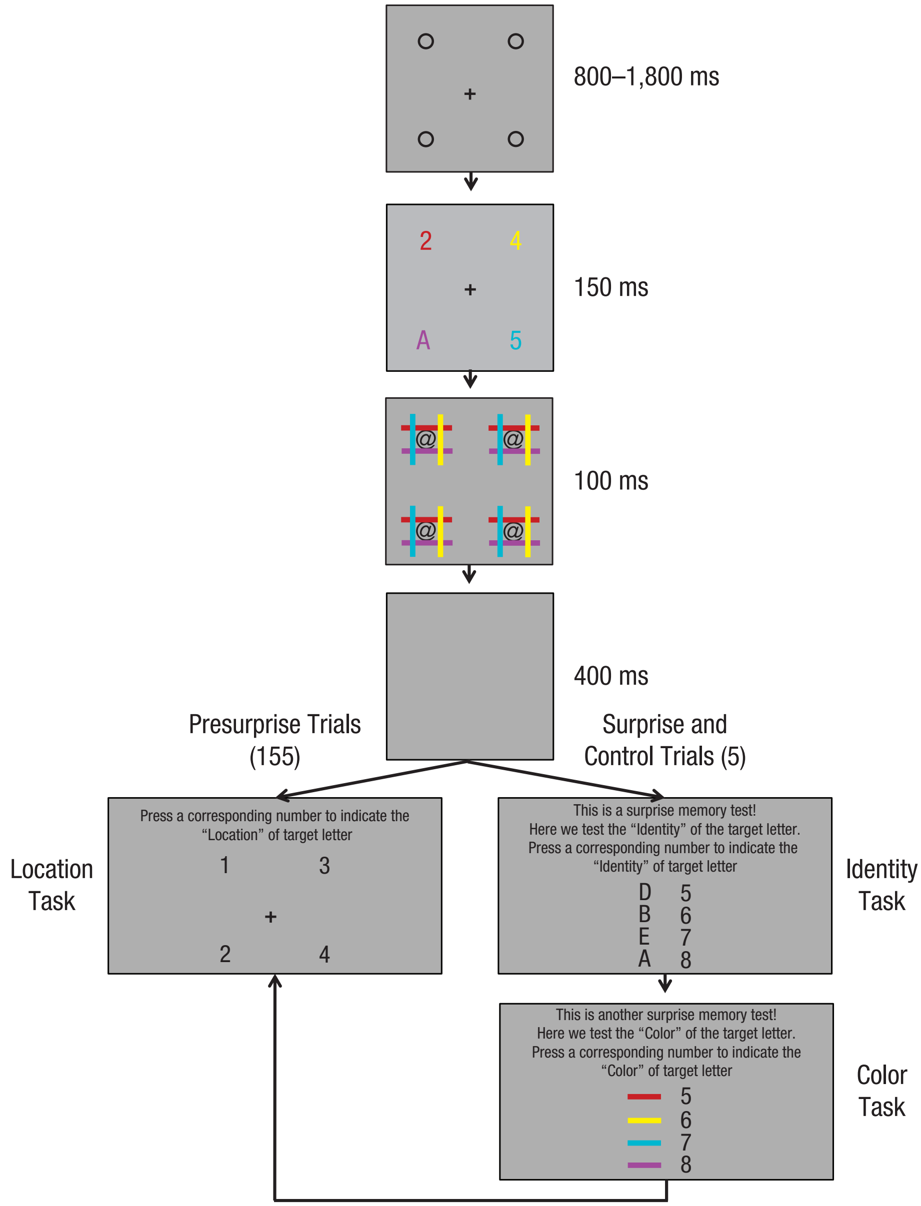

Fig. 1. Sample trial sequences in Experiment 1a. Each trial began with a black fixation cross and four black placeholder circles on a gray background. This display was followed by a stimulus array consisting of a target letter and three distractors (Arabic numbers), each randomly assigned one of four colors. The stimuli were then masked, and the screen went blank. Finally, on presurprise trials, participants were asked to report the location of the target. In the surprise trial, before the location question was presented, there was a surprise test of memory for the target's identity and color. Note that stimuli are depicted larger than their true scale for the purpose of illustration. Participants each completed 160 trials in this experiment. The first 155 trials proceeded as just described. On the 156th trial (i.e., the surprise trial), participants were unexpectedly presented with two forced-choice questions. They were asked to indicate which of four black letters presented on the screen was the target letter (identity task) and which of four colored lines matched the color of the target letter (color task). The order of the identity and color tasks was counterbalanced across participants. The four possible responses for each question (i.e., four black letters or four colored lines) were presented in random order. The surprise trial concluded with the location task. Following the surprise trial, participants performed four control trials that were in the same format as the surprise trial.

invisible square (6.25° × 6.25°) centered on the screen. After a variable duration (800–1,800 ms), the stimulus array was presented for 150 ms. The stimulus array included a target (a letter from the Latin alphabet: *A, B, D*, or *E*; 0.86° × 0.62°) and three distractors (Arabic numbers: 2–5; 0.86° × 0.62°). Each stimulus was a different color, which was randomly assigned: red, blue, yellow, or magenta. A mask then appeared for 100 ms. The mask consisted of a black "@" and a hash-mark pattern of four colored lines, one of each of the four colors (i.e., red, blue, yellow, and magenta; see Fig. 1). The mask was followed by a 400-ms blank screen. Finally, four black numbers (1–4) were presented at the locations of the four placeholders; these numbers remained on-screen until participants reported the location of the letter by pressing the corresponding number key ("1", "2," "3," or "4"; location task).

Results

On the presurprise trials, 89% of responses in the location task were correct, which indicates that participants could easily locate the target by using the critical attribute. To analyze the data from the surprise trial, we first divided participants into two groups defined by the order of the surprise tasks (identity task first vs. color task first). We found that the results were almost the same in these two groups. Accordingly, we combined the data for these groups in the analyses reported here. Only 6 of 20 (30%) participants correctly reported the color of the target letter, which is not much better than chance level of 25% (because there were four choices). Furthermore, performance on the identity task (25% correct) was exactly at chance level. These results demonstrate that participants were not capable of reporting a task-relevant attribute of a stimulus that had reached awareness less than 1 s before (i.e., attribute amnesia). Moreover, in the surprise trial, participants' performance on the location task, unlike their performance on the color and identity tasks, was good (80% correct), and in fact was approximately as good as their performance on the location task in the presurprise trials (89% correct). This indicates that the poor performance on the color and identity tasks was not induced by the surprise test itself; it more likely reflects participants' failure to remember these attributes.

Participants exhibited a dramatic increase in reporting accuracy for the target letter's color (70% correct) and identity (75% correct) on the first control trial (i.e., the trial immediately after the surprise trial). The improvement in each case was significant—color: 70% versus 30%, $\chi^2(1, N = 40) = 6.40$, $p = .011$, $\varphi = .40$; identity: 75% versus 25%, $\chi^2(1, N = 40) = 10.00$, $p < .005$, $\varphi = .50$. Performance on these two tasks remained constant on the final three control trials (color: 75%, 70%, and 80% correct; identity: 75%, 80%, and 75% correct). Participants' performance on the location task was almost the same on the surprise trial (80% correct) as on the control trials (80%, 85%, 80%, and 70% correct). These results indicate a crucial role for expectation in controlling participants' ability to report the attributes of a consciously perceived object. Therefore, Experiment 1a showed that when participants did not expect to report a particular attribute of an attended object, they were incapable of doing so, even when that same attribute had reached awareness immediately prior to the test.

Experiment 1b

To test whether these results could be obtained when the stimuli were clearly visible, we replicated this design with a longer stimulus duration and without poststimulus masks.

Method

This experiment was identical to Experiment 1a except that the duration of the stimulus array was increased from 150 ms to 250 ms and the masks were not used.

Results

The results of this experiment were essentially the same as those of Experiment 1a. As in Experiment 1a, we found that the results were almost the same in the two groups (i.e., identity task first vs. color task first). Accordingly, we combined the data for these groups in the analyses reported here. Participants were poor at reporting both the target's color (30% correct) and its identity (30% correct) on the surprise trial, but their performance on these tasks increased dramatically on the control trials (color: 75%, 100%, 100%, and 100% correct; identity: 80%, 90%, 90%, and 95% correct). As in Experiment 1a, these improvements were highly significant on the first control trial—color: 75% versus 30%, $\chi^2(1, N = 40) = 8.120$, $p = .004$, $\varphi = .45$; identity: 80% versus 30%, $\chi^2(1, N = 40) = 10.101$, $p = .001$, $\varphi = .50$. Performance on the location task was high on both the presurprise trials (96% correct) and the control trials (65%, 85%, 95%, and 85% correct). However, unlike in Experiment 1a, performance on the location task dropped on the surprise trial (50% correct) compared with the presurprise trials. These findings essentially replicate those of Experiment 1a and demonstrate that the failure to report the task-relevant attribute can occur even when the duration of stimulus presentation is extended to 250 ms and the stimulus display is not masked.

Experiment 2

It could be argued that participants in Experiment 1a located the target by category, without resolving its identity. We think that this is highly unlikely, given the lengthy display duration and the use of easily discriminated stimuli. However, to increase our confidence that participants were momentarily aware of the identity of the target, in

Experiment 2 we asked participants to detect either an odd number among even numbers or vice versa. It has been well documented that adult participants automatically access meaning (i.e., identity) of numbers during the parity task (e.g., Dehaene, Bossini, & Giraux, 1993; Fias, Brysbaert, Geypens, & d'Ydewalle, 1996; Reynvoet & Brysbaert, 1999).

Method

This experiment was very similar to Experiment 1a, with the following exceptions. Half of the participants were required to locate a colored even number (*12, 14, 16*, or *18*) presented among three different-colored odd numbers (*13, 15, 17*, or *19*), and the other half were asked to locate a colored odd number among three different-colored even numbers. In addition, because a pilot experiment showed that this location task was much more difficult than that in Experiment 1a, we increased the duration of the stimulus array from 150 ms to 250 ms to ensure that participants could become aware of the target and then correctly locate it.

Results

The results of this experiment were essentially the same as those of Experiment 1a. As in Experiment 1a, we found that the results were almost the same in the two groups (i.e., identity task first vs. color task first). Accordingly, we combined the data for these groups in the analyses reported here. Participants performed poorly on both the color task (40% correct) and the identity task (30% correct) on the surprise trial, but their performance increased dramatically by the second control trial (color: 30%, 80%, 90%, and 80% correct on the first, second, third, and fourth control trials, respectively; identity: 65%, 75%, 90%, and 80% correct). Location-task performance was high on presurprise trials (80% correct) and on the surprise trial (70% correct), as well as on control trials (70%, 85%, 100%, and 85% correct). As in Experiment 1a, performance on the identity task improved significantly on the first control trial relative to the surprise trial (65% vs. 30%), $\chi^2(1, N = 40) = 4.912$, $p = .027$, $\varphi = .35$. However, the increase in color-report accuracy began with the second, rather than the first, control trial (80% vs. 40%), $\chi^2(1, N = 40) = 6.667$, $p < .01$, $\varphi = .41$. This experiment replicated the findings of Experiment 1a and provided an even stronger demonstration of attribute amnesia for an identified stimulus.

Experiment 3

Next, we explored the boundary conditions of this amnesia effect by determining whether it held for a highly salient feature: a pop-out color.

Method

Experiment 3 was similar to Experiment 1a, with the following changes. There were 15 possible target letters (*A, B, C, D, F, H, J, K, L, N, P, R, T, V*, and *X*), and each target was presented in one of the four colors. The distractors were chosen from the same set of letters and were presented in black. No letters were repeated on a trial. On each trial, one colored letter and three black letters appeared. The participants were asked to locate the nonblack target letter on the first 155 trials. On the surprise trial, the surprise test (before the location task) asked only for the color of the target letter. As in the previous experiments, color was also queried in four subsequent control trials.

Results

We replicated the findings of Experiment 1a. Participants were generally unable to report the color of the target letter on the surprise trial (35% correct), even though the color was a highly salient feature that defined the target. As in Experiment 1a, color-task performance increased dramatically on the first control trial (95% correct) and was significantly better on that trial than on the surprise trial (95% vs. 35% correct), $\chi^2(1, N = 40) = 15.824$, $p < .001$, $\varphi = .63$. Performance remained stable on the following three control trials (95%, 100%, and 100% correct).

Participants' accuracy on the location task was close to ceiling (98% correct) on the presurprise trials, which indicates that the color of the targets was highly salient, and it was very easy for participants to use this pop-out feature to locate the target. More important, as in Experiment 1a, location-task accuracy on the surprise trial (80% correct) was also quite high, which suggests that the surprise test itself did not result in a clearing of the contents of working memory. Location-task accuracy on the four control trials was also high (100%, 95%, 95%, and 95% correct). The results of this experiment thus demonstrate that attribute amnesia can hold even for a highly salient, task-relevant feature. Note that subjects might have located the pop-out stimulus using a feature gradient; however, we view this as unlikely given the presentation conditions.

Experiment 4

Participants performed a large number of trials before the surprise trial in the preceding experiments. In Experiment 4, we explored whether attribute amnesia occurs without such a long sequence of trials prior to the surprise trial.

Method

This experiment was identical to Experiment 1a except that there were only 11 trials before the surprise trial (i.e., a total of 16 trials).

Results

The results were similar to those of Experiment 1a. As in Experiment 1a, we found that the results were almost the same in the two groups (i.e., identity task first vs. color task first). Accordingly, we combined the data for these groups in the analyses reported here. On the surprise trial, participants exhibited attribute amnesia on both the color task (25% correct) and the identity task (35% correct). Furthermore, performance on these tasks improved considerably on the control trials (color: 60%, 65%, 75%, and 85% correct; identity: 65%, 60%, 80%, and 85% correct). The increase in color-task performance was significant on the first control trial (60% vs. 25%), $\chi^2(1, N = 40) = 5.013$, $p = .025$, $\varphi = .35$; the increase in identity-task performance was marginally significant on the first two control trials and highly significant by the third control trial (80% vs. 35%), $\chi^2(1, N = 40) = 8.286$, $p < .005$, $\varphi = .46$. As in the previous experiments, location-task performance was similar across the presurprise trials (76% correct), surprise trial (70% correct), and control trials (60%, 70%, 90%, and 70% correct). The results of this experiment demonstrated that attribute amnesia, like inattentional blindness, does not require a prolonged series of trials before the surprise trial, although whether attribute amnesia would occur on the very first trial remains an open question.

Discussion

These experiments provided converging evidence that participants could not report an attribute of an attended object when they did not expect to report it, even when the attribute had reached awareness shortly before. Furthermore, participants could accurately report these same attributes once they expected that they would be asked to do so.

Are awareness and attention sufficient for immediate report?

Existing studies show that attention to an object is not sufficient for detection of changes to that object (Levin & Simons, 1997; Simons & Levin, 1998) or ability to report its irrelevant attributes (Eitam, Yeshurun, & Hassan, 2013). However, these findings leave open the question of whether awareness of an attended attribute is sufficient for it to be remembered for immediate report. This is the core question addressed by the amnesia hypothesis, which holds that people's inability to report a stimulus does not necessarily mean that they have not consciously perceived that stimulus (Moore, 2001; Moore & Egeth, 1997; Wolfe, 1999). There is, however, only indirect support for such amnesia. For example, Moore and Egeth (1997) found that unreportable stimuli in the background could influence participants' performance on the primary task (e.g., line-length report), but this study did not address whether the unreportable stimuli were consciously perceived. Also, Wolfe and his colleagues (Wolfe, 1999; Wolfe, Klempen, & Dahlen, 2000; Wolfe, Reinecke, & Brawn, 2006) found that repeating a search display produced no improvement in search efficiency, a result that appears to favor the amnesia hypothesis. However, when participants were asked to list the stimuli in the repeated display, they could do so. Thus, these studies could be interpreted as evidence that participants remembered the repeated items but could not use such memory to improve their visual search.

To our knowledge, the present study provides the first evidence directly supporting the amnesia hypothesis by showing a failure to report an attended attribute that had reached a full level of awareness right before the test. Two lines of evidence indicate that the unreportable attribute had reached awareness. First, the attribute was attended, and participants could use it to discriminate between the target and distractors to produce highly accurate location judgments. This finding is in accord with popular definitions of awareness by Lamme (2004) and Holender (1986). Second, the stimuli appeared on the screen for 150 to 250 ms, which is much longer than the suggested threshold for awareness (50 ms; see Del Cul, Baillet, & Dehaene, 2007). Note that we are arguing that the attended attributes had reached awareness in our particular paradigm, not that an attended attribute must reach awareness in all cases.

Thus, our results suggest that directing attention toward a stimulus attribute and being aware of it are not sufficient to ensure its reportability immediately afterward. This implies that some demonstrations of inattentional blindness (but certainly not all) might not necessarily reflect a failure of conscious perception.

How is attentional set defined by a task?

There is a rich history of attentional-set studies showing that the expectations of participants affect how well they will report information (e.g., Gross, 1959; Haber, 1966; Long, Toppino, & Mondin, 1992). The attentional set in visual-attention studies can be described as having two components: a *key attribute* and a *response attribute* (Botella, Barriopedro, & Suero, 2001; or as termed by Remington & Folk, 2001, *defining feature* and *reported dimension*). The term *key attribute* refers to target-defining information, and the term *response attribute* refers to information that should be reported. For instance, participants whose task is to report the identity of a colored letter presented among black letters would have a key attribute of color and a response attribute of letter identity. Presumably, when an object has been selected by using a key attribute, its response attribute is stored in a relatively durable memory trace that persists across multiple cognitive events, whereas the key attribute is not well encoded. The study reported here demonstrates this distinction by showing that participants reported key attributes poorly and response attributes accurately.

One possible explanation is that in our experiments, the key attributes were encoded in a fragile form of memory (Sligte, Scholte, & Lamme, 2008). Such information could have been momentarily encoded and then forgotten during the process of reading the surprise question. However, it is also true that memory for location typically did persist through the surprise tasks, which demonstrates a difference in the durability of memory for key and response attributes. More sensitive measures (Hoffman, Bein, & Maril, 2011) could be useful for exploring in greater detail the extent to which key attributes are stored in memory.

In conclusion, these results show that attending to a specific piece of information is insufficient to produce a memory trace for that information. We suggest that attentional sets can be configured separately for attributes that define targets and attributes that define information to be remembered. Moreover, these results suggest that the processes governing access to working memory exhibit sharp delineations between information that is relevant and irrelevant to participants' goals.

Author Contributions

H. Chen and B. Wyble developed the study concept. H. Chen performed the programming, data collection, analysis, and most of the writing. B. Wyble assisted with the writing and editing. Both authors approved the final version of the manuscript for submission.

Acknowledgments

We thank Mary C. Potter, Karen Gasper, Richard Carlson, and Brian Scholl for helpful advice.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

This project was supported by National Science Foundation Grant BCS-1331073.

Open Practices

All data have been made publicly available via Databrary and can be accessed at https://nyu.databrary.org/volume/79. The complete Open Practices Disclosure for this article can be found at http://pss.sagepub.com/content/by/supplemental-data. This article has received the badge for Open Data. More information about the Open Practices badges can be found at https://osf.io/tvyxz/wiki/view/ and http://pss.sagepub.com/content/25/1/3.full.

Note

1. Moore and Egeth (1997) suggested that inattentional blindness might reflect a failure to remember a perceived stimulus (which may not reach awareness). This phenomenon was termed inattentional amnesia by Wolfe (1999), who suggested that even stimuli reaching full awareness might not be remembered.

References

Block, N. (1996). How not to find the neural correlate of consciousness. In A. O'Hear (Ed.), *Current issues in philosophy of mind* (pp. 23–34). Cambridge, England: Royal Institute of Philosophy. doi:10.1017/CBO9780511563744.003

Botella, J., Barriopedro, M., & Suero, M. (2001). A model of the formation of illusory conjunctions in the time domain. *Journal of Experimental Psychology: Human Perception and Performance*, *27*, 1452–1467.

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision*, *10*, 433–436.

Coltheart, M. (1980). Iconic memory and visible persistence. *Perception & Psychophysics*, *27*, 183–228.

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. *Journal of Experimental Psychology: General*, *122*, 371–396.

Del Cul, A., Baillet, S., & Dehaene, S. (2007). Brain dynamics underlying the nonlinear threshold for access to consciousness. *PLoS Biology*, *5*(10), Article e260. Retrieved from http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0050260

Eitam, B., Yeshurun, Y., & Hassan, K. (2013). Blinded by irrelevance: Pure irrelevance induced "blindness." *Journal of Experimental Psychology: Human Perception and Performance*, *39*, 611–615.

Fias, W., Brysbaert, M., Geypens, F., & d'Ydewalle, G. (1996). The importance of magnitude information in numerical processing: Evidence from the SNARC effect. *Mathematical Cognition*, *2*, 95–110.

Gross, F. (1959). The role of set in perception of the upright. *Journal of Personality*, *27*, 95–103.

Haber, R. N. (1966). Nature of the effect of set on perception. *Psychological Review*, *73*, 335–351.

Hoffman, Y., Bein, O., & Maril, A. (2011). Explicit memory for unattended words: The importance of being in the "no." *Psychological Science*, *22*, 1490–1493.

Holender, D. (1986). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *Behavioral & Brain Sciences*, *9*, 1–23.

Kanwisher, N., & Driver, J. (1992). Objects, attributes, and visual attention: Which, what, and where. *Current Directions in Psychological Science*, *1*, 26–31.

Lamme, V. A. F. (2004). Separate neural definitions of visual consciousness and visual attention; a case for phenomenal awareness. *Neural Networks*, *17*, 861–872.

Levin, D. T., & Simons, D. J. (1997). Failure to detect changes to attended objects in motion pictures. *Psychonomic Bulletin & Review*, *4*, 501–506.

Long, G. M., Toppino, T. C., & Mondin, G. W. (1992). Prime time: Fatigue and set effects in the perception of reversible figures. *Perception & Psychophysics*, *52*, 609–616.

Mack, A., & Rock, I. (1998). *Inattentional blindness*. Cambridge, MA: MIT Press.

Mitroff, S. R., Simons, D. J., & Levin, D. T. (2004). Nothing compares 2 views: Change blindness can occur despite preserved access to the changed information. *Perception & Psychophysics*, *66*, 1268–1281.

Moore, C. M. (2001). Inattentional blindness: Perception or memory and what does it matter. *Psyche*, *7*. Retrieved from http://www.theassc.org/files/assc/2496.pdf

Moore, C. M., & Egeth, H. (1997). Perception without attention: Evidence of grouping under conditions of inattention. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 339–352.

Most, S. B., Scholl, B. J., Clifford, E. R., & Simons, D. J. (2005). What you see is what you set: Sustained inattentional blindness and the capture of awareness. *Psychological Review*, *112*, 217–242.

Most, S. B., Simons, D. J., Scholl, B. J., Jimenez, R., Clifford, E., & Chabris, C. F. (2001). How not to be seen: The contribution of similarity and selective ignoring to sustained inattentional blindness. *Psychological Science*, *12*, 9–17.

Neisser, U., & Becklen, R. (1975). Selective looking: Attending to visually specified events. *Cognitive Psychology*, *7*, 480–494.

Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision*, *10*, 437–442.

Potter, M. C. (1976). Short-term conceptual memory for pictures. *Journal of Experimental Psychology: Human Learning and Memory*, *2*, 509–522.

Remington, R. W., & Folk, C. L. (2001). A dissociation between attention and selection. *Psychological Science*, *12*, 511–515.

Rensink, R. A., O'Regan, J. K., & Clark, J. J. (1997). To see or not to see: The need for attention to perceive changes in scenes. *Psychological Science*, *8*, 368–373.

Reynvoet, B., & Brysbaert, M. (1999). Single-digit and two-digit Arabic numerals address the same semantic number line. *Cognition*, *72*, 191–201.

Rock, I., Linnett, C. M., Grant, P., & Mack, A. (1992). Perception without attention: Results of a new method. *Cognitive Psychology*, *24*, 502–534.

Scholl, B. J. (2000). Attenuated change blindness for exogenously attended items in a flicker paradigm. *Visual Cognition*, *7*, 377–396.

Scholl, B. J., Noles, N. S., Pasheva, V., & Sussman, R. (2003). Talking on a cellular telephone dramatically increases 'sustained inattentional blindness.' *Journal of Vision*, *3*(9), Article 156. Retrieved from http://www.journalofvision.org/content/3/9/156

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentional blindness for dynamic events. *Perception*, *28*, 1059–1074.

Simons, D. J., & Chabris, C. F. (2011). What people believe about how memory works: A representative survey of the U.S. population. *PLoS ONE*, *6*(8), Article e22757. Retrieved from http://www.plosone.org/article/info:doi/10.1371/journal.pone.0022757

Simons, D. J., & Levin, D. T. (1998). Failure to detect changes to people during a real-world interaction. *Psychonomic Bulletin & Review*, *5*, 644–649.

Simons, D. J., & Rensink, R. A. (2005). Change blindness: Past, present, and future. *Trends in Cognitive Sciences*, *9*, 16–20.

Sligte, I. G., Scholte, H. S., & Lamme, V. A. F. (2008). Are there multiple visual short-term memory stores? *PLoS ONE*, *3*(2), Article e1699. Retrieved from http://www.plosone.org/article/info:doi/10.1371/journal.pone.0001699

Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs: General and Applied*, *74*, 1–29.

Wolfe, J. M. (1999). Inattentional amnesia. In V. Coltheart (Ed.), *Fleeting memories: Cognition of brief visual stimuli* (pp. 71–94). Cambridge, MA: MIT Press.

Wolfe, J. M., Klempen, N., & Dahlen, K. (2000). Postattentive vision. *Journal of Experimental Psychology: Human Perception and Performance*, *26*, 693–716.

Wolfe, J. M., Reinecke, A., & Brawn, P. (2006). Why don't we see changes? The role of attentional bottlenecks and limited visual memory. *Visual Cognition*, *14*, 749–780.