IMPLICIT DETECTION OF CHANGE: CAN WE DO WITHOUT AWARENESS?

Algis Norvilas

Professor
Saint Xavier University
Psychology Department
3700 W. 103rd St.
Chicago, IL 60655 USA
Tel. (773) 298-3470
E-mail: norvilas@sxu.edu

J. Conrath Miller

Graduate Student
Department of Psychology
W112 Lagomarcino Hall
Iowa State University
Ames, IA 50011 USA
Tel. (515) 294-1742
E-mail: jcmiller@iastate.edu

D. Fernandez-Duque and I. M. Thornton (2000) seemingly demonstrated "unconscious detection of change" (p. 338), i.e. a person being able to register stimulus change without being aware of it. However, as the authors themselves point out, their experiment might harbor a potential flaw: the failure to include a control condition. In a series of two experiments, we tested participants' ability to detect change, while not being aware of it, both in the absence and in the presence of a control condition. With the control condition absent, both experiments failed to replicate D. Fernandez-Duque and I. M. Thornton's finding of an increase in change detection for unaware trials. With the control condition present, change detection did exceed the chance level. We argue that a correlated conscious strategy hypothesis offers a better account of the change detection results for unaware trials than the unconscious change detection hypothesis.

Keywords: *change detection, awareness, implicit change detection, conscious strategy.*

Introduction

People generally assume that in order to perceive change, a person must consciously attend to the object that undergoes some kind of displacement or alteration. For example, one day the family car appears intact, but then at some point I notice that the left-front fender has been bent. Psychological theory, too, has highlighted the central role of attention and awareness in change perception (Rensink, 2002; Rensink et al., 1997; Werner and Thies, 2000). D. J. Simons and R. A. Rensink (2005) are very explicit on this point: "attention is needed to see change" (p. 17).

However, in an experiment that has received considerable attention, D. Fernandez-Duque and I. M. Thornton (2000) claim to have demonstrated that detection of change can occur implicitly, that is without the mediation of attention or awareness. Using the dissociative paradigm, they presented participants with a clock-like display, first introduced by C. W. Eriksen and J. F. Collins (1969), that had a ring of small rectangles, akin to numbers on a clock, arranged on the periphery and equidistant from the fixation point in the middle. Half of the rectangles were in a vertical and half in a horizontal position. The participants were shown two rapid exposures of a given display, with one of the rectangles undergoing a change in orientation, either from vertical to horizontal or vice versa. On the third showing of the display, the changed rectangle was highlighted together with its polar opposite that had not changed. At that point, participants were asked to indicate, using a mouse-pointer, which of the two rectangles had undergone a change. Upon making this choice, they had to press one of two buttons on a key pad, one button indicating that they had actually been aware and the other that they had not been aware of the change that had taken place.

The authors found that when participants became aware of change, as one might expect, they were very accurate in their selection of the changed target. In the case of the 8-item display, selection accuracy was as high as 89%. Interestingly, in those cases where participants failed to notice the change taking place, i.e. it had become dissociated from explicit awareness, they still correctly chose the changed item 63% of the time, a result that was significantly above the chance level of 50%. Thus, it would appear that individuals possess a representational system that can register event changes outside of awareness, and it can even detect the location where the change had taken place. In the case of the car example, one might have been registering the damage all along, but simply became aware of it sometime later.

However, the study harbors one major weakness – it failed to include a control condition, or what the authors call "catch trials", to test for possible effects of conscious processes that might account for performance differences. Because trials with no change were not included, the experiment lacks a baseline against which to assess the presumed presence of change detection, especially in the absence of awareness. Is it a case of change detection without awareness or simply the implementation of some adventitious explicit strategy? Given that the assumption of implicit change detection and even implicit processes in general remains controversial (e.g., Butler and Berry, 2001; Mitroff and Simons, 2002; Mitroff et al., 2002; Shanks, 2005; Simons and Silverman, 2004), we thought it important to replicate D. Fernandez-Duque and I. M. Thornton's study both in its original form and also with the presence of a control condition. The introduction of a control condition was hoped to provide a closer glimpse of the change detection process and possibly help delineate the role that explicit–implicit processes might play in the perception of change.

Experiment 1

The goal of the first experiment was twofold: to replicate D. Fernandez-Duque and I. M. Thornton's (2000) experiment in conjunction with a control condition and to test the generality of their findings regarding implicit change detection. To this end, the experiment contrasted two test situations: one, like D. Fernandez-Duque and I. M. Thornton, had no control trials and the other incorporated control trials. Both tests used the same 8-item clock-like display of the kind shown in Figure 1. Specifically, in the case of control trials the observer had to identify the "location" of change when in fact no change had taken place. Thus, on the second presentation of the display, a rectangle underwent a change in orientation for the experimental trials, but no such change took place for the control trials; however, during the test phase, on every trial the observer was shown two highlighted rectangles and asked to indicate which one of the two might have undergone a change. Following standard practice, the tacit criteria of "correct" change location for the control trials was the actual changes in orientation that occurred in parallel for the experimental trials. Obviously, for the control trials in which no change has taken place, if the forced-choice test results are driven purely by chance, "correct" choices should approximate the 50% level that would normatively be expected given a two-choice option. If they do not, that might possibly indicate the presence of some nonspecific conscious strategy that might be affecting the results not only of the control trials, but more generally of trials associated with the absence of awareness.

Although the experiment replicated the major features of D. Fernandez-Duque and I. M. Thornton's (2000) study, it also departed from the original method in some important respects with the aim of testing

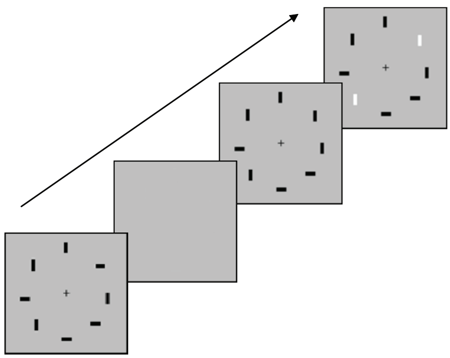

Figure 1. ***Progression of one trial: the first three slides were presented for 250 ms each and the fourth slide was given unlimited time for the participants to make the final decision***

the limits of the occurrence of explicit and implicit change detection. One important departure involved the selection of participants. Unlike D. Fernandez-Duque and I. M. Thornton (2000) who required participants to achieve "a 70% accuracy criterion for aware trials" (p. 329) to qualify for the experiment, in this study, in order to avoid the danger of self-selection, we imposed no accuracy criterion, but instead increased the number of participants. Furthermore, the participants were not given practice trials, but rather introduced to the experiment with a detailed set of instructions. The purpose in this case was to observe change detection at the very onset and to track its development over successive trials.

Based on D. Fernandez-Duque and I. M. Thornton's (2000) results, we expected to find significant change detection for the unaware trials both in the absence and in the presence of control trials. We also assumed that the control trial outcomes might help identify the possible source of change detection associated with the unaware trials. If for the control trials "change detection" is at the chance level, one would have to rule out the likelihood of some inadvertent conscious strategy influencing the change detection process. Change detection for unaware trials would then need to be explained as a within-task phenomenon that depended on some specific change detection process. However, if for the control trials "change detection" is above chance, the argument for the presence of implicit change detection would be weakened. Instead, the change detection results for unaware trials might better be explained as a function of some nonspecific conscious strategy.

Method

Participants

Forty-eight Introductory Psychology students at Saint Xavier University took part in the study for partial course credit. However, unlike D. Fernandez-Duque and I. M. Thornton, participants were not expected to meet some performance criterion in order to qualify for the study. Thus, we hoped to avoid a possible self-selection bias from influencing the results.

Design and Stimuli

The experiment was a 2 x 2 mixed design. One variable, a between-subjects variable, was absence or presence of control trials (no control vs. control). The other, a within-subjects variable, was presence or absence of awareness in relation to change judgement (aware vs. unaware).

The experiment generally followed D. Fernandez-Duque and I. M. Thornton's research design. The stimulus display consisted of a clock-like format, with eight separate rectangular shaped items (30 x 10 screen pixels) configured (starting with 12 o'clock) in a circular fashion (see Figure 1). Note that the rectangles and the cross-hair fixation point were black, while the background was light gray. The rectangles were equidistant from each other and stood at an 8 cm radius relative to the central fixation point. At the start of each trial, four of the rectangles in the clock-like display were oriented horizontally while the other four were oriented vertically. All possible arrangements (30 in all) of four horizontal and four vertical rectangles, with the restriction that neither type of rectangle occur more than twice in sequence, were used in the clock-like stimulus display. It is important to note that the eight-item display encompasses four opposite standing, dyadic pairs. The change in orientation took place at either end of a dyad. Altering the orientation of a rectangle from horizontal to vertical or vice versa constituted a stimulus change. Hence, a complete test sequence consisted of the presentation of 30 possible initial alignment arrangements tested for change orientation with the four dyadic pairs at both ends of each of the pairs for a total of 240 stimulus displays. Each sequence of stimulus displays was presented in random order using the control program's (Cedrus "SuperLab") event randomizer.

Procedure

Forty-eight participants were tested individually, 24 in the experimental test with no control condition and 24 with a control condition present. They were first given detailed instructions regarding every phase of the procedure, accompanied by an example of the changes that might take place. The clock-like displays were presented on an 18 in. (34 x 27 cm), no glare, flat-screen LCD monitor, which was set to a resolution of 1,280 x 1,024 pixels and a frame rate of 75 Hz. The monitor was attached to an Acer laptop computer and controlled by custom programming on Cedrus' SuperLab software. Participants sat approximately 40 inches away from the monitor. The screen was adjusted at the beginning of the session to be oriented perpendicular to each participant's line of sight in order to accommodate differences in height.

As the displays were presented, the participants were asked to focus on the crosshair in the middle of the screen. A trial sequence consisted of four separate events: an initial 250 ms display of eight rectangles, next a 250 ms blank-screen inter-stimulus interval, then a second 250 ms display in which one of the rectangles had undergone a change in orientation, and, finally, immediately following the second display, a third display with the same figure arrangement as the second one. The third display highlighted a set of dyadic rectangles by changing two of the rectangles from black to white. The participants had to identify the rectangle that had changed orientation by moving a mouse pointer over the selected white rectangle and clicking it. Participants had unlimited time to make this choice and were only directed to make a selection when the experimenter noticed a significant delay (more than approximately five seconds) in the response. The mouse was situated on the right-side of the laptop-base and controlled with the right hand. In the control condition, one-sixth of the displays, in a counterbalanced fashion, showed no change, but the observers, nevertheless, had to identify a rectangle where "change" had taken place. After the change location was selected, the observers used their left hand to press one of two buttons on a key-pad, one marked "aware" and the other "unaware", to indicate awareness or non-awareness of the change that had taken place. The inter-trial sequences were separated by 1000 ms intervals.

Results and Discussion

The number of participants who became aware of change on the experimental trials was 55% for the group with no control condition and 51% for the group with a control condition. These percentages are comparable to the 52% level of change awareness that D. Fernandez-Duque and I. M. Thornton (2000) found with the 8-item circular display.

Since participants were not bound by an accuracy criterion of correct change detection for aware trials, their correct detection scores spanned a wide range of values – from 57% to 96% for the group with no control condition and from 50% to 99% for the group with a control condition. An attempt was thus made to assess the performance relatedness or independence of the two states of consciousness – aware vs. unaware – by correlating the change detection values of the aware trials in relation to the unaware trials. Interestingly, in both cases the correct detection scores of aware trials and unaware trials were significantly correlated: Pearson's $r = 0.43$, $p < 0.05$ and $r = 0.53$, $p < 0.01$ for the groups without and with a control condition, respectively. However, for the group with the control condition, correct detection scores of the aware trials showed no correlation with those of the control trials ($r = -0.24$, $p = 0.25$).

The main factor effects were evaluated using a repeated measures analysis of variance. In order to observe performance trends across trials, the correct detection results were viewed across the four quadrants of the 240 stimulus displays. Since the correct change detection results for the aware trials across the groups without and with a control condition were approximately the same $F(1, 46) = 0.86$, $p > 0.05$, they were averaged across the two experimental groups: 75%, 77%, 81%, and 84%. We see that for aware participants the correct detection of change was not only high, but also increased significantly across trials $F(3, 138) = 9.56$, $p < 0.01$.

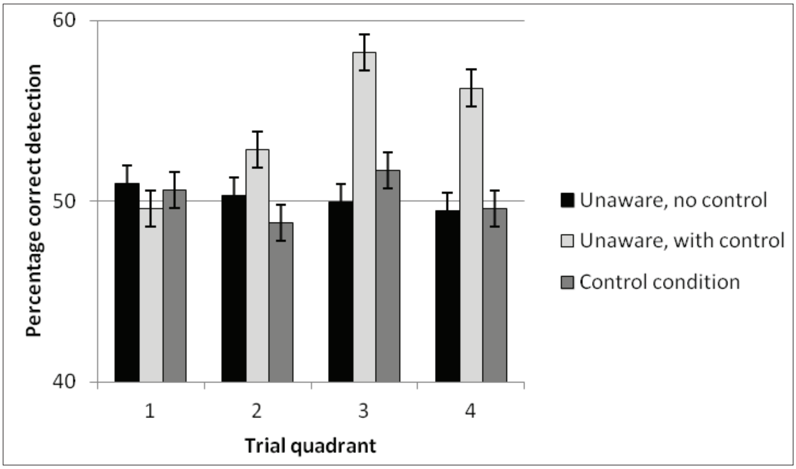

Figure 2. ***Percentage correct target detection in relation to trial quadrant as a function of unaware trials without or with control trials and the control condition (error bars represent standard errors of the mean)***

Figure 2 shows the percentage correct in change detection across the four quadrants for the unaware trials of the groups without and with a control condition, and for the control trials. In the case of the group with no control condition, correct target detection (51%) for the unaware trials was not different according to a t-test from the chance criterion $t(23) < 1$. In each quadrant, the percentage of correct detection was close to chance: 51%, 50%, 50%, and 49%. However, in the group with a control condition, the overall correct change detection (54%) for unaware trials was significantly above chance $t(23) = 2.77$, $p < 0.05$. Moreover, as in the case of the aware trials, the correct detection percentiles increased steadily across the quadrants, starting at the chance level for quadrant 1 (50%), moving up to 53%, then 58%, and dipping somewhat in quadrant 4 (56%) $F(3, 69) = 3.09$, $p < 0.03$. The latter two percentage averages are significantly different from the chance level: $t(23) = 4.29$ and 2.03, $p < 0.001$ and 0.05, respectively. But notice that the overall "correct" target selection (50%) for the control trials was at the chance level $t(23) < 1$. Such a null finding, as we had argued, makes it unlikely that some nonspecific cognitive strategy might stand behind change detection.

The reaction time means presented here are based on raw data. We had attempted to reduce some of the noise associated with raw reaction times by using median values instead, but discovered that the relative relationships among the raw and median based reaction time mean values were essentially identical. In the case of aware trials, reaction times to correct targets were significantly faster than to distracter targets in both the no control condition group (2536 ms vs. 2869 ms) $t(23) = -3.63$, $p < 0.001$ and the plus control condition group (2360 ms vs. 2924 ms) $t(23) = -3.50$, $p < 0.001$. However, in the case of the unaware trials, reaction times to correct and distracter targets were not significantly different, being 3272 ms vs. 3267 ms for the no control condition group and 3085 ms vs. 3166 ms for the plus control condition group, for both $t(23) < 1$. In the plus control condition group, the mean reaction time for the control trials was 2882 ms. Note that this reaction time outperforms the two reaction times associated with the unaware trials, 3085 ms for the correct and 3166 ms for the distracter targets, respectively.

Within the dissociation paradigm framework, the results of this experiment are inconclusive regarding the possibility of implicit change detection. An attempt to replicate D. Fernandez-Duque and I. M. Thornton's (2000) original experiment was not successful: for the unaware trials, contrary to D. Fernandez-Duque and I. M. Thornton's findings, correct change detection failed to exceed the chance level. On the other hand, with control trials present, correct target detection for the unaware trials did rise above chance performance, but only in the last two quadrants. Similarly, with respect to reaction time results, when D. Fernandez-Duque and I. M. Thornton found that for unaware trials reaction time to correct targets was faster than to distracter targets, they interpreted this finding as evidence for the presence of implicit processes in change detection. However, in our experiment, in both the no and plus control condition groups there was no difference between these two reaction times.

Additionally, what these results show is that change detection outcomes bear a close resemblance across the aware and unaware trials. Apparently, participants who were good at detecting change while aware were also good detectors while unaware. Also, for the group with the control condition, change detection improved over trials both for the aware and unaware trials. In a similar vein, D. Fernandez-Duque and I. M. Thornton's finding for unaware trials that reaction times to correct targets outpaces the reaction times to distracter targets is analogous to what one finds for the aware trials. This correspondence of results obviously points to a certain ambiguity that often accompanies attempts to demonstrate implicit change detection. Given that the outcomes of aware and unaware trials often overlap, is that because both express the same underlying process or simply show convergence of performance that is driven by distinct processes, one for aware trials and the other for unaware trials?

Not surprisingly, some have argued that the demonstration of implicit change detection with the classic dissociation paradigm (Fernandez-Duque and Thornton, 2003; Thornton and Fernandez-Duque, 2000) invariably suffers from the exclusiveness criterion (Reingold and Merikle, 1990). Hence, there is always the possibility that the implicit change detection we observe might simply be an artifact of some subtle conscious activity. At best, what each demonstration of the explicit vs. implicit exemplifies is a nominal distinction which in itself does not provide a deeper understanding of the underlying processes. In order to circumvent this predicament, E. M. Reingold and P. M. Merikle (1990) have suggested that rather than pursuing a nominal distinction between aware and unaware processes, we should instead try to establish qualitative differences between the two processes under various test conditions (see also Reingold, 2004). In fact, D. Fernandez-Duque and I. M. Thornton (2003) attempt to identify some qualitative performance differences in relation to aware and unaware trials; unfortunately, they do so merely on a post hoc basis.

The goal of the next experiment was to move beyond simply attempting to establish a nominal distinction between explicit vs. implicit change detection. Following B. J. Underwood and J. J. Shaughnessy (1975), we first propose hypothetical processes that might be involved in the perception of explicit and implicit change detection and then proceed to test them.

Experiment 2

Although consciousness (awareness, attention) is often seen as making detection of change possible, its manner of change detection may be direct or indirect. In direct change detection, a person is aware of attending to stimuli that are explicitly compared to each other in some fashion (Dulany, 1997; Fernandez-Duque and Thornton, 2000; Rensink, 2002; Mitroff, et al., 2002; Simon and Levin, 1998). As a result, the person can take full account of the aspects of a change situation that require comparison for change to be seen. Thus, explicit change detection occurs when the observer becomes aware of the features involved in the change process.

In the case of indirect change detection, an observer may attend to the aspects of a task that indirectly result in change detection or perhaps simply create the appearance of "change detection". Consciousness in this case would intrude itself on a task as a kind of "correlated conscious" content (Dulany, 1997, p. 199; see also Shanks, 2005). In the current detection task, the hidden presence of consciousness may manifest itself in a variety of ways. For example, participants may engage in a strategy whereby they focus on a portion of a target display and, if no change is seen, proceed to locate change in the non-seen portion of the display (Fernandez-Duque and Thornton, 2000; Mitroff et al., 2002). Or they may perceive the display as an organized configuration whose disruption may be indicative of a possible location of change (Jiang et al., 2000; Ryan and Villate, 2009). Although observers may not explicitly be aware of the change items, they nevertheless consciously grasp the aspects of the task that enable them to make the change choices that may exceed chance performance.

In contrast to these two consciousness-based interpretations of change detection, D. Fernandez-Duque and I. M. Thornton (2000) argue for the possibility of unconscious detection of change. They propose the idea of a "non-attentional representational system capable of registering change in the absence of awareness" (p. 341). Presumably, this system would operate automatically; it would compute mismatches between successive views of a target (see Laloyaux et al., 2006). The products of these mismatches would persist and be carried over to subsequent encounters with the target and thus influence the way an observer might see it and react to it. Consequently, the observer would seemingly be able to detect the occurrence of change despite the absence of conscious awareness.

The three accounts of the involvement or absence of consciousness in the process of change detection were assessed by carrying out a modified version of the first experiment. Here, too, the participants were shown an eight-item display. In the test phase, however, assessment of change detection was not limited to opposite pairs of rectangles, but encompassed all possible combinations of rectangles. For the eight item display, the pairs of test rectangles could stand at different distances relative to each other: the changed rectangle might stand right next to the non-changed rectangle (0 rectangle separation, or contiguous), one rectangle apart, two, or three (opposite, dyadic pairs).

We assume that the three hypotheses regarding the presence or absence of consciousness in change detection would make different predictions in relation to aware and unaware trials for the four different types of paired-test situations. As for aware trials, since observers are fully conscious of the change that has taken place, they should be able to pinpoint the location of change and do so effectively. Hence, correct change detection should be high and also equivalent across the four types of paired rectangle combinations: 0 (contiguous) through 3 (opposite pairs).

Obviously, in the case of unaware trials, direct explicit awareness is presumed not to operate. Therefore, any attempt to account for the presence of change detection would have to turn to the remaining two hypotheses: some correlated conscious intrusion or unconscious registration of change. In considering first the possibility of correlated conscious intrusion, the process that has been entertained most often is the elimination strategy (Fernandez-Duque and Thornton, 2000; Mitroff et al., 2002). In this deliberative strategy, the observer focuses on a limited number of items, hoping to spot the changed item, but in fact none are seen to change. If during the test phase one of the non-changed items happens to be presented as part of a test pair, the observer is able to “eliminate” it as the carrier of change, and opt for the opposite item. Interestingly, this is the strategy that our participants mentioned most often during informal debriefing. Assuming that our observers might resort to the elimination strategy, the likelihood of change detection would clearly be influenced by the spacing relationship between the paired test rectangles. Since 0 spacing would often place both items of a test pair beyond the limited field of focus, one would expect least correct change detection. Most likely, the choice between the two items would often be driven by guessing and thus fail to exceed the chances level. As for the noncontiguous pairs (spacing 1, 2, and 3), since the separation between paired test items is larger, it becomes less likely that both of the test items would fall outside the field of focus, thus increasing the chances of correct elimination.

As for the unconscious change registration hypothesis, detection of change is assumed to be item-specific and to take place automatically. This implies that detection will occur with respect to a specific location and, therefore, should not be affected by the distance relationship of the paired rectangles. Thus, the likelihood of change detection, assuming that it exceeds chance performance, should be identical across the four spacing relationships (0, 1, 2, and 3) of the test-item pairs.

Method

Participants

Sixty Introductory Psychology students at Saint Xavier University participated in this experiment for partial course credit. As in the first experiment, their participation was not criterion-based.

Design and Stimuli

The experiment was a 2 x 2 x 4 mixed design. There was one between-subjects variable: absence or presence of a control condition (no control vs. control), and two within-subjects variables: presence or absence of awareness in relation to change judgment (aware vs. unaware) and four distances defined by the number of intervening rectangles that came between paired rectangles selected for testing (0 for contiguous, 1, 2, 3 for opposite pairs).

The stimulus display was identical to that of the first experiment. However, this time the participants were tested with all possible paired combinations of the eight rectangular figures in a within-subjects fashion. As before, a stimulus change was created by altering the orientation of one of the paired rectangles from horizontal to vertical or vice versa. Here, too, the test encompassed 30 possible arrangements of four horizontal and four vertical rectangular figures. The arrangements were presented in sets of five where, for every individual arrangement, each of the eight figure-positions were paired-off with the other seven positions, resulting in a sequence that consisted of 280 stimulus displays. The presentation of each sequence was random.

Procedure

Sixty participants were tested individually – 30 with no control and 30 with a control condition. The test environment and the rate of display presentation were the same as in the first experiment. In the control condition, one-fifth of the displays, in a counterbalanced fashion, showed no change, but the participants, nevertheless, had to indicate where they thought a “change” had taken place.

Results and Discussion

The overall awareness of change was comparable to that of the first experiment: 52% and 54% for the groups without and with a control condition, respectively. Correct change detection for aware trials ranged from 46% to 99% for the no control condition group and 48% to 98% for the plus control condition group. Again, in both of these groups, the incidence of change detection was significantly correlated between aware and unaware trials: $r = 0.38$, $p < 0.05$ and $r = 0.46$, $p < 0.01$ for the no control and the plus control condition groups, respectively. As in the first experiment, for the group with the control condition, correct detection scores of the aware trials did not correlate with “correct” detection of the control trials ($r = 0.08$, $p > 0.05$).

Correct target detection was analyzed by first cumulating the results in relation to the four spacing conditions of the test-item pairs. A factorial analysis of correct detection scores for the groups without and with control conditions in relation to the aware trials across the four intra-pair spacing conditions (0, 1, 2, and 3) showed no significant difference $F(1, 58) = 1.15$, $p = 0.29$. Hence, the change detection results of the two experimental groups were combined across the four spacing conditions: 74%, 74%, 73%, and 73% for spacing conditions 0, 1, 2, and 3, respectively. Clearly, when observers are consciously aware of the changes that take place, they are able to locate them accurately, irrespective of the surrounding context. Thus, performance for contiguous pairs was just as effective as for separated pairs.

The percentage correct change detection scores for unaware trials of the groups without and with control conditions, together with the “correct” responses of the control trials, are shown in Figure 3. As in the first experiment, the overall “correct” target detection in the control trials was basically at the chance level (50%) $t(29) = 0$. Likewise, for unaware trials of the no control condition group, the overall correct detection (52%) was not different from chance $t(29) = 1.41$, $p = 0.17$. However, for unaware trials of the control condition group, the overall correct detection (53%) did exceed chance performance $t(29) = 2.62$, $p = 0.01$.

We next took a closer look at the correct detection scores for unaware trials of the plus control condition group in relation to the four spacing conditions. As one can see in Figure 3, performance at 0 spacing (50%) was basically equal to chance $t(29) < 1$. It was significantly above chance at spacing 1 (54%) and 2 (55%) $t(29) = 2.72$, $p = 0.01$ and 2.47, $p = 0.02$, respectively, but it failed to reach a significant difference at spacing 3 (52%) $t(29) < 1$.

These results, clearly, fail to support the unconscious registration of change hypothesis. Again, unlike D. Fernandez-Duque and I. M. Thornton’s (2000) results, when no control condition was present, correct target detection for the unaware trials remained at the chance level. But, as in Experiment 1, correct target detection did exceed chance in the context of the control trials. However, the pattern of these results did not favor the unconscious change registration hypothesis which expected change detection to occur at the same level of performance across all of the spacing conditions. What we do find in these change detection results is significant support for the elimination hypothesis. As predicted, for test-pairs with 0 spacing, performance was at the chance level. Amongst

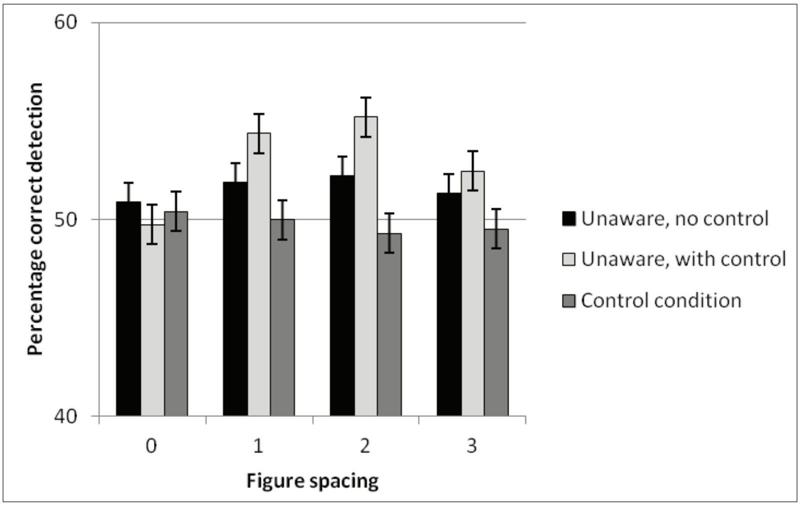

Figure 3. ***Percentage correct target detection in relation to spacing between paired test figures as a function of unaware trials without or with control trials and the control condition (error bars represent standard errors of the mean)***

the three noncontiguous test-pairs, all three had higher change detection scores than chance, but they only reached significant levels for pairs with spacings 1 and 2.

The mean reaction time results were similar to those of Experiment 1. When participants were aware of changes, correct target reaction times were markedly faster than distracter target reaction times: 2426 ms vs. 2817 ms for the no control condition group and 2360 ms vs. 2674 ms for the plus control condition group, respectively $t(29) = -4.36$ and -5.44, both $p < 0.001$. On the other hand, reaction times to correct and distracter targets for unaware trials were not significantly different: 3132 ms vs. 3201 ms for the no control condition group $t(29) = -1.42$, $p = 0.17$ and 2926 ms vs. 3015 ms for the plus control condition group, $t(29) = -1.53$, $p = 0.14$. Moreover, mean reaction time (2913 ms) for the control trials was similar to the two mean reaction times for the plus control condition group $F(2, 58) = 1.38$, $p = 0.26$.

General Discussion

The results of the two experiments cast doubt on the reality of an implicit change detection process that is understood as an unconscious change registration system. As we saw, repeated attempts to replicate D. Fernandez-Duque and I. M. Thornton's (2000) finding of implicit change detection by using their experimental design, which presented change trials without a control condition, were not successful. Unlike D. Fernandez-Duque and I. M. Thornton's observers who were able during unaware trials to detect change significantly above chance, our own observers detected change only at the chance level. In addition, our reaction time results failed to replicate D. Fernandez-Duque and I. M. Thornton's observation that for unaware trials reaction time in the case of correct targets was quicker than in that of distracter targets. For them, this observation meant that an implicit detection process had to be operative, since what else could account for the expedited reaction in the absence of awareness? However, our results showed no difference between the two reaction times. They even question the appropriateness of such a relative comparison since the reaction times for the unaware trials failed to exceed, or at best equaled, the reaction time for the control trials.

In searching for a possible source of the discrepancy between D. Fernandez-Duque and I. M. Thornton's original study and our replication, one important difference stands out between the two experiments: the manner of selecting participants. In their experiment, D. Fernandez-Duque and I. M. Thornton imposed a strict participant selection criterion of 70% accuracy of change detection for aware trials. Our experiment, however, did not adhere to the accuracy criterion. As a result, the participants' accuracy scores for aware trials ranged widely, permitting the calculation of a correlation between the change detection scores for the aware trials and the unaware trials. In each case, as we saw, the correlation was highly significant.

In view of a close relationship in change detection between aware and unaware trials, we decided to take a closer look at how the participants that met the 70% criterion vs. those who did not fair in their correct change detection scores on unaware trials. In order to keep N sufficiently high, the correct change detection scores for those falling above vs. below the 70% criterion were combined across the two experiments. Interestingly, observers who exceeded the 70% criterion (N = 33) were on the average able to locate change correctly 53% of the time, a result that was significantly above chance (50%) performance $t(32) = 2.27$, $p = 0.03$. Whereas observers who failed to exceed the 70% criterion (N = 21) detected change correctly only 49% of the time.

In one respect, this result suggests that the two sets of experiments were not that different after all. However, taking a methodological perspective, one might wonder whether D. Fernandez-Duque and I. M. Thornton's findings of the presence of significant change detection for unaware trials is simply an artifact of participant self-selection. At the very least, it raises the question of why observers who are better at detecting change for aware trials are also better at doing the same for unaware trials. Is it because they possess some kind of an implicit change detection mechanism that the poorer performers do not, or is it because they excel in cognitive skills that permit them to consciously zero in on the changed item?

On the other hand, the introduction of control trials – i.e. trials in which no change takes place – in some cases brought about a significant increase in correct change detection in the unaware trials. However, given that "correct" change detection for the control trials hovered at the chance level, it is unlikely that the upswing in correct change detection for the unaware trials in the two experiments is due to some nonspecific extra-trial factor. Barring the presence of a nonspecific factor, the only source for the increase must be intra-trial and specific to the event itself. It should be pointed out, however, that the control trials could have played an indirect role in facilitating correct change detection for the unaware trials. Possibly, the absence of change in the control trials could have served as a point of contrast to the change trials, highlighting transient signals that lead to the implementation of some conscious strategy. What happens here at a complex cognitive level might be analogous to what happens in the case of perception of object-relative movement: a sole object that otherwise might not be seen as moving, suddenly appears to be moving in the presence of a stationary object (Graham, 1965; Sekuler et al., 2002).

What, then, might be the source of the increase in change detection for unaware trials in the context of a control condition? Considering first the unconscious registration hypothesis, it clearly fails to account for the changes we see in the two experiments. Assuming that the process of registering change operates automatically, unconscious registration hypothesis has difficulty in explaining why in Experiment 1 change detection increases gradually over trials. As for Experiment 2, its prediction of equivalent performance across the spacing conditions was not supported. Furthermore, if we contrast the results of the groups with and without control trials, it fails to explain why change detection should be affected one way or another by the absence or presence of the control condition.

On the other hand, the correlated conscious intrusion hypothesis, considered here specifically in the form of the elimination hypothesis, appears to account for most of the results of the two experiments. Looking back at Experiment 1, one can reasonably argue that application of a conscious elimination strategy requires a learning process that would take time to implement, and therefore one would expect improvement in change detection over trials. The elimination hypothesis offered a generally accurate prediction of the outcome of Experiment 2. The shortfall of the change detection prediction associated with the opposite pairs might need to engage additional processes, such as, for instance, the counter-effect that the inhibition of return might have on the observer's choices in relation to opposite pairs (Spalek, 2007). Finally, the difference in performance of the groups with and without control trials, as mentioned before, may be a product of the selective engagement of pertinent conscious processes.

In summary, the results of this experiment, first, failed to achieve a direct replication of D. Fernandez-Duque and I. M. Thornton's finding of change detection in the absence of awareness. Second, presence of non-change control trials enhanced a person's sensitivity for change detection in the case of unaware trials. Third, we argue that the correlated conscious intrusion hypothesis offers a more successful account of the increase in change detection for unaware trials with control trials present than does the unconscious change registration hypothesis.

Finally, we would like to conclude by making three observations regarding the search for the underpinnings of change detection. First, we wonder if it is still worthwhile to frame the question of change detection in terms of two exclusive nominal categories: explicit vs. implicit. Our inquiry into the sources of change detection might be better served by offering hypotheses about underlying processes and testing them. We hope our experiments will move the debate in that direction.

Second, any excursion into the explicit–implicit debate should be prepared to introduce the appropriate control conditions that hopefully would help to identify the underlying processes. In the absence of a comparative frame of reference, it is very difficult to capture the processes involved, not to speak of offering a meaningful interpretation of the results.

Third, consciousness appears to insert itself at every phase of change perception. As others have argued, instead of ignoring the presence of intentionality, it would be more fruitful to lay it open (Bruner and Postman, 1949; Dulany, 1997; Simons and Mitroff, 2001). We certainly think that speculation regarding the conscious process involved in change detection, such as, e.g., elimination strategy, should be complemented with subject reports that shed light on what participants actually do as they struggle to come up with the correct response.

REFERENCES

Bruner J. S., Postman L. On the perception of incongruity: A paradigm // Journal of Personality. 1949, vol. 18, p. 206–223.

Butler L. T., Berry D. C. Implicit memory: Intention and awareness revisited // Trends in Cognitive Sciences. 2001, vol. 5, p. 192–195.

Dulany D. E. Consciousness in the explicit (deliberative) and implicit (evocative) // Scientific Approaches to Consciousness / Ed. by J. D. Cohen, J. W. Schooler. Mahwah, New Jersey: Erlbaum, 1997. P. 179–211.

Eriksen C. W., Collins J. F. Temporal course of selective attention // Journal of Experimental Psychology. 1969, vol. 80 (2), p. 254–261.

Fernandez-Duque D., Thornton I. M. Change detection without awareness: Do explicit reports underestimate the representation of change in the visual system? // Visual Cognition. 2000, vol. 7, p. 323–344.

Fernandez-Duque D., Thornton I. M. Explicit mechanisms do not account for implicit focalization and identification of change: An empirical rely to Mitroff et al. (2002) // Journal of Experimental Psychology: Human Perception and Performance. 2003, vol. 29, p. 846–858.

Graham C. H. Perception of motion // Vision and Visual Perception / Ed. by C. H. Graham. New York: Wiley, 1965. P. 575–588.

Jiang Y., Olson I. R., Chun M. M. Organization of visual short-term memory // Journal of Experimental Psychology: Learning, Memory, and Cognition. 2000, vol. 26, p. 683–701.

Laloyaux C., Destrebecqz A., Cleeremans A. Implicit change identification: A replication of Fernandez-Duque and Thornton (2003) // Journal of Experimental Psychology: Human Perception and Performance. 2006, vol. 32, p. 1366–1379.

Mitroff S. R., Simons D. J. Changes are not localized before they are explicitly detected // Visual Cognition. 2002, vol. 9, p. 937–968.

Mitroff S. R., Simons D. J., Franconeri S. L. The siren song of implicit change detection // Journal of Experimental Psychology: Human Perception and Performance. 2002, vol. 28, p. 798–815.

Reingold E. M. Unconscious perceptions: Assumptions and interpretive difficulties // Consciousness and Cognition. 2004, vol. 13, p. 117–122.

Reingold E. M., Merikle P. M. On the inter-relatedness of theory and measurement on the study of unconscious processes // Mind and Language. 1990, vol. 5, p. 9–28.

Rensink R. A. Change detection // Annual Review of Psychology. 2002, vol. 53, p. 245–267.

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

Ryan J. D., Villate C. Building visual representations: The binding of relative spatial relations across time // Visual Cognition. 2009, vol. 17 (1/2), p. 254–272.

Sekuler R., Watamaniuk S. N. J., Blake, R. Visual motion perception // *Stevens' Handbook of Experimental Psychology: Vol. 1. Sensation and Perception (3rd edition)* / Ed. by H. Pashler (Series Ed.), S. Yantis (Vol. Ed.). New York: Wiley, 2002. P. 121–176.

Shanks D. R. Implicit learning // Handbook of Cognition / Ed. by K. Lamberts, R. Goldstone. London: Sage, 2005. P. 202–220.

Simons D. J., Levin D. T. Failure to detect changes in people in a real-world interaction // Psychonomic Bulletin & Review. 1998, vol. 5, p. 644–649.

Simons D. J., Mitroff S. R. The role of expectations in change detection and attentional capture // Vision and Attention / Ed. by M. Jenkins, L. Harris. New York: Springer-Verlag, 2001. P. 189–207.

Simons D. J., Rensink R. A. Change blindness: Past, present, and future // Trends in Cognitive Sciences. 2005, vol. 9, p. 16–20.

Simons D. J., Silverman M. Neural and behavioral measures of change detection // The Visual Neurosciences / Ed. by L. M. Chalup, J. S. Werner. Cambridge, MA: MIT Press, 2004. P. 1524–1537.

Spalek T. M. A direct assessment of the role of expectation in inhibition of return // Psychological Science. 2007, vol. 18, p. 783–787.

Thornton I. M., Fernandez-Duque D. An implicit measure of undetected change // Spatial Vision. 2000, vol. 14, p. 21–44.

Underwood B. J., Shaughnessy J. J. Experimentation in Psychology. New York: Wiley, 1975.

Werner S., Thies, B. Is "change blindness" attenuated by domain-specific expertise? An expert-novice comparison of change detection in football images // Visual Cognition. 2000, vol. 6, p. 163–173.

NUMANOMO POKYČIO APTIKIMAS: AR GALIME APSIEITI BE SĄMONĖS ĮSITERPIMO?

Algis Norvilas, J. Conrath Miller

S a n t r a u k a

D. Fernandez-Duque ir I. M. Thornton (2000) tariamai atrado, kad asmuo gali užfiksuoti pakitimą ir be sąmonės įsiterpimo. Tačiau šį atradimą gerokai menkina vienas pačių autorių pripažintas metodologinis trūkumas – kontrolinių bandymų nebuvimas. Siekdami tiksliau nustatyti, ar norint pastebėti pakitimą reikia sąmonės tarpininkavimo, ar jo užfiksavimas gali vykti ir be sąmonės įsiterpimo, dar kartą tyrėme, kaip matomame objekte aptinkamas pasikeitimas, tačiau šį kartą tyrėmė dvejopai: vienu atveju be kontrolinių bandymų, kaip ir D. Fernandez-Duque ir I. M. Thorntonas, o kitu atveju atlikome ir kontrolinius bandymus.

Pirmasis tyrimas bendrais bruožais pakartojo D. Fernandez-Duque ir I. M. Thorntono atliktą tyrimą. Norėta pažiūrėti, ar rasis nesąmoningas pasikeitimo pastebėjimas, kaip buvo D. Fernandez-Duque ir I. M. Thorntono tyrime, darant ir kontrolinius bandymus. Kompiuterio ekrane vienas po kito buvo rodomi laikrodžio pavidalo apskritimai, kuriuose vietoj skaičių buvo matyti aštuoni nedideli stačiakampiai, kurių keturi stovėjo stačiomis ir keturi gulėjo gulsčiomis (žr. 1-ą pav.). Per kiekvieną bandymą buvo paeiliui pateikiami trys apskritimai. Pirmas bandymas truko 250 ms, paskui buvo 250 ms tarpelis. Antrame bandyme, irgi trukusiame 250 ms, pasirodžius apskritimui, vieno stačiakampio padėtis buvo pakeista iš stačios į gulsčią ar priešingai. Apskritimui su stačiakampiais pasirodžius trečią kartą, jame ryškumu išsiskyrė du priešiais stovintys stačiakampiai – tas, kuris buvo patyręs pokytį, ir stovintis priešingoje pusėje. Dabar dalyvis pelytės rodykle turėjo nurodyti, kurio iš tų dviejų stačiakampių padėtis buvo pakeista. Tai atlikęs, mygtuko nuspaudimu nurodė, ar vertinamą pokytį buvo suvokęs sąmoningai, ar ne. Atlikus nesuvoktų pasirinkimų įvertinimą paaiškėjo, kad rezultatai nėra vienodi. Viena vertus, grupėje, kurioje buvo pakartojamas tyrimas nedarant kontrolinių bandymų, nesuvoktų pokyčių tikslus pasirinkimas, priešingai D. Fernandez-Duque ir I. M. Thorntono bandymui, neviršijo atsitiktinumo lygio. Kita vertus, grupėje, kurioje kontroliniai bandymai buvo atlikti, nesuvoktų pokyčių tikslus pasirinkimas atsitiktinumo lygį viršijo.

Šie rezultatai neteikia aiškios paramos hipotezei, kad galima nesąmoningai pastebėti pakitimą. Todėl ryžtasi antrą kartą tirti nesuvokto pokyčio patyrimo reiškinį, bet šį kartą taikant sudėtingesnio turinio užduočių. Antrame tyrime taip pat norėta įvertinti du galimus nesuvokto pokyčio pasirinkimo aiškinimus: nesuvokto pokyčio užfiksavimo hipotezė ir santykinio sąmonės pasireiškimo hipotezė. Pagal pastarąją, nors pokytis ir nėra pastebimas, jis vis dėlto gali būti pasirinktas sąmoningomis pastangomis. Pavyzdžiui, nurodydamas, kurio stačiakampip padėtis keitėsi, dalyvis gali sąmoningai taikyti atmetimo strategiją. Pagal ją jis renkasi stačiakampį, stovintį priešais tą, kurio padėtis nesikeitė, taip didindamas galimybę atlikti teisingą pasirinkimą.

Šios dvi hipotezės buvo tikrintos antrame tyrime. Bendrais bruožais šis tyrimas buvo panašus į pirmąjį, tik sudėtingesnė pasirinkimo užduotis. Šiuo atveju pasirinkimui pateiktos stačiakampių poros apėmė visus galimus derinius: poras, kurių stačiakampiai stovėjo šalimais, per vieną tarpinį stačiakampį, per du ir per tris (priešingos poros). Suvedus rezultatus, ir šį kartą kontrolinių bandymų nedariusiųjų grupės nesuvoktų pokyčių tikslus pasirinkimas neviršijo atsitiktinumo lygio. Tačiau grupės, kurioje buvo atlikti kontroliniai bandymai, rezultatai buvo kiek sudėtingesni. Nustatyta, kad rodant poras su šalimais esančiais stačiakampiais, tikslus pokyčių pasirinkimas vyko atsitiktinumo lygiu. Tačiau rodant tarpines stačiakampių poras jis buvo aukštesnis, pasiekė net statistiškai aukštą lygį, kai poras skyrė vienas ir du stačiakampiai. Autorių nuomone, šiuos rezultatus santykinio sąmonės pasireiškimo hipotezė paaiškina tinkamiau, negu nesuvokto pokyčio užfiksavimo hipotezė.

Pagrindiniai žodžiai: pokyčio aptikimas, suvokimas, numanomo pokyčio aptikimas, sąmonė.

Įteikta 2010-09-21