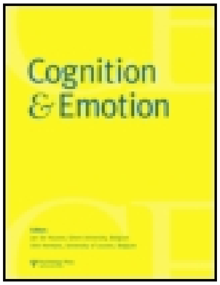

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The snake in the grass revisited: An experimental comparison of threat detection paradigms

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The snake in the grass revisited: An experimental comparison of threat detection paradigms

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The current investigation compares the results of two commonly used visual detection paradigms—the standard adult button-press detection paradigm used in Öhman, Flykt, and Esteves (2001), and the new child-friendly touch-screen detection paradigm used in LoBue and DeLoache (2008)—within the same samples of adult participants. Results suggest that both paradigms produce the same pattern of findings with regard to detection latency for threat-relevant versus threat-irrelevant stimuli: Adults detected threat-relevant targets more quickly than threat-irrelevant targets across the varying procedures. However, results with respect to automaticity of detection as suggested by Öhman et al. (2001) were only replicated with the classic button-press paradigm. The findings validate the touch-screen visual search procedure and have important implications for choosing an appropriate methodology for studying threat detection.

Keywords: Threat; Perception; Detection.

How humans respond to threatening or fear-relevant stimuli has been a topic of interest in psychology for decades. More specifically, researchers have used various detection paradigms to investigate whether adults and children are perceptually sensitive to threats in the environment, and whether they detect the presence of threatening or *threat-relevant* stimuli more quickly than neutral or *threat-irrelevant* stimuli. The current investigation focused on comparing two commonly used methodologies to measure threat detection, and whether each methodology produced differential responding to threat within the same participants. Given the large number of studies using these paradigms, it is important to understand how they might elicit differences in behavioural responding to threat.

Öhman, Flykt, and Esteves (2001) were the first to publish data suggesting that adults detect threat-relevant stimuli more quickly than threat-irrelevant stimuli in a visual search task. In their standard adult detection paradigm, participants are presented with nine photographs arranged in 3×3 matrices. The matrices contain nine photographs from the same

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category, or eight photographs from the same category with a single image from a discrepant category. Participants are generally instructed to detect as quickly as possible whether a discrepant photograph is present in each matrix by pressing one of two microswitches, each held in a separate hand. Using this procedure, Öhman et al. (2001) reported that participants detect threat-relevant stimuli (snakes and spiders) more quickly than threat-irrelevant stimuli (flowers and mushrooms), suggesting that threat relevance plays an important role in detection.

Öhman et al. (2001) interpreted additional findings as evidence that the detection of threat-relevant stimuli occurs *automatically*. Treisman and Gelade (1980) argued that if objects are processed automatically, detection of the targets should not be affected by variations in the number of distracters present in a visual search display. Accordingly, Öhman et al. (2001) demonstrated that the number of distracters present in each matrix did not affect the speed of detection for threat-relevant stimuli. Using the same visual search paradigm, the researchers asked participants to detect discrepant photographs in both 2×2 and 3×3 matrices. When there was a single discrepant snake or spider present in the matrix, participants' performance did not vary as a function of the number of distracters (three or eight). However, when there was a single discrepant flower or mushroom, participants were significantly slower at detecting its presence when there were more distracters in the matrix.

The procedure used in Öhman et al. (2001) is common in detection research among adult participants (e.g., Blanchette, 2006; Brosch & Sharma, 2005; Lipp, 2006; Lipp, Derakshan, Waters, & Logies, 2004; Tipples, Young, Quinlan, Broks, & Ellis, 2002). However, this classic procedure is too difficult for young children, and thus research on threat perception was for a long time limited to adults. Recently, LoBue and DeLoache (2008) developed a new touch-screen visual search procedure that has extended research in this domain to pre-school children, allowing investigators for the first time to examine threat detection from a developmental perspective. This is important: In order to study the process by which threatening stimuli become privileged in perception, we must study the phenomenon developmentally (LoBue, 2013; LoBue, Rakison, & DeLoache, 2010). Further, research has suggested that certain emotionally valenced stimuli vary in salience based on different time points in development (Todd, Cunningham, Anderson, & Thompson, 2012). As in the classic adult visual search paradigm, participants are generally presented with 3×3 matrices of photographs, but instead of pressing one of two buttons, they are simply asked to find a target and touch it on a screen. Having to decide whether a discrepant photograph is present and then having to press one of two buttons on a keyboard is a multi-step process that requires a great deal of language competence to understand. Using a touch-screen simplifies the task and makes the procedure easy for children and also appropriate for adults.

Using this new methodology, researchers have reported a pattern of results similar to those found with adults using the classic button-press method: Both 3-year-olds and adults detected snakes more quickly than flowers, frogs, and caterpillars, and spiders more quickly than mushrooms and cockroaches (LoBue, 2010a; LoBue & DeLoache, 2008). However, there are various differences between the two paradigms that might yield differences in the results they produce. First, there are low-level procedural differences between the two paradigms including the number of trials participants generally see, and the specific photographs that are used. Second, the behavioural response required differs between the two methodologies. In the button-press paradigm, participants are required to press one of two buttons depending on whether a discrepant photograph is present in each matrix. In the touch-screen procedure, participants are required to find a specific target and touch it on the screen. This difference might yield an important difference in behavioural responding: Having to reach out and touch a threat-relevant target requires an approach response that is not required of the classic paradigm. This might make reaction times for threats slower instead of faster, as participants might be reluctant to touch them. Third, and perhaps most importantly, in the adult button-press paradigm, participants are required to first decide whether or not a discrepant category is present in each matrix, and then choose which button to press accordingly. Conversely, in the touch-screen procedure, participants already know that each display will have a specific target and their only task is to locate it: The target is always labelled when the study is introduced. Knowing that a target is present might yield important differences in search strategies when compared to just deciding whether a discrepant category is present in each matrix.

The new touch-screen paradigm is being used more commonly to examine threat detection in children, adults, and even non-human primates (e.g., LoBue, 2009, 2010a, 2010b; LoBue & DeLoache, 2008, 2011; LoBue & Larson, 2010; Masataka & Shibasaki, 2012; Shibasaki & Kawai, 2009). Further, as touch-screen technology is becoming more accessible via ipads, tablets, touch-screen laptops, and smartphones, this new methodology can provide important opportunities for threat detection research across a wide age range. Thus, it is important to understand whether using the touch-screen methodology produces findings directly comparable to those produced by the classic button-press paradigm. The main goal of the current work was to validate the touch-screen procedure, comparing results produced by this new methodology to results produced by the classic paradigm within the same participants. In Experiment 1, we compared the standard button-press procedure with the standard touch-screen procedure. In Experiment 2, we modified the button-press procedure to specifically examine whether knowing that a target is present produces differences in detection. Finally in Experiment 3, we examined the detection of both 2×2 and 3×3 matrices in the touch-screen procedure.

EXPERIMENT 1

The goal of Experiment 1 was to replicate the exact methodologies used by Öhman et al. (2001) and LoBue and DeLoache (2008) within the same adult participants. Thus, a group of adults first performed the standard button-press task from Öhman et al. (2001), and then performed the touch-screen detection task from LoBue and DeLoache (2008). The question of interest was whether we would find any differences in the detection of threat-relevant versus threat-irrelevant targets between the two paradigms.

Method

Participants

Participants were 27 university students, 15 female and 12 male ($M_{\text{age}} = 20$ years; range = 18–36). One participant did not complete the touch-screen task. All participants tested were recruited from the Rutgers University human subjects participant pool and received course credit for their participation. The Rutgers University Institutional Review Board approved all procedures and all participants signed an informed consent.

Standard button-press method

Materials. The stimuli were colour photographs from Öhman et al. (2001). Photographs consisted of four different categories—snakes, spiders, mushrooms, and flowers—arranged in 3×3 and 2×2 matrices. Each matrix contained four or nine pictures from a single category, or three or eight pictures from one category and a single discrepant picture from a second category. As in Öhman et al. (2001), discrepant threat-relevant targets (snakes and spiders) appeared with threat-irrelevant distracters (flowers and mushrooms) and vice versa, resulting in eight combinations of stimuli: Snakes among flowers; snakes among mushrooms; spiders among flowers; spiders among mushrooms; flowers among snakes; flowers among spiders; mushrooms among snakes; and mushrooms among spiders. Threat-relevant targets never appeared with threat-relevant distracters (e.g., snakes among spiders), and threat-irrelevant targets never appeared with threat-irrelevant distracters (e.g., flowers among mushrooms).

For 3 × 3 matrices, the target appeared in the nine positions an equal number of times, resulting in 72 (nine possible positions × eight combinations of stimuli) matrices with one target and eight distracters. To balance the design, there was an additional 72 matrices with no targets (nine photos from a single category), for a grand total of 144 3 × 3 matrices. For 2 × 2 matrices, the photographs were positioned in the upper right, upper left, lower right, and lower left corners of the screen. The targets again appeared in the four positions of the matrix an equal number of times, resulting in 32 (four possible positions × eight combinations for stimuli) matrices with one target and three distracters, and an additional 32 matrices with no target (four photos from a single category), for a grand total of 64 2 × 2 matrices. As in Öhman et al. (2001), to more closely match the number of 2 × 2 and 3 × 3 stimuli, the 64 2 × 2 matrices were presented twice, for a grand total of 128 2 × 2 matrices.

Procedure. Each participant was seated at a desk approximately 60–80 cm in front of a 22 inch (55.9 cm) widescreen colour monitor with attached keyboard. At the beginning of each trial, a single matrix appeared in the centre of the screen. Participants were instructed to respond as fast as possible by pressing "A" on the keyboard if all of the photos in the matrix were from the same category, and to press "L" if one of the photos was from a different category. Participants responded to all 144 3 × 3 matrices interspersed with all 128 2 × 2 matrices in a random order. Latency to press a button on the keyboard was automatically recorded from the onset of each matrix.

Touch-screen method

Materials. The stimuli consisted of four sets of 24 photographs from LoBue and DeLoache (2008) and LoBue (2010a). The photographs were arranged in 3 × 3 matrices, with a single target picture from one category and eight distracter pictures from a second category. No target-absent matrices were used. Further, 2 × 2 matrices have never been used with the touch-screen paradigm in previous work, so in order to replicate the procedure exactly, they were not used here either. The stimulus categories were spiders, snakes, mushrooms, and flowers. A 19 inch GVision touch-screen LCD monitor was used to present each picture matrix. Each of the 24 pictures in the target category served as the target once, appearing in each of the nine positions in the matrix two or three times. The 24 pictures from the distracter category appeared approximately the same number of times across trials. One stimulus order was created by randomly arranging matrices, and the second order was the reverse of the first order. An outline of handprints was located on the table immediately in front of the monitor.

Procedure. Each participant was seated in front of the touch-screen monitor (approximately 40 cm from the base of the screen). First, a set of seven practice trials was given to teach the participant how to use the touch screen. On the first two trials, a single picture appeared on the screen. The first picture was from the target category and the second from the distracter category. Participants were asked to touch each picture on the screen. In the next two trials, participants were presented with one target and one distracter picture and asked to touch only the target picture. The last three practice trials consisted of different nine-picture matrices. Participants were told that for each trial, the task was to find the "X" (target) among "Y" (distracters) as quickly as possible, and touch it on the screen. All participants learned the procedure quickly.

In a series of 24 test trials, a matrix containing one target and eight distracters was presented on each trial. In between trials, a grey screen appeared that read, "Are you ready?" To ensure participants' attention to the middle of the screen at the start of each trial, participants were asked to touch a large emoticon under the text to advance to the next trial, and place their hands on the handprints on the table. Latency was automatically recorded from the onset of the matrix to when the participant touched one of the images on the screen.

Participants performed this procedure four times, detecting snakes among flowers, flowers among snakes, spiders among mushrooms, and mushrooms among spiders. The order of tasks was counterbalanced across participants.

Analyses

Across experiments, we used mixed-effects analyses of variance (ANOVAs) to analyse trial-level data rather than group means with participant as a fixed variable. This type of model has several key advantages to traditional ANOVAs. The most important advantage is that it allows us to consider every data point in the analyses instead of using a single mean for every participant. By using every data point, mixed models take into account individual differences in a participants' behaviour over the course of many trials, reducing the potential for error (Baayen, Davidson, & Bates, 2008). One of the disadvantages of using mixed effects models is that they do not provide us with clear effect sizes typically reported for traditional ANOVAs. Mixed models differ from traditional ANOVAs in that they use maximum likelihood estimation instead of least squares estimation. In such cases, standard effect sizes such as R^2 that are appropriate for least squares estimation are not meaningful, and the p-value is actually a better proxy for effect size (Baayen et al., 2008; Bagiella, Sloan, & Heitjan, 2000; Gueorguieva & Krystal, 2004). Thus, for all of the models described below, only F- and p-statistics are reported, as standard effect sizes are not appropriate for mixed effects models.

As in previous visual search research, only trials in which the participants made correct responses were used in the main analyses; errors were analysed separately. Finally, as in previous work, targets located in middle rows and columns were eliminated from the analyses because they always yielded the fastest detection latencies (Öhman et al., 2001).

Results

Standard button-press method

The goal of the first set of analyses was to examine whether we replicated the results first reported by Öhman et al. (2001) using the same button-press detection method. We first analysed latency to press "L" or "A" on the keyboard for matrices in which no targets were present. In a 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA on latency to hit the keyboard for target-absent matrices, there was a main effect of Target, $F(1, 3485) = 4.1$, $p = .042$, and a main effect of Matrix Size, $F(1, 3484) = 19.7$, $p = .000$. Replicating Öhman et al.'s (2001) results, participants were faster at determining that no target was present in matrices composed solely of threat-relevant photographs ($M = 1{,}439.7$ ms) than in matrices with threat-irrelevant photographs ($M = 1{,}514.5$ ms). Participants were also faster at determining that no target was present in 2 × 2 matrices ($M = 1{,}387.0$ ms) than they were in 3 × 3 matrices ($M = 1{,}557.7$ ms).

Next, we analysed latency to detect a target in matrices with a single discrepant photograph. In a 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA on latency to detect the target for target-present matrices, we found a main effect of Target, $F(1, 2479) = 11.5$, $p = .001$, and a main effect of Matrix Size, $F(1, 2470) = 11.2$, $p = .001$, and a Target by Matrix Size interaction, $F(1, 2479) = 7.4$, $p = .007$. Again replicating the findings of Öhman et al. (2001), threat-relevant targets ($M = 1{,}430.4$ ms) were detected more quickly than threat-irrelevant targets ($M = 1{,}494.8$ ms) and targets present in 2 × 2 matrices ($M = 1{,}424.4$ ms) were detected more quickly than targets in 3 × 3 matrices ($M = 1{,}496.5$ ms). The significant Target by Matrix Size interaction replicated the results of Öhman et al. (2001), revealing an effect of matrix size for threat-irrelevant targets only. Matrix size did not affect detection of threat-relevant targets—participants were equally fast at detecting snakes and spiders regardless of whether there were three or eight distracters, $F(1, 1237) = 0.276$, $p = .599$. Conversely, when detecting flowers and mushrooms, participants were significantly slower when

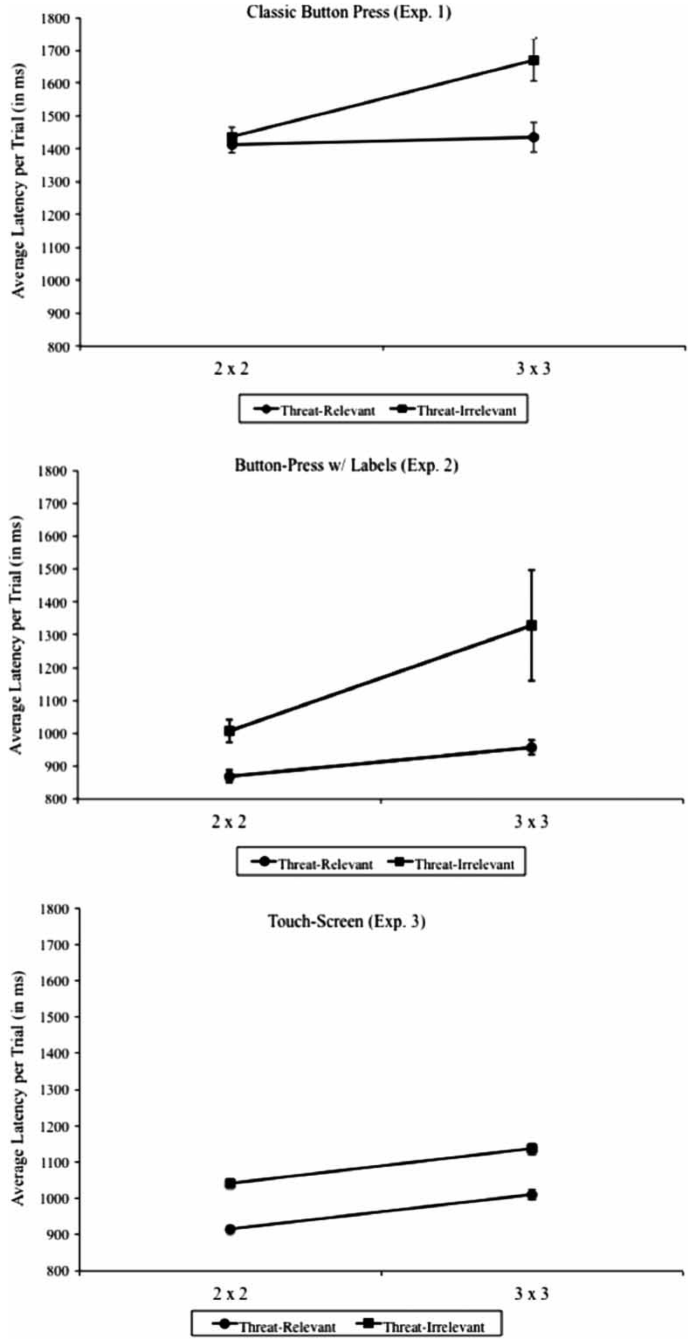

Figure 1. *Average latencies to detect target stimuli in the button-press procedure in Experiment 1, the modified button-press procedure in Experiment 2, and the touch-screen method in Experiment 3. There was only a target by matrix size interaction for Experiment 1, indicating that detection of threat-relevant targets was not affected by number of distracters in each matrix, whereas detection of threat-irrelevant targets was faster in 2 ×2 than in 3 ×3 matrices. Such an interaction was not found in Experiments 2 and 3.*

there were eight distracters as opposed to three, $F(1, 1242) = 14.3$, $p = .000$ (see Figure 1, top).

Finally, we examined the errors participants made during the detection task. In a 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA on the number of errors made in the task for target present matrices, we found a main effect of Target, $F(1, 3518) = 16.0$, $p = .000$, a main effect of Matrix Size, $F(1, 3518) = 28.0$, $p = .000$, and a Target by Matrix Size interaction, $F(1, 3518) = 8.8$, $p = .003$. Participants made more errors when detecting threat-irrelevant targets (*proportion of errors over total number of trials* = .11) than when detecting threat-relevant targets (.07). The interaction indicates that there was a larger difference in the errors between matrices with three and eight distracters for flower and mushroom targets (eight distracters, $M = 0.20$; three distracters, $M = 0.07$), $F(1, 1242) = 46.3$, $p = .000$, than there was for snake and spider targets (eight distracters, $M = 0.10$; three distracters, $M = 0.06$), $F(1, 1237) = 6.0$, $p = .014$. There were no significant effects for errors in target-absent matrices.

Touch-screen method

We used the touch-screen method to attempt to replicate findings reported by LoBue and colleagues (LoBue, 2010a; LoBue & DeLoache, 2008), and to compare the pattern of results obtained for the touch-screen paradigm with results from the standard button-press paradigm (Öhman et al., 2001). A mixed-effects ANOVA was conducted on latency to detect the threat-relevant versus threat-irrelevant targets. As in previous work, there was a significant main effect of Target, $F(1, 1238) = 50.1$, $p = .000$, with threat-relevant targets ($M = 870.0$ ms) being detected more quickly than threat-irrelevant targets ($M = 990.0$ ms).

To examine the errors participants made across matrices, a mixed-effects ANOVA was undertaken on the number of errors made in the task, revealing a main effect of Target, $F(1, 2493) = 12.1$, $p = .001$. Consistent with previous findings, participants made more errors when detecting threat-irrelevant targets(.01) than when detecting threat-relevant targets (.00).

Correlations between methods

To examine whether there is a relationship between behavioural responding in the standard button-press task and the touch-screen task, we ran additional correlational analyses on each participant's average latency to detect threatening and non-threatening targets in 3 × 3 matrices between tasks. Results indicated that there were only significant correlations within the same task, not between them. More specifically, there was a significant correlation between the detection of threatening and non-threatening targets within the button-press task ($r = .750$, $p = .001$), and within the touch-screen task ($r = .513$, $p = .007$), but correlations between tasks were very small and not statistically significant ($r = -.14$ to .07; see Table 1). These findings suggest that although the button-press and touch-screen tasks produce a similar pattern of results with regard to detection of threatening versus non-threatening stimuli, there is little or no relationship in behavioural responding between the two.

EXPERIMENT 2

The results of Experiment 1 suggest that across both detection paradigms, participants detected threat-relevant targets more quickly and accurately than threat-irrelevant targets. This is consistent with previous work using both paradigms (LoBue, 2010a; LoBue & DeLoache, 2008; Öhman et al., 2001). These results thus confirm that the touch-screen paradigm produces the same pattern of results as the classic button-press paradigm within the same participants.

Further, this study suggests that some of the differences between the two paradigms described above do not necessarily lead to differences in responding. First, low-level procedural differences, such as the number of trials used, specific photographs displayed, whether there were practice trials, etc., did not lead to differences in the pattern of results obtained. Second, the nature of the behavioural response required for each methodology, such as having to reach out and touch a threat-relevant stimulus versus simply pressing a button, did not change the pattern of results. Finally, knowing that there was a target present did not change the overall pattern of results. Even though in one procedure participants searched for a discrepant target and in the other they searched for a particular target, participants detected the presence of threats more quickly than non-threats across paradigms.

Despite these similarities, some of the findings from Experiment 1 suggest that there could be important differences between the paradigms as well. First, the fact that the two search tasks produce a similar *pattern* of results does not mean that they measure exactly the same process, as the actual search strategies and cognitive and perceptual processes that underlie them might differ between paradigms. In fact, the correlational analyses suggest that there is little relationship between responding in one task and responding in the other. Second, although the results of Experiment 1 demonstrate the same response patterns across the two paradigms, one procedural difference—knowing that a target is present in each matrix—might affect the search *strategies* participants employ to detect the target. As mentioned above, Öhman and colleagues (2001) reported evidence that adults detect threatening targets automatically. In other words, they found that the number of distracters present in each matrix did not affect detection of threatening targets. This issue was not addressed in Experiment 1, as we sought to replicate the touch-screen and button-press paradigms exactly.

Experiment 2 attempted to clarify this issue by more carefully controlling elements of the button-press paradigm so that it was more similar to the touch-screen method. In order for the touch-screen paradigm to be usable with children, all matrices contain a target, and the target is explicitly labelled. Asking individuals to find a discrepant photograph among varying sized matrices with varying categories of photographs is too difficult for young participants, so such modifications were necessary in order make the procedure appropriate for children (LoBue & DeLoache, 2008). In order to more closely examine whether these modifications change the search strategy participants use to detect targets, we attempted to modify the button-press paradigm so that it more closely resembled the touch-screen procedure. In Experiment 2, adults participated in both the touch-screen visual search paradigm and a modified version of the button-press paradigm. In this study, only target-present matrices were used in the button-press procedure to make it more similar to the touch-screen procedure. Further, participants were told explicitly to detect a specific target in each matrix.

Based on the results of Experiment 1, we did not expect these modifications to affect the overall pattern of results: Participants should detect the threatening stimuli in both procedures more quickly than the non-threatening stimuli. However, it may affect the search strategy participants use to detect targets—it is possible that knowing a target is present in each matrix would recruit more top-down processes for detection, which are typical of serial search, and that an initial parallel or automatic search would no longer be necessary. The current research did not argue for or against the automaticity view—our goal was to provide a validation of the touch-screen method and produce recommendations for researchers interested in studying visual search. Thus, we felt that it was important to see if procedural differences changed the strategies participants used to detect threatening targets.

Method

Participants

Participants were 24 university students, 12 female and 12 male ($M_{age} = 19$ years; range = 18–23). Two additional participants were excluded for failure to follow directions.

Standard button-press method

The button-press procedure was identical to that of Experiment 1 with a few exceptions. Participants only received target-present matrices (72 3×3 matrices, and 64 2×2 matrices). The matrices were presented in four blocks, based on the target—one block for snake targets, one block for flower targets, one block for spider targets, and a fourth block for mushroom targets. The order of the blocks was counterbalanced across participants. Before each block of trials, directions appeared on screen instructing participants to detect a specific target on the screen and press a button on the keyboard. Latency to button press was automatically recorded from the onset of each matrix.

Touch-screen method

The touch screen procedure used in Experiment 2 was identical to the procedure used in Experiment 1.

Results

Modified button-press method

The goal of Experiment 2 was to examine whether knowing that a target is present in each matrix changes behavioural responding in detection tasks. First we analysed latency to detect the target stimulus in a 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA. The analysis yielded a main effect of Target, $F(1, 2226) = 15.1$, $p = .000$, and a main effect of Matrix Size, $F(1, 2226) = 9.8$, $p = .002$. Replicating the findings of both Öhman et al. (2001) and Experiment 1, threat-relevant targets ($M = 898.4$ ms) were detected more quickly than threat-irrelevant targets ($M = 1{,}114.3$ ms). Also, targets in 2 × 2 matrices ($M = 937.2$ ms) were detected more quickly than in 3 × 3 matrices ($M = 1{,}140.2$ ms). However, contrary to the results of Experiment 1, there was no significant Target by Matrix Size interaction, indicating that participants were equally affected by an increase in the number of distracters across target categories.

We also examined errors made by participants across matrices in a 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA. The analysis yielded a main effect of Target, $F(1, 3163) = 92.2$, $p = .000$. Again participants made more errors when detecting threat-irrelevant targets (.05) than when detecting threat-relevant targets (.00). Again, contrary to the results of Experiment 1, there was no Target by Matrix Size interaction.

Touch-screen method

The touch screen method was again used in order to compare results from the standard button-press paradigm with the touch-screen paradigm. A mixed-effects ANOVA on latency to detect the target yielded a significant main effect, $F(1, 1188) = 10.2$, $p = .001$. Consistent with previous work, threat-relevant targets ($M = 990.0$ ms) were detected more quickly than threat-irrelevant targets ($M = 1{,}060.0$ ms). A mixed-effects ANOVA was also undertaken on the number of errors made in the task and yielded no significant effects, $F(1, 2398) = 0.21$, $p = .649$.

Correlations between methods

To examine whether there was a relationship between behavioural responding in the standard button-press task and the touch-screen task, we again ran additional correlational analyses on each participant's average latency to detect threatening and non-threatening targets in 3 × 3 matrices between tasks. Unlike the results of Experiment 1, when participants were told to search for a particular target, several significant correlations emerged within and between the tasks. The correlations ranged from $r = .341$ to .766; most were statistically significant, and the ones that were not still carried medium sized correlations and likely did not reach significance because of the small sample size (see Table 1). The only small relationship we found was in the detection of non-threatening targets between tasks ($r = .066$, $p = .766$). These results indicate that there is a significant relationship between behavioural responding in the button-press and touch-screen tasks when participants are explicitly told to search for a specific target.

EXPERIMENT 3

The results of Experiment 2 once again confirm that across detection paradigms, participants detected threat-relevant targets more quickly and accurately than threat-irrelevant targets. However, contrary to the results of Experiment 1, there was no significant target by matrix size interaction in Experiment 2, indicating that participants were

Table 1. *Correlations between average latency to detect threatening and non-threatening targets for Experiments 1 and 2*

	Button-press threat	*Button-press non-threat*	*Touch-screen threat*	*Touch-screen non-threat*
Experiment 1				
Button-press threat	1.000	**.750****	.041	.061
Button-press non-threat	**.750****	1.000	.070	−.141
Touch-screen threat	.041	.070	1.000	**.513****
Touch-screen non-threat	.061	−.141	**.513****	1.000
Experiment 2				
Button-press threat	1.000	.341	**.463***	.356
Button-press non-threat	.341	1.000	**.544****	.066
Touch-screen threat	**.463***	**.544****	1.000	**.766****
Touch-screen non-threat	.356	.066	**.766****	1.000

Note: $^{*}p < .05$; $^{**}p < .01$.
Bold indicates the significant correlations.

equally affected by an increase in the number of distracters across target categories. This suggests that when searching for specific targets that are labelled prior to the task, there is no evidence the search occurs automatically for threat. Thus far, it is unclear whether this result would also hold for the touch-screen paradigm in which the target is always labelled, as the paradigm has only been used with 3 × 3 matrices. In Experiment 3, we sought to explore this issue further by examining detection of threatening and non-threatening stimuli in both 2 × 2 and 3 × 3 matrices using the touch-screen procedure.

Method

Participants

Participants were 21 university students, 14 female and 7 male ($M_{\text{age}} = 19$ years; range = 18–24). Four participants completed all tasks except the 2 × 2 mushroom target task, one participant completed all but the 3 × 3 snake target task, and one participant completed all but the 2 × 2 snake target task. These conditions were considered missing data in the analyses. All participants tested here were recruited from the Rutgers University human subjects participant pool and received course credit for their participation. The Rutgers University Institutional Review Board approved all procedures and all participants signed an informed consent.

Touch-screen method

The touch-screen procedure used in Experiment 3 was identical to the procedure used in Experiments 1 and 2 with one exception. Instead of performing the procedure four times, in Experiment 3 participants performed the touch-screen procedure eight times, detecting snakes among flowers, flowers among snakes, spiders among mushrooms, and mushrooms among spiders in both 2 × 2 and 3 × 3 matrices. The order of tasks was random for each participant.

Results

A 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA was conducted on latency to detect the

Table 2. *Average latency to detect the target stimuli across procedures for Experiments 1 to 3*

	2 × 2		*3 × 3*	
	Threat	*Non-threat*	*Threat*	*Non-threat*
Button-press (Exp. 1)	1411.5	1437.4	1435.9	1671.7
Button-press (Exp. 2)	868.5	1007.4	957.7	1329.6
Touch screen (Exp. 3)	915.7	1040.6	1010.7	1136.1

targets. As in the previous experiments, there was a significant main effect of Target, $F(1, 4181) = 9.9$, $p = .000$, with threat-relevant targets ($M = 953.0$ ms) being detected more quickly than threat-irrelevant targets ($M = 1{,}088.2$ ms). There was also a main effect of Matrix Size, $F(1, 4181) = 23.4$, $p = .000$, with participants detecting targets in 2×2 matrices ($M = 981.9$ ms) more quickly than targets in 3×3 matrices ($M = 1{,}074.0$ ms). Importantly, there was no significant interaction, $F(1, 4181) = 0.0$, $p = .983$ (see Figure 1). An additional 2 (Target) × 2 (Matrix Size) mixed-effects ANOVA was conducted on the number of errors participants made in each condition. There was only a main effect of Matrix Size, $F(1, 158) = 4.4$, $p = .035$, with participants making fewer errors when detecting targets in 2×2 matrices ($M = .03$) than in 3×3 matrices ($M = .12$).

Analyses across methods

In order to compare findings across the three methods, we conducted several additional analyses comparing detection latencies for the target-present matrices in the classic button-press paradigm in Experiment 1, the modified button-press paradigm in Experiment 2, and the touch-screen paradigm in Experiment 3. Average latency to detect the target stimuli across procedures is listed in Table 2. First we examined latency to detect each target in 3×3 matrices only in a one-way mixed-effects ANOVA, resulting in a statistical significance, $F(2, 5629) = 98.5$, $p = .000$. Post hoc analyses (Tukey) indicated that the classic button-press method from Experiment 1 ($M = 1{,}496.5$ ms) was significantly different from the modified button-press method in Experiment 2 ($M = 1{,}067.1$ ms) and the touch-screen method in Experiment 3 ($M = 1{,}074.0$ ms), $p = .00$. The modified button-press and touch-screen methods were not significantly different from each other, $p = .979$. A similar analysis on the 2×2 matrices yielded a significant difference as well, $F(1, 5125) = 294.3$, $p = .000$, with the classic button-press method from Experiment 1 ($M = 1{,}424.4$ ms) producing significantly slower response times than the modified button-press method in Experiment 2 ($M = 937.8$ ms) and the touch-screen method in Experiment 3 ($M = 981.9$ ms), $p = .00$. Again, the modified button-press and touch-screen methods were not significantly different from each other, $p = .103$.

A second set of analyses was run adding threat-relevance as a variable to examine whether the methodologies differentially affected the detection of threat-relevant versus threat-irrelevant targets. In a 2 (Target) × 3 (Methodology) mixed-effects ANOVA on latency to detect the target in 3×3 matrices, there was a significant main effect of Method, $F(2, 5626) = 98.5$, $p = .000$, a significant main effect of Threat, $F(1, 5626) = 23.7.9$, $p = .000$, with no interaction, $F(2, 5626) = 1.0$, $p = .383$. As in the previous analyses, threat-relevant targets were detected more quickly than threat-irrelevant targets, and the classic button-press method produced slower reaction times than the modified button-press method from Experiment 2 and the touch-screen method from Experiment 3. The same analysis on 2×2 matrices also yielded the same main effect of Method, $F(1, 5122) = 298.1$, $p = .000$, and Target, $F(1, 5122) = 29.0$, $p = .000$, with a significant Target by Method interaction, $F(1, 5122) = 3.9$, $p = .021$. Breakdown of the interaction suggests that there was a larger difference between methods when detecting threatening stimuli than when detecting non-threatening stimuli.

GENERAL DISCUSSION

In the current experiments we attempted to validate the new child-friendly touch-screen visual search methodology by comparing it to the classic button-press visual detection procedure within the same set of adult participants. The studies yielded two findings that have important implications for choosing a threat detection methodology. First, across all three experiments, participants consistently detected threat-relevant stimuli more quickly than threat-irrelevant stimuli. They also made more errors when detecting threat-irrelevant stimuli than when detecting threat-relevant stimuli. These findings replicate previous results using both procedures (LoBue, 2010a;

LoBue & DeLoache, 2008; Öhman et al., 2001). Thus, despite both high-level and low-level procedural differences between the button-press and touch-screen paradigms, both methodologies produce a consistent pattern of results with regards to detection of threat-relevant stimuli.

The second major finding is relevant to automaticity of detection. First, we replicated Öhman et al.'s (2001) original results using the classic button-press procedure in Experiment 1, demonstrating that only detection of threat-irrelevant stimuli was affected by the number of distracters in each matrix—detection of threat-relevant targets was unaffected by matrix size. However, when we modified the button-press paradigm in Experiment 2 so that participants were searching for specific targets that were labelled for them prior to the task, this result was not found with latency to detect the target, or with the number of errors participants made. We also failed to find such an interaction when comparing the detection of 2×2 and 3×3 matrices using the touch-screen procedure in Experiment 3. Thus, when participants knew which target they were searching for, both threat-relevant and threat-irrelevant stimuli were equally affected by adding distracters to the task. Similarly, the correlational analyses across the two studies emphasise that there was only a significant relationship in behavioural responding between the two methodologies in Experiment 2 where we explicitly told participants to search for specific targets. There was no such relationship in Experiment 1 where we replicated the touch-screen and button-press methods exactly. This suggests that the two search tasks might not be measuring exactly the same process despite the fact that they produce the same overall pattern of results with respect to detection.

These results have important implications for researchers choosing a visual search paradigm. First, using the touch-screen and button-press paradigm both result in superior detection of threat-relevant versus threat-irrelevant targets. Overall, the touch-screen paradigm and the modified button-press procedure yielded faster reaction times than classic button-press procedure, which produced the longest reaction times. Thus, it appears that labelling the target stimuli prior to detection resulted in shorter reaction times overall. Given that there were no significant differences between detecting targets in the touch-screen and modified button-press paradigm, there was no evidence that differences in behavioural responding (pressing a button vs. touching the screen) yielded any significant differences in detection. This is perhaps not surprising, as in the standard button-press task it is unclear whether there is a discrepant photo in each matrix so the search is exhaustive and must cover all locations to reach a decision; in the touch-screen and modified button-press tasks, participants already knew a target was present, so the search ends once the target is detected. These factors might have made the touch-screen and modified button-press reactions times faster overall. However, the *pattern* of results was the same across methods, with threat-relevant targets being consistently detected more quickly than threat-irrelevant targets. Thus, for researchers simply seeking to study detection of threat-relevant versus threat-irrelevant targets, the two procedures produce the same results.

Findings with regard to automaticity, however, did vary between paradigms. First, we replicated Öhman et al.'s (2001) finding with the button-press paradigm in Experiment 1 with respect to matrix size—threat-relevant targets were not affected by the number of distracters in each matrix, whereas participants were slower to detect threat-irrelevant targets when more distracters were present. In Experiment 2, we used a modified version of the button-press paradigm in which participants were told to find specific targets in each matrix. With this small modification, we failed to produce the interaction with matrix size reported by Öhman et al. (2001) and in Experiment 1 of the current investigation. Further, we failed to produce this interaction in Experiment 3 using the touch-screen procedure. Thus, if a researcher's goal is to examine *automaticity* of threat detection, it is important to use the traditional button-press paradigm, as paradigms in which the targets are labelled did not produce the same findings.

Such a discrepancy between methodologies with respect to automaticity in detection is perhaps not surprising given the nature of the two tasks. In the natural environment, it would be important to quickly detect the presence of threatening stimuli like snakes and spiders without being warned of their presence. In other words, while taking a casual walk through the woods, we might not be actively searching for dangerous threats, and there is certainly no one to tell us when a dangerous snake might approach. In this way, Öhman et al.'s (2001) paradigm is closer to what we might encounter in the real world, and thus might be more sensitive to capturing natural variation in detection most effectively. While the touch-screen procedure is useful and necessary for measuring detection in young children, participants already knew which target to expect. Although this produces the same pattern of findings with regard to overall speed of detection, it is less natural than the button-press model, and might thus be less effective in capturing subtler differences required in studying automaticity of detection.

Further, not knowing whether a discrepant photograph is present in each matrix might encourage parallel search. In other words, when simply searching for a discrepant photograph and not knowing what that photograph might be, individuals might first scan the entire visual field as a whole for any low-level differences that might help guide later search (Treisman & Gelade, 1980; Wolfe, 1994). This strategy is not as effective if an individual already knows the identity of the target. In this case, the participant might make use of more top-down strategies for search since they already have some knowledge about the target. It is important to note that Öhman et al.'s (2001) original contention about the automaticity of threat detection has received much criticism in the literature from other researchers who suggest that top-down strategies are necessary in producing a search advantage for emotionally valenced stimuli (e.g., Cave & Batty, 2006). As mentioned above, the current research does not argue for or against the automaticity view—our goal was to provide a validation of the touch-screen method and produce recommendations for researchers interested in studying visual search. Future research could provide more insights into *why* knowing the identity of the target changes the search patterns for each task, and whether adults do in fact detect threatening stimuli automatically in the button-press paradigm. More specifically, using an eye-tracker to measure precise eye-gaze patterns might reveal more specific information about differences in patterns of detection between the two tasks, and might better tap into whether they measure different processes for search entirely. An eye-tracking methodology might also provide important information about differences in the process of detection that might result from the two paradigms. Future research can address these important issues.

In conclusion, the current studies provide a validation of the touch-screen visual search method by comparing it directly to the classic button press paradigm. Results suggest that either methodology—the classic button-press procedure and the newer child-friendly touch-screen procedure—can be used to measure differences in overall detection latencies for threat-relevant versus threat-irrelevant stimuli. However, if a researcher's goal is to study more subtle characteristics of threat detection, such as automaticity of search, the classic button-press paradigm is preferred. This is not to discount the importance of the new touch-screen method—this new procedure is still the only one that can be used to study threat detection in participants as young as three years of age. Thus, overall, researchers' experimental hypotheses should drive which methodology they choose.

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