ARTICLE IN PRESS

Evolution and Human Behavior xxx (xxxx) xxx

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.elsevier.com/locate/ens

Are natural threats superior threats?

Danielle Sulikowski [a], [b], *

[a] Perception and Performance Research Group, School of Psychology, Charles Sturt University, Panorama Ave., Bathurst, NSW 2795, Australia
[b] School of Psychology, Charles Sturt University, Panorama Ave., Bathurst NSW 2795, Australia

ARTICLE INFO

Keywords:
Threat superiority effect
Visual search
Attention biases
Ontogenetic threats
Phylogenetic threats
Snakes and spiders
Weapons
Caution

ABSTRACT

Threat superiority effects describe the reaction time advantage for locating threatening objects in a visual search paradigm, compared to locating visually similar non-threatening objects. They are widely reported for threats of both natural (snakes and spiders) and man-made (guns and knives) origins. Across two experiments, the current study contrasts threat superiority effects for natural and man-made targets. When targets are not depicted held, snakes and spiders tended to exhibit larger threat superiority effects, and were searched for with additional caution, than were guns and knives. When snakes and spiders were depicted held and weapons wielded, systematic differences between the natural and man-made threats disappeared. This means the advantage for threats of natural origin observed when all targets were depicted not held may be attributable to differences in animation – snakes and spiders are alive and may strike at any time if in your vicinity, whereas a weapon can only inflict harm if wielded. From these data there is no evidence that evolved visual sensitivities to the basic shapes of venomous animals support faster detection and response times to these animals than can occur to targets such as guns and knives, whose shapes must be learned. The selection pressures that led to the evolution of such sensitivities (observable even in infancy) may therefore lie in protecting young children and babies from envenomation, before they even have the cognitive capacity to understand the dangers that snakes and spiders pose.

1. Introduction

Threat superiority effects are the attentive priority given to threatening targets relative to comparable non-threatening targets, in visual search tasks. Threats from the natural world, including snakes and spiders (Flykt, 2005; Öhman, Flykt, & Esteves, 2001; Sulikowski, 2012) are commonly used targets, and reliably capture attention more quickly than do similar non-threatening targets (including beetles, caterpillars, and frogs). Man-made threatening objects, typically weapons (Blanchette, 2006; Brosch & Sharma, 2005; Fox, Griggs, & Mouchlianitis, 2007; LoBue, 2010a; Subra, Muller, Fourgassie, Chauvin, & Alexopoulos, 2018; Sulikowski & Burke, 2014), also reliably produce threat superiority effects.

Much more information is available in the visual environment, than to which any organism could attend (Dukas & Kamil, 2001). Threat superiority effects presumably reflect adaptive mechanisms of attention that increase the likelihood that an individual will quickly detect a potential threat to their safety within their immediate environment. While fast detection of potential threats could yield obvious adaptive advantages, in the absence of immediate threats, there would still presumably be benefits in prioritising the vast information available (Abbott & Sherratt, 2013).

Differential prioritisation of non-threatening targets also occurs with baby (compared to adult) faces (Brosch, Sander, Pourtois, & Scherer, 2008), attractive opposite-sex others (Koranyi & Rothermund, 2012), and food (whereby hunger moderates attention for high calorie foods, Gearhardt, Treat, Hollingworth, & Corbin, 2012; and men and women differentially attend to the nutrients most valuable to them, Love & Sulikowski, 2018). Such targets are socially, sexually, and/or biologically relevant, and so responses to them have adaptive consequences. As such, threat superiority effects are best viewed as just one subset of a much larger group of empirical attentional biases. Collectively, these reflect a system of visual attention evolved and developed to maximise the utility of information processed from the surrounding environment (Abbott & Sherratt, 2013; Miller & Bee, 2012).

Much theoretical stock has been placed in whether threat superiority

---

* Corresponding author at: Perception and Performance Research Group, School of Psychology, Charles Sturt University, Panorama Ave., Bathurst, NSW 2795, Australia.

E-mail address: dsulikowski@csu.edu.au.

https://doi.org/10.1016/j.evolhumbehav.2021.08.003
Received 5 February 2021; Received in revised form 26 June 2021; Accepted 18 August 2021

Please cite this article as: Danielle Sulikowski, *Evolution and Human Behavior*, https://doi.org/10.1016/j.evolhumbehav.2021.08.003

effects differ between targets of natural (typically snakes, and spiders) versus man-made (typically weapons) origin. Unfortunately, several authors have framed utility-based (or relevance-based) explanations of attentional biases as inconsistent with evolutionary accounts of attentional biases (for example, Quinlan, 2013; Subra et al., 2018). An oft-repeated claim is that the mere existence of threat superiority effects in response to modern guns and knives, which were not present in our evolutionary past, challenge evolutionary accounts of attentional biases. Such claims invoke the false nature-nurture dichotomy, presuming that behaviours which are supported by developmental and experiential factors are 'learned' and, thus, by definition, 'not evolved'. The folly of this position has been thoroughly explicated elsewhere (Moore, 2001; Schneider, 2007). It is worth re-iterating, however, that no behavioural mechanism could ever be selected for how it operates in the absence of the organism's experience, development, environment, and opportunities to learn. This is for the simple reason that no behavioural mechanism has ever had the opportunity to operate in the absence of the organism's experience, development, environment, and opportunities to learn. Conversely, every behavioural mechanism that has ever been favoured by natural (or sexual) selection has been favoured because it provided an adaptive advantage *in the context of* the organism's experience, development, environment, and opportunities to learn. Evidence that a behaviour is dependent on learning, therefore, can never be evidence against the utility or legitimacy of theorising about the function and evolution of the mechanisms which produce that behaviour.

Lobue (LoBue et al., 2010; LoBue, 2012) have previously suggested that attentional biases for threat may arise via one of two pathways. The first is via evolved perceptual sensitivities, and the second via learning mechanisms. Although she argues that possessing both pathways would provide for more adaptive behaviour than either pathway on its own (LoBue, 2012, p.8), this dual-pathway model does not resolve the nature-nature dichotomy invoked by the relevance-based explanations of attentional biases discussed above. It merely proposes that attention biases for snakes and spiders are the result of "evolutionary adaptations" while weapons are detected quickly via "domain general learning mechanisms"(LoBue, 2012, pg.8). Crucially, this theory is silent as to whether there ought to be a systematic advantage to detecting ancient (snakes and spiders), compared to modern (weapons) threats.

The pitching of relevance-based, or experience-based explanations of attentional biases as mutually exclusive of evolutionary explanations is unfortunate because it has coloured most investigations that have directly compared threat superiority effects for natural and man-made threats. Such comparisons are important, not because they allow us to determine whether or not evolution has shaped mechanisms of visual attention, but because they might reveal differences in how, when, and why different types of threats are prioritised (Young, Brown, & Ambady, 2012), as well as by whom (Sulikowski & Burke, 2014). In the context of threat superiority effects, natural and man-made threats differ in at least two key aspects. Natural threats, which have almost exclusively been operationalised as venomous snakes and spiders, share a comparatively long evolutionary history with people. Our visual system has potentially had sufficient time to evolve sensitivities to the defining visual characteristics of these creatures, such as the coiled shape of snakes (LoBue & DeLoache, 2011), and the distinctive eight-legged blob shape of spiders (Rakison & Derringer, 2008).

Modern weapons have appeared comparatively recently. While humans have a long evolutionary history of interpersonal violence, which may well have selected for attention biases for weapons (once the individual has learned to recognise a weapon, Sulikowski & Burke, 2014), few would argue that modern guns and knives have been around long enough to support the evolution of experience-independent sensitivities to their defining visual characteristics. Direct comparisons between the threat superiority effects induced by natural and man-made threats, therefore, can reveal whether or not such visual sensitivities can support faster detection and response times than are possible in their absence.

The second way in which natural and man-made threats differ is animation. Snakes and spiders are alive and can potentially inflict harm, or even kill, if they are in an individual's immediate vicinity. Weapons are inanimate objects. Unless at the disposal of another individual, they present no imminent danger. If targets are depicted devoid of any contextual background the images of the snakes and spiders present an apparent immediate threat. Similar images of weapons, though, are ambiguous as to the immediacy of the threat. When the target images are depicted within a contextual background showing the weapons not being held, then, in contrast to the animal targets, the weapon images contain explicit information that they present no immediate threat. Prior studies have tended to present weapons targets in one of these ways (Blanchette, 2006; Brosch & Sharma, 2005; Fox et al., 2007). Since we know that even within groups of threatening targets, responses vary according to the level of threat implied (Sulikowski, 2012), differences in responses to natural versus man-made threats observed when the weapons are not depicted wielded could be due to differences in the immediacy of the threat, rather than to the threats' natural or man-made status. Notably, Subra et al. (2018) presented their weapons wielded, in the only study to observe a stronger attentional bias for weapons over venomous animals (although these authors adopted a peripheral cueing task, rather than a visual search task).

Although a multitude of studies have demonstrated threat superiority effects for targets of either natural or man-made origin, far fewer studies have directly compared attentional biases between these two types of threats. Brosch & Sharma, 2005, directly compared threat superiority effects for snakes and spiders, with those for guns and syringes, and found no systematic difference between them. Problematically, this study confounded the distractors between threatening and non-threatening targets (using threatening distractors when the targets were non-threatening and vice versa). Estimates in the size of the threat superiority effect rely on differences in response time between otherwise similar threatening and non-threatening targets. So, confounding the distractors between these conditions also confounds estimates of the size of the threat superiority effect. Blanchette (2006) similarly confounded the distractors between threatening and non-threatening targets. Like Brosch and Sharma (2005), Blanchette (2006) observed robust threat superiority effects for all targets, but no evidence that these were consistently larger for either type of threat.

The threat superiority effect refers precisely to threatening and non-threatening response time differences. There is potentially some debate as to whether direct comparisons between absolute target present response times between threatening natural and man-made targets may provide a better indicator of whether natural threats capture attention more effectively than do man-made ones. Unfortunately, Blanchette (2006), also confounded distractors between the natural and man-made threats (surrounding each target with distractors from the same origin only). Fox et al. (2007) surrounded natural and man-made targets with the same distractors. These were all of a natural origin (Fox et al., 2007, Experiment 1, potentially confounding target-distractor similarity with target origin, Duncan & Humphries, 1989). In any case, neither Blanchette (2006), Brosch and Sharma (2005), nor Fox et al. (2007) observed consistently faster response times to locate either the natural or man-made threats. In Experiment 2, Fox et al. (2007), resolved the issues with target-distractor similarity, but still observed similar response times between natural and man-made threatening targets.

More recent studies have used peripheral cueing tasks to measure attentional biases toward natural and man-made threats (Subra et al., 2018; Young et al., 2012). Such tasks present the cue image (weapon or animal) in the periphery, briefly followed by a neutral target (such as a dot) on the same or opposite side as the cue. When the dot appears on the opposite side to the cue responses are slower (relative to when it appears on the same side) to the extent that the cue has attracted and held attention (in spite of participants being instructed to ignore the cue). Young and colleagues observed no general bias to attend to natural or man-made threats preferentially, but reported context-dependent biases. When natural (or man-made) environments were primed, participants preferentially attended to the congruent threatening targets. Subra et al. (2018) presented ancient and modern threats simultaneously to participants and found a bias toward the modern threats.

In the current study, the visual search tasks adopted a mixture of natural and man-made non-threatening distractors for all target types, with distractor sets precisely matched between threatening and non-threatening and natural and man-made targets, avoiding issues associated with confounded distracters. Experiment 1 permitted direct comparisons between response times to locate natural versus man-made threats. Experiment 2 included non-threatening targets, enabling comparisons between the threat-superiority effects associated with natural and man-made targets, respectively.

Most investigations of threat superiority effects have used visual search paradigms in which participants must indicate whether or not a target is present among multiple distracter stimuli. Criticisms of this paradigm (Quinlan, 2013; Subra et al., 2018) have questioned its reliability, but the design of the current study addresses many of these criticisms. Traditionally, threat superiority effects have embedded a threatening target among benign distractors, and compared response times to locate that target with the inverse presentation, wherein a benign target is embedded among threatening distractors. Quinlan (2013) rightly points out that such designs confound the distracter stimuli. It is not possible to attribute faster response times to the target, as opposed to the distractors, when both differ between key conditions. He also criticises the lack of basic similarity between threatening and non-threatening targets, where prior studies compared threatening snakes and spiders, with non-threatening flowers and mushrooms. In the present experiments, distracter sets are heterogenous and matched between threatening and non-threatening targets. Similarly, non-threatening targets were chosen because of their basic similarity to the threatening targets (spiders versus beetles, for example).

Quinlan (2013) also noted inconsistencies in response times during target absent trials across various prior studies. A cogent explanation for the apparent discrepancies, however, lies in considering processes of decision-making as well as attentional capture during these tasks (Sulikowski, 2012). Decision-making on target-absent trials does not consist of serial inspection of each distractor item, followed by the decision to declare the target absent once all items have been inspected (Chun & Wolfe, 1996). Rather it comprises a timed period of search, during which the probability that the target is present (given that it has not yet been located) decreases. Once the amount of time it normally takes to find the target has passed (as indicated by prior experience on target present trials), the participant becomes increasingly confident that the target is in fact absent, and at some point, makes the decision to declare it so (Chun & Wolfe, 1996; Sulikowski, 2012). From this perspective the difference in response times between target present and target absent trials provides an index of how certain the participant needs to be that a target truly is absent before they make their decision, that is, how cautiously they are behaving. (See Quinlan, 2013, p. 1083 and Sulikowski, 2012, pp. 365–369, for a detailed account of apparent inconsistencies in target absent response times across studies and how predicted differences in caution can account for these findings.)

Based on the above reasoning, Sulikowski (2012) derived a caution score. Participants return high caution scores when searching for threatening compared to non-threatening animals (Sulikowski, 2012) and weapons (Sulikowski & Burke, 2014); and caution further increases when threatening animals are presented in peri-personal space and weapons are presented wielded (Sulikowski, 2012; Sulikowski & Burke, 2014). The presumption is that participants search more cautiously because the costs of failing to notice a potentially dangerous target in the immediate vicinity is greater for threatening than non-threatening objects. Consistent with this, men and women exhibit more caution when searching for the macro-nutrients most valuable to them (protein- and carbohydrate-based foods, respectively), especially when they are hungry (Love & Sulikowski, 2018). In the current study we examine caution scores to determine whether they are systematically higher or lower for natural compared to man-made targets.

The current study comprises two experiments. The first compares accuracy, response time, and caution for participants searching for natural (spiders and snakes) and man-made (guns and knives) threatening targets in a visual search task. This study provides for a direct comparison between responses to natural and man-made threats in a paradigm in which the distractor stimuli are identical (a combination of natural and man-made objects) across the target origin divide. In Experiment 2, participants searched for these same threatening targets, as well as for similarly shaped non-threatening targets. All targets were depicted in two contexts: held and not held. Across both experiments the aims were to investigate whether potential innate visual sensitivities to their defining characteristics has afforded natural threats overall faster response times than man-made threats; whether natural or man-made threats elicited higher caution scores; and whether depicting all threats as immediate (weapons wielded, and animals held) reduced or removed observed differences in response time and caution between animate (natural) and inanimate (man-made) threatening targets.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Thirty-three female (aged 18–50, M = 23, SD = 6.3) and 15 male (aged 19–43, M = 25.5, SD = 6.4) Australian participants were recruited from an intermediate level psychology course. Participants were not rewarded for participating and all gave informed consent. The ethical aspects of the study were approved by the Macquarie University Human Research Ethics Committee, (Ref. no. HE27FEB2009-RO6284L&P). During testing participants completed a series of visual search tasks in addition to those reported in the current paper (see Sulikowski, 2012, and experiment 1 of Sulikowski & Burke, 2014). These tasks were completed in counter-balanced order over the 48 participants.

2.1.2. Stimuli

Photos were sourced either online or from the private collection of the author. All stimulus to rectangles of 198 × 283 pixels at a resolution of 72 pixels/in., and presented during the experiment in full RGB colour against a black background. Copyright restrictions prevent publication of the full stimulus set, however, it is available by request from the author.

2.1.2.1. Target and distracter stimuli. Thirty-six target images, nine from each of four categories (spiders, snakes, guns and knives) and one hundred and eighty distracter images, ten from each of nine man-made (book, bottle, lamp, chair, mug, paintbrush, bowl, shoe and clock); and nine natural (cat, flower, tree, goldfish, frog, rock, butterfly, shell and bird) categories were used during the experiment.

2.1.2.2. Target-present and target-absent arrays. Each target-present trial presented a 3 × 3 grid of nine images including eight distracters (four natural and four man-made, all from different categories) and a target. Nine such arrays were used for each target category, with a different target image appearing in each of the nine positions exactly once. No single distracter image was used more than once within a set of nine target-present arrays. The nine target-absent arrays used for each target category were identical to the target-present arrays with the exception that the target was replaced by a distracter from a category with the same origin (natural versus man-made).

Unique sets of distracters (with no overlapping images) were used for the spider and snake targets, respectively. The distracter set used for the spider targets was then also used for the gun targets, and similarly, the snake set was also used for the knife targets. This afforded direct comparisons between the natural and man-made target response times, without the problem of confounded distracter sets.

2.1.3. Design

The experiment contained 4 conditions (varied within-subjects), determined by the category of the target object for which participants were instructed to search: spiders, snakes, guns and knives. Each condition contained 18 trials (9 target-present trials and 9 target-absent trials). Trials were blocked by condition and presented in random order within each condition. Participants also completed the four conditions in random order.

2.1.4. Procedure

Participants completed the experiment on a 17-in. iMac computer. The stimuli were delivered, and responses recorded by Superlab v4.0.3c for Mac. As a condition of ethics approval participants were initially shown some hardcopy photographs of spiders, snakes, guns and knives and instructed not to participate if they had any phobias or anxieties related to the stimuli, or were for any reason uncomfortable with the stimuli. This screening process did not rule out any potential participants.

The s-key and k-key on the keyboard were labelled 'absent' and 'present', respectively (counterbalanced across participants). On screen instructions told participants the target type they would be searching for at the beginning of each block of trials (snakes, spiders, guns or knives), and to respond by key press as quickly and accurately as they could as to whether a target was absent or present. Each trial began with a white fixation cross on a black screen (for 500 ms) followed by the array of images, which remained on the screen until the participant responded.

2.1.5. Dependent variables

In addition to mean accuracy (proportion correct) and reaction time (RT, mean RT for correct responses only), an additional dependent variable, the caution score, was calculated as follows:

$$\mathrm{RT}_{\mathrm{absent}} - \mathrm{RT}_{\mathrm{present}}$$

$$\mathrm{RT}_{\mathrm{absent}} + \mathrm{RT}_{\mathrm{present}}$$

where $\mathrm{RT}_{\mathrm{absent}}$ refers to the mean RT from the target-absent trials and $\mathrm{RT}_{\mathrm{present}}$ refers to the mean RT from the target-present trials. This formula creates a normalised score that reflects the relative difference between the mean RT of the target-absent and target-present trials, but is independent of the absolute RT values (see Sulikowski, 2012 for more detail regarding the derivation of this score).

2.2. Results

All analyses were conducted using SPSS v20 for Mac. All alpha values set to 0.05 unless otherwise indicated. The variable 'distracter set' is included in the following analyses. It groups the spider/gun targets and snake/knife targets due to their common distracters. Effects of this variable could, however, be due either to differences in distracter sets or to differences between responses to targets from the same origin (that is, differences between spiders and snakes, or differences between guns and knives). Anonymous data are available in the supplementary material.

2.2.1. Accuracy

A repeated-measures ANOVA with target origin (2 levels: natural, man-made) and distracter set (2 levels) as within-subjects variables revealed a significant main effect of target origin, ($F(1,47) = 4.86$, $p = 0.032$, $\eta_\rho^2 = 0.094$), with participants locating the snakes more accurately than the knives ($p = 0.036$, $\eta_\rho^2 = 0.090$), though not the spiders more accurately than the guns ($p = 0.302$, $\eta_\rho^2 = 0.023$), see Fig. 1A. The distractor sets used were yoked between the snakes and knives, and between the spiders and guns, respectively, meaning that different distractor images surrounded the snakes versus guns, and the spiders versus the knives. The distractor sets were highly heterogenous, however, making systematic differences in low-level target-distracter similarity across the targets unlikely. Pairwise comparisons were therefore conducted between the yoked and unyoked natural and man-made targets (for accuracy, reaction time, and caution scores). For accuracy, spiders were located more accurately than were knives ($p < 0.001$, $\eta_\rho^2 = 0.305$), but snakes were not located more accurately than were guns ($p = 0.281$, $\eta_\rho^2 = 0.025$). Sex was originally included as a factor in the model but was dropped as it did not explain significant variance as a main effect or as part of an interaction (all $p > 0.49$).

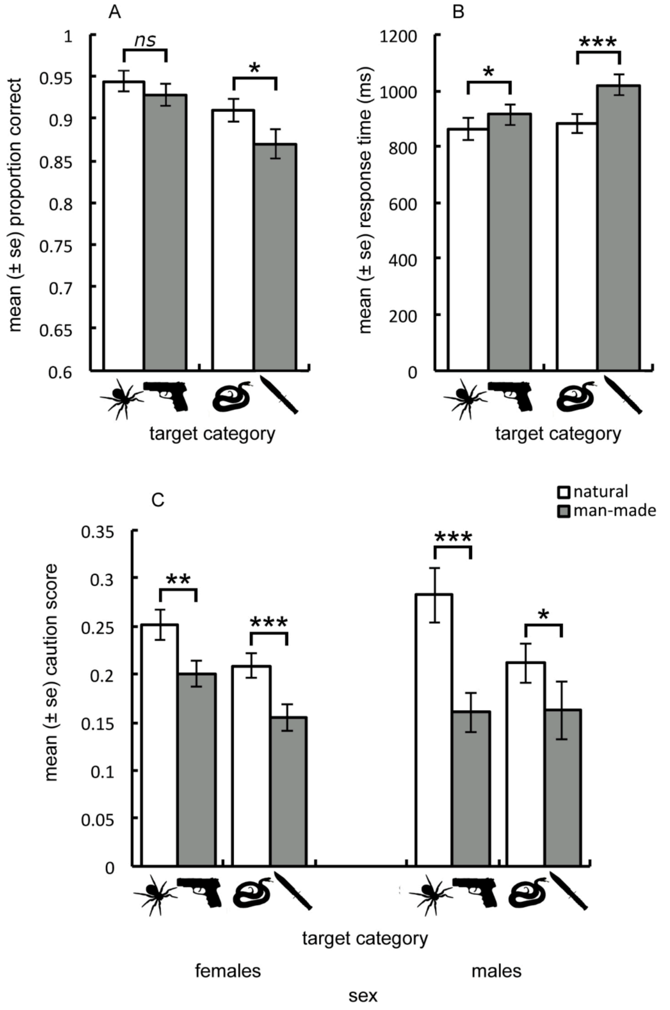

Fig. 1. Shows the mean (+/− se) proportion correct (A), response time (B) and caution scores (C) for participants searching for all four targets in Experiment 1. Participants exhibited faster, more accurate, and more cautious search for the natural, compared to man-made threatening targets. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, #$p < 0.1$, ns = not significant.

2.2.2. Reaction time

The same analysis described for the accuracy data was applied to response times. Again there was a significant main effect of target origin ($F(1,47) = 41.01$, $p < 0.001$, $\eta_\rho^2 = 0.466$), with participants locating the spiders more quickly than the guns ($p = 0.045$, $\eta_\rho^2 = 0.083$) and the snakes more quickly than the knives ($p < 0.001$, $\eta_\rho^2 = 0.465$), see Fig. 1B. In addition, spiders were also located more quickly than knives ($p < 0.001$, $\eta_\rho^2 = 0.433$), and snakes more quickly than guns ($p = 0.039$, $\eta_\rho^2 = 0.088$). As previously, sex was dropped from the initial model (all $p > 0.10$).

2.2.3. Caution score

The same analysis (this time with sex retained) was also applied to the caution scores. Again there was a main effect of target origin (F(1,46) = 46.215, $p < 0.001$, $\eta_\rho^2 = 0.501$), with participants exercising more caution in their search for spiders compared to guns ($p < 0.001$, $\eta_\rho^2 = 0.469$) and for snakes compared to knives ($p < 0.001$, $\eta_\rho^2 = 0.225$), see Fig. 1C. Participants also showed more caution when searching for spiders compared to knives ($p < 0.001$, $\eta_\rho^2 = 0.480$), and when searching for the snakes compared to guns ($p = 0.007$, $\eta_\rho^2 = 0.149$). The analysis also revealed a significant three-way interaction between target origin, distracter set and sex (F(1, 46) = 4.198, $p = 0.046$, $\eta_\rho^2 = 0.084$). While both males and females searched for both natural targets more cautiously than both man-made targets (all $p < 0.041$, all $\eta_\rho^2 > 0.088$), the interaction occurred as women exhibited more caution when searching for guns compared to knives ($p < 0.001$, $\eta_\rho^2 = 0.250$) while men exhibited similar caution with respect to the two weapons targets ($p = 0.925$).

3. Experiment 2

In Experiment 1 both men and women searched more accurately, more quickly, and more cautiously for threatening targets of a natural origin (venomous spiders and snakes) than for man-made threatening targets (guns and knives). Thus, when compared using identical distracters, natural threats are located more quickly and implicitly perceived as presenting a greater theft if left undetected, when compared to man-made threats. Presuming that people exhibit evolved, experience-independent visual sensitivities to snakes' and spiders' unique shapes (in addition to any experience-dependent mechanisms), these data suggest that innate visual sensitivities may support faster detection than is observed for weapons, whose defining visual characteristics must be learned.

These data, however, are also consistent with other explanations. In spite of our daily visual diet of man-made objects, the human visual system is more adept at recognising objects of natural, rather than man-made, origins. To examine this possibility, Experiment 2 required participants to search for both threatening and non-threatening man-made and natural targets. If the search advantage for spiders and snakes is due only to their natural origins and not to their threat status per se, then participants should show the same sized threat superiority effect for spiders (versus beetles) and snakes (versus lizards) as they do for guns (versus staplers) and weapon knives (versus kitchen knives). To the extent that the search advantage observed in Experiment 1 is due to the threatening status of spiders and snakes, however, participants should exhibit a larger threat superiority effects for objects of natural origin than for man-made objects.

The search advantage for spiders and snakes observed in Experiment 1 could also have arisen due to the immediacy of the threat presented by spiders and snakes, as animate objects, compared to inanimate weapons. The guns and knives in Experiment 1 were depicted unwielded, which means that the images contained explicit information that the weapons, while potentially dangerous, presented no immediate threat. This can be contrasted to the snakes and spiders, which if present in a person's vicinity could present an immediate threat. In Experiment 2, therefore, all targets were presented in two conditions: one which depicted the targets not held (as in Experiment 1) and another in which weapons (and non-weapon objects) were depicted wielded and the animals were depicted on or in a person's hand. In this latter condition, both natural and man-made targets are depicted presenting an immediate threat. If the search advantage for natural targets was due to the immediacy of the threat depicted, then we should observe similar sized threat superiority effects for targets of both natural and man-made origins when all targets are depicted in hands.

In Experiment 1 there was no evidence of a sex difference in response time or caution when searching for guns and knives, which is not entirely consistent with the findings of Sulikowski and Burke (2014), who reported a male search advantage for weapons. In that previous study, however, a male advantage for weapons was largest when the weapons were depicted wielded, and was only apparent in one of two studies (where the number of participants was much higher than in Experiment 1 of this paper) when weapons were not depicted wielded. From this perspective, therefore, it is not too surprising that a male advantage was not observed in Experiment 1 here. Therefore, the 'held' and 'not held' conditions described above also served to investigate whether the male search advantage for weapons is robust, and whether or not it requires that the weapons be depicted wielded.

3.1. Methods

3.1.1. Participants

Eighty female (aged 20–53, M = 34.3, SD = 8.2) and 54 male (aged 18–60, M = 35.5, SD = 11.3) Australian participants were recruited from introductory and intermediate-level psychology courses. An additional 3 male participants completed the task but were excluded for having excessively long (>30 trials with response times longer than 5 s) or short (>30 trials with response times shorter than 250 ms) response times. Participants received course credit for participating and all gave informed consent. The ethical aspects of the study were approved by the Charles Sturt University School of Psychology Ethics Committee, (Ref. no. 113–2011-18).

3.1.2. Stimuli

The search arrays were constructed similarly to those described for Experiment 1. For the 'not held' conditions distracter categories remained the same, however, the distracter set used for knife and snake targets in Experiment 1 was used for spider, gun, beetle and stapler targets in Experiment 2. The distracter set used for spider and gun targets in Experiment 1, was used for snake, knife, lizard and cooking knife targets in Experiment 2. All new target images (nine from each target category) were used for Experiment 2.

For the 'held' conditions, distracter categories were plants, cats, butterflies, flowers, birds, rocks, frogs, shells, soil, watches, musical instruments, tools, pens, paintbrushes, keyboards, racquets, knitting needles and hands on their own. All distracter images contained hands holding/manipulating the distracter objects. This ensured that participants still had to search for the held target object and could not differentiate targets from distracters, simply by looking for the image with the hands. One distracter set was used for spiders, guns, beetles and staplers, and a second set (with no overlapping images with the first set), was used for snakes, knives, lizards and cooking knives. Nine target images depicting the target object/animal held were used for each target category. Copyright restrictions prevent publication of the full stimulus set, however, it is available by request from the author.

3.1.3. Design

The experiment contained 16 conditions (varied within-subjects), in a 2 (target origin: natural, man-made) x 2 (hands: held, not held) x 2 (threat status: safe, dangerous) x 2 (distracter sets) design. Each condition contained 18 trials (9 target-present trials and 9 target-absent trials). Trials were blocked by condition and presented in random order within each condition. Participants completed either all the safe target conditions (in random order) first, or all the dangerous target conditions (also in random order) first (counterbalanced).

3.1.4. Procedure

The experiment was controlled by Inquisit Web v3.0.6 by Millisecond Software, and participants completed the experiment online. Participants were initially shown example images of spiders, snakes, guns and knives and instructed not to participate if they had any phobias or anxieties related to the stimuli, or were for any reason uncomfortable with the stimuli. This screening process did not rule out any potential participants.

On screen instructions told participants the target type they would be searching for at the beginning of each block of trials (snakes, spiders, guns, knives, lizards, beetles or staplers), and to respond by key press (‘a’ for absent and ‘p’ for present) as quickly and accurately as they could as to whether the target was absent or present. Each trial began with a white fixation cross on a black screen (for 700 ms) followed by the array of images, which remained on the screen until the participant responded. Trials were separated by a 400 ms inter-trial interval.

3.2. *Results*

Anonymous data are available in the supplementary material. Accuracy (proportion of correct response to target present trials), reaction time (RT, mean RT for correct target present responses only, excluding individual responses longer than 5000 ms and shorter than 250 ms), and caution (as calculated for Experiment 1) were calculated for each participant for each condition. Mixed-effects ANOVAs with target origin (2 levels: natural, man-made), threat (2 levels: safe, dangerous), hands (2 levels: not held, held) and distracter set (2 levels) as within-subjects variables, and sex, as a between-subjects variable, were applied to the accuracy data.

Reaction time data were analysed with similar models (target origin, threat, and distractor set as within-subjects variables) applied separately to the ‘not held’ and ‘held’ conditions (given the large mean RT difference between these conditions, Sulikowski, 2012). Additionally, age was retained as a covariate in the analyses of reaction times (‘not held’ conditions: $F(1,129) = 24.877$, $p < 0.001$, $\eta_{\rho}^{2} = 0.162$; ‘held’ conditions: $F(1,129) = 19.504$, $p < 0.001$, $\eta_{\rho}^{2} = 0.131$) and a further between-subjects variable (denoting whether participants searched for all the safe, or all the dangerous targets first) was also included. This was because participants tended to speed up over the course of the experiment resulting in significant first conditions completed-by-threat interactions in both the ‘not held’ ($F(1,129) = 77.633$, $p < 0.001$, $\eta_{\rho}^{2} = 0.376$) and ‘held’ ($F(1,129) = 115.155$, $p < 0.001$, $\eta_{\rho}^{2} = 0.472$) conditions.

Caution scores were analysed with an omnibus ANOVA as described for the accuracy data, which was subsequently followed by smaller models (target origin, threat, and distractor set as within-subjects variables) applied to ‘not held’ and ‘held’ conditions separately.

3.2.1. *Do natural targets show a search advantage over man-made targets, and does this persist even when both are depicted presenting an immediate threat?*

3.2.1.1. Accuracy. Significant main effects of threat ($F(1,132) = 34.286$, $p < 0.001$, $\eta_{\rho}^{2} = 0.206$) and target origin ($F(1,132) = 50.079$, $p < 0.001$, $\eta_{\rho}^{2} = 0.275$) were observed as participants located threatening targets more accurately than safe targets, and natural targets more accurately than man-made targets. These main effects were qualified by significant threat-by-target origin ($F(1,132) = 5.489$, $p = 0.021$, $\eta_{\rho}^{2} = 0.040$) and threat-by-target origin-by-hands ($F(1,132) = 8.026$, $p = 0.005$, $\eta_{\rho}^{2} = 0.057$) interactions. Pairwise comparisons revealed no simple effects of target origin within the ‘not held’ conditions (all $p > 0.1$), while all natural targets were found more accurately than their man-made counterparts in the ‘held’ conditions (all $p < 0.023$). All simple effects of threat were significant as expected (all $p < 0.030$) with the exception of knives in the ‘not held’ condition ($p = 0.061$), spiders/beetles in the ‘held’ condition ($p = 0.061$), and snakes/lizards in the ‘held’ condition (where lizards were located with more accuracy than were snakes, $p < 0.001$, see Fig. 2A and B).

3.2.1.2. Reaction time. The main effect of threat was significant for both the ‘held’ ($F(1,129) = 171.475$, $p < 0.001$, $\eta_{\rho}^{2} = 0.571$) and ‘not held’ ($F(1,129) = 345.065$, $p < 0.001$, $\eta_{\rho}^{2} = 0.728$) conditions. Within the ‘not held’ conditions, there was also a significant threat-by-target origin interaction ($F(1,129) = 62.241$, $p < 0.001$, $\eta_{\rho}^{2} = 0.325$), as participants exhibited larger threat superiority effects for targets of natural (spider/beetle, $p < 0.001$, $\eta_{\rho}^{2} = 0.520$; snake/lizard, $p < 0.001$, $\eta_{\rho}^{2} = 0.676$), rather than man-made, origin (gun/stapler, $p < 0.001$, $\eta_{\rho}^{2} = 0.392$; knives, $p < 0.001$, $\eta_{\rho}^{2} = 0.385$). Further, participants actually exhibited an advantage in locating the man-made threatening ($p = 0.013$, $\eta_{\rho}^{2} = 0.047$) and non-threatening ($p < 0.001$, $\eta_{\rho}^{2} = 0.460$) targets more quickly than their natural counterparts, suggesting that the effect of target origin in Experiment 1 was not due to a general advantage in identifying naturally occurring, compared to man-made, objects (see Fig. 2C).

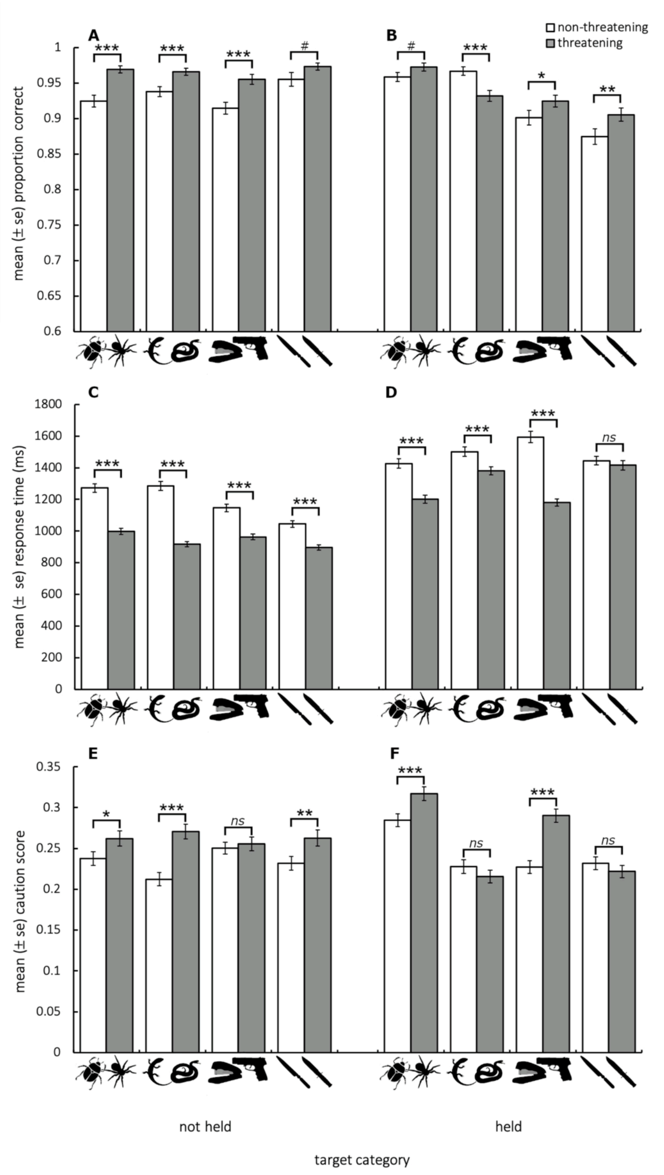

Fig. 2. Shows the mean (+/− se) proportion correct (A, B), response time (C, D) and caution scores (E, F) for participants searching for the four threatening and four non-threatening targets in Experiment 2. Targets were depicted either not held (A, C, E) or held (B, D, F). When targets were depicted not held, participants tended to show larger threat superiority effects for natural, compared to man-made targets. When targets were depicted held, however, similar threat superiority effects were exhibited for natural and man-made targets. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\#}p < 0.1$, *ns* = not significant.

Within the ‘held’ conditions, there was no significant main effect of target origin ($F(1,129) = 1.631$, $p = 0.204$), but a significant threat-by-target origin interaction ($F(1,129) = 4.513$, $p = 0.036$, $\eta_{\rho}^{2} = 0.034$), and a significant threat-by-target origin-by-distracter set interaction (F(1,129) = 21.093, $p < 0.001$, $\eta_\rho^2 = 0.141$) were both observed. These interactions were observed as participants exhibited a larger threat-superiority effect for guns (and staplers, $p < 0.001$, $\eta_\rho^2 = 0.619$) compared to spiders (and beetles, $p < 0.001$, $\eta_\rho^2 = 0.346$); but a smaller threat-superiority effect for weapon knives (and cooking knives, $p = 0.185$, $\eta_\rho^2 = 0.014$), compared to snakes (and lizards, $p < 0.001$, $\eta_\rho^2 = 0.130$, see Fig. 2D). Therefore, when both natural and man-made objects are depicted presenting an immediate threat, targets from neither origin exhibit a consistently larger threat superiority effect.

3.2.1.3. Caution. When both the held and not held targets were examined collectively, a significant main effect of threat was observed (F(1,132) = 33.886, $p < 0.001$, $\eta_\rho^2 = 0.204$), qualified by a significant threat-by-hands-by-target origin (F(1,132) = 10.817, $p = 0.001$, $\eta_\rho^2 = 0.076$) interaction. Pairwise comparisons examining the simple effects of hands revealed that, as expected, participants exhibited increased caution in the 'held' compared to the 'not held' condition for spiders ($p < 0.001$, $\eta_\rho^2 = 0.213$), guns ($p < 0.001$, $\eta_\rho^2 = 0.115$), and weapon knives ($p < 0.001$, $\eta_\rho^2 = 0.099$), and not for cooking knives ($p = 0.818$, $\eta_\rho^2 = 0.000$) or lizards ($p = 0.168$, $\eta_\rho^2 = 0.015$). Participants, however, also exhibited increased caution when beetles ($p < 0.001$, $\eta_\rho^2 = 0.160$) and staplers ($p = 0.004$, $\eta_\rho^2 = 0.063$) were depicted held, and decreased caution when snakes were depicted held ($p < 0.001$, $\eta_\rho^2 = 0.214$). When directly compared, the increase in caution for spiders was similar to that for beetles ($p = 0.630$), while the increase in caution for guns was significantly larger than that for staplers ($p = 0.045$, $\eta_\rho^2 = 0.030$).

Within the 'not held' target conditions, a significant threat-by-target origin (F(1,132) = 5.953, $p = 0.016$, $\eta_\rho^2 = 0.043$) interaction was observed. Linear contrasts revealed that while both natural ($p < 0.001$, $\eta_\rho^2 = 0.171$) and man-made ($p = 0.011$, $\eta_\rho^2 = 0.048$) targets exhibited significant effects of threat, these were three times larger for the natural targets. Similar levels of caution were exhibited toward the natural and man-made threatening targets ($p = 0.397$, $\eta_\rho^2 = 0.005$), while significantly less caution was exhibited when searching for natural non-threatening, compared to man-made non-threatening targets ($p = 0.010$, $\eta_\rho^2 = 0.049$, see Fig. 2E).

When the targets were depicted held there was a significant main effect of target origin (F(1,132) = 12.466, $p < 0.001$, $\eta_\rho^2 = 0.086$), qualified by significant threat-by-target origin (F(1,132) = 5.603, $p = 0.019$, $\eta_\rho^2 = 0.041$) and target origin-by-distractor set (F(1,132) = 27.431, $p < 0.001$, $\eta_\rho^2 = 0.172$) interactions. Pairwise contrasts revealed significant simple effects of threat for spiders (compared to the beetles, $p < 0.001$, $\eta_\rho^2 = 0.091$) and guns (compared to staplers, $p < 0.001$, $\eta_\rho^2 = 0.291$) but not toward the snakes or weapon knives (compared to the lizards, $p = 0.209$, $\eta_\rho^2 = 0.012$; and cooking knives, $p = 0.541$, $\eta_\rho^2 = 0.003$, respectively, see Fig. 2F).

3.2.2. Do sex differences in responses to weapons require those weapons to be depicted wielded?

3.2.2.1. Accuracy. No main effect of sex was observed (F(1,132) = 0.714, $p = 0.400$, $\eta_\rho^2 = 0.005$), but there were significant sex-by-threat (F(1,132) = 4.611, $p = 0.034$, $\eta_\rho^2 = 0.034$), and sex-by-target origin-by-distracter set (F(1,132) = 7.495, $p = 0.007$, $\eta_\rho^2 = 0.054$) interactions. Linear contrasts revealed that in the 'not held' conditions, men tended to locate the weapons more accurately than did women (guns: $p = 0.067$, $\eta_\rho^2 = 0.025$; knives: $p = 0.099$, $\eta_\rho^2 = 0.020$), with no significant sex differences for any other targets (all $p > 0.129$, $\eta_\rho^2 < 0.017$, see Fig. 3A). In the 'held' conditions, men located the weapon knives significantly more accurately than did women ($p = 0.028$, $\eta_\rho^2 = 0.036$), with no significant sex differences for any other targets (all $p > 0.232$, $\eta_\rho^2 < 0.011$, see Fig. 3B).

3.2.2.2. Reaction time. There was no significant main effect of sex for either the 'held' (F(1,129) = 0.430, $p = 0.513$) or 'not held' (F(1,129) = 0.956, $p = 0.330$) conditions. Within the 'not held' conditions, there was also no significant threat-by-target origin-by-sex interaction (F(1,129) < 0.100, $p = 0.991$), although uncorrected pairwise comparisons revealed that men located guns more quickly than did women ($p = 0.032$, $\eta_\rho^2 = 0.035$), with no other significant sex differences for any other targets (all $p > 0.125$, $\eta_\rho^2 < 0.018$). Both sexes exhibited threat superiority effects for all target pairs (all $p < 0.001$, $\eta_\rho^2 > 0.184$, see fig. 3C).

Within the held conditions, though, the threat-by-target origin-by-sex interaction was significant (F(1,129) = 4.583, p = 0.034, $\eta_\rho^2 = 0.034$). This was due to men locating the weapons significantly more quickly than did the women ($p = 0.031$, $\eta_\rho^2 = 0.036$), with no significant

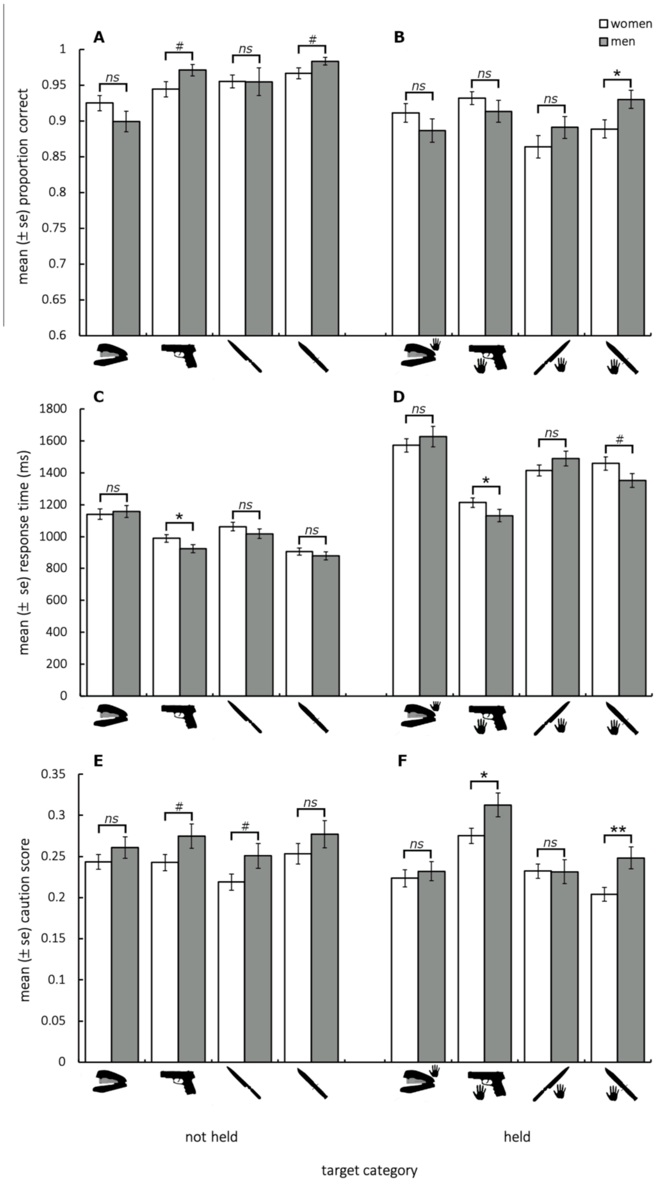

Fig. 3. Shows the mean (+/− se) proportion correct (A, B), response time (C, D) and caution scores (E, F) separately for male and female participants searching for the man-made objects. Targets were depicted either not held (A, C, E) or held (B, D, F). When targets were depicted not held men tended to find the guns more quickly, accurately and cautiously than did women, but not so for the weapon knives. When were depicted held, men located the guns more quickly and more cautiously, and the weapon knives more accurately and more cautiously than did women. $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\#}p < 0.1$, *ns* = not significant.

sex differences emerging for the non-weapon objects ($p = 0.335$) or dangerous animals ($p = 0.138$), although women did tend to locate the safe animals more quickly than did men ($p = 0.051$, $\eta_\rho^2 = 0.029$). Both sexes exhibited threat superiority effects for all target pairs (all $p < 0.009$, $\eta_\rho^2 > 0.052$), with the exception that women did not show such an effect for knives ($p = 0.257$, $\eta_\rho^2 = 0.010$, see Fig. 3D).

3.2.2.3. Caution. No significant main effects of sex were observed for either the 'held' ($F(1,132) = 0.085$, $p = 0.771$, $\eta_\rho^2 = 0.001$) or 'not held' ($F(1,132) = 1.892$, $p = 0.171$, $\eta_\rho^2 = 0.014$) conditions. Within the 'not held' conditions no significant simple effects of sex were observed for any individual target, although men tended to exhibit more caution than did women when searching for guns ($p = 0.057$) and cooking knives ($p = 0.064$), but not when searching for weapon knives ($p = 0.248$, see Fig. 3E). Within the 'held' conditions, however there were significant threat-by-sex ($F(1,132) = 4.058$, $p = 0.046$, $\eta_\rho^2 = 0.030$), target origin-by-sex ($F(1,132) = 21.003$, $p < 0.001$, $\eta_\rho^2 = 0.137$) and threat-by-target origin-by-sex ($F(1,132) = 4.185$, $p = 0.043$, $\eta_\rho^2 = 0.031$) interactions. Planned contrasts confirmed that these interactions occurred as men exhibited more caution than did women when searching for guns ($p = 0.024$) and weapon knives ($p = 0.003$), but not when searching for any other targets (all $p > 0.110$, see Fig. 3F).

4. Discussion

This study directly compared visual search task performance for threatening targets of natural versus man-made origins. In Experiment 1 participants searched for both types of targets and located the spiders and snakes more quickly and more accurately than the guns and knives. They also exhibited relatively more caution when searching for venomous animals compared to the weapons (Fig. 3).

In Experiment 2, when the targets were depicted as in Experiment 1 (not held), the natural targets again elicited larger threat superiority effects (defined as the decrease in response time between matched non-threatening and threatening targets) than did the man-made targets. This was not attributable to a simple perceptual advantage for objects of natural origin, since the absolute mean response times for the man-made targets (both threatening and non-threatening) were faster than those for the natural targets. This observation, however, is also inconsistent with the postulate that innate visual sensitivities to unique characteristics of spiders and snakes provides a search advantage relative to the learned biases that facilitate fast detection of weapons. When both natural and man-made targets were depicted presenting an immediate threat (weapons wielded and snakes/spiders in or on a person's hand) neither elicited consistently larger threat superiority effects. Taken together, these findings suggest that differences in the immediacy of the apparent threat between the animate snakes and spiders and the inanimate weapons, was likely responsible for the search advantage seen for natural over man-made objects in Experiment 1.

In Experiment 1, participants also searched for the natural threats with more caution than when searching for the man-made threats. This suggests that independent of visual sensitivities and attentional biases, there was a greater danger perceived in failing to detect the natural compared with the manmade targets. In the 'not held' conditions of Experiment 2, larger simple effects of threat were observed for the natural compared to man-made targets. Interpretation of this result is complicated, however, as participants expressed similar levels of caution toward the natural and man-made threatening targets. The larger simple effects of threat associated with the natural targets occurred as less caution was exhibited toward the non-threatening natural, compared to non-threatening man-made targets. Furthermore, when the targets were depicted held in Experiment 2, no clear patterns emerged favouring either type of target. With respect to the levels of caution exhibited on target absent trials, then, the same conclusions must be drawn as was the case for reaction time data. There is some evidence that natural threats may be perceived as more dangerous than are man-made threats, but this is likely due to the latter's inanimate status. When both are depicted presenting immediate threats, they are searched for with similar levels of caution.

The accuracy data tell a similar story. When the targets were not depicted held, participants located the threatening natural targets more accurately, than the man-made ones in Experiment 1, but showed no differences as a function of target origin in Experiment 2. When the targets were depicted held in Experiment 2, the advantage for targets of natural origin returned. This advantage, however, extended to threatening and non-threatening targets alike. Overall, then, there is no compelling evidence of a threat-specific accuracy advantage for targets of natural origin. These conclusions concur with those of prior visual search studies (Blanchette, 2006; Brosch & Sharma, 2005 and Fox et al., 2007). Even though the present design rectified confounds between distractor sets and targets present in these prior studies, it still yielded no robust evidence for consistently larger threat superiority effects for natural, compared to man-made, threats.

From the above, then, the adaptive function of developmentally innate visual sensitivities to venomous creatures (snakes: LoBue & DeLoache, 2010, 2011; spiders: Rakison & Derringer, 2008), is not to support faster detection of these animals in adulthood, than could occur if the same visual sensitivities arose via learning and experience (as they do for weapons). Another possibility is that these sensitivities arose via a Baldwin effect (Baldwin, 1902; aka genetic accommodation, Crispo, 2007). Under this scenario visual sensitivities to snakes and spiders first manifested via learning. Selection pressures then favoured earlier and earlier manifestation of these sensitivities, relying on fewer, and less specific, experiences. Ultimately, they came to develop early in an infant's life, prior to having any adverse experience with snakes or spiders, and prior to possessing the cognitive maturity to understand the danger these animals pose. This implies that the functional significance of innate visual sensitivities to venomous creatures is to protect very young children (who are most vulnerable to snake and spider venom due to their small body size, Sankar, Nabeel, Sankar, Priyambada, & Mahadevan, 2013) from envenomation. Further research confirming whether developmentally innate visual sensitivities for snakes manifest in infants as they do for spiders (Rakison & Derringer, 2008; sensitivities for snakes already been demonstrated in pre-school aged children, LoBue, 2010b), and the motor responses these facilitate would be informative.

Subra et al. (2018) recently demonstrated an attentional bias for weapons over venomous animals using a peripheral cueing task. The authors argued that this observation was consistent with a relevance (or utility) explanation of attentional capture because weapons presented a more ecologically relevant threat for their (French) participants than did snakes, spiders, and scorpions. In the current study, participants resided in Australia, where snakes and spiders are relatively common, compared to Europe. In Australia snakes, spiders, and weapons all present realisable threats, in a way that may not be generally true for French participants. This could account for the similarity of responses to natural threats and wielded weapons in the current study versus the attentive priority given to wielded weapons in Subra et al.' (2018) study.

This reasoning, however, deserves further scrutiny. It may be true that the probability of being threatened by a weapon is higher than the probability of being threatened by a venomous animal for the average French person. But in the situation simulated in the Subra et al. (2018) experiments that probability has eventuated; the snake or the gun is depicted there in the immediate vicinity. It is not clear that the likelihood of a scenario occurring is functionally relevant to determining the most adaptive response in that scenario. For this explanation to hold, it implies that biases of visual attention are shaped by learning and experience conforming not just to the level of threat a target represents, but also to the probability of its occurrence. This explanation is also consistent with previously reported context effects (Young et al., 2012), whereby participants exhibit attention biases for weapons in an urban context, and for venomous creature in a wilderness context. Further studies investigating the impacts of the participants' own environment, manipulating contextual cues, and manipulating the probability of different types of threats appearing across trials could combine to robustly test this possibility.

Sex differences favouring men in visual search tasks with weapon targets have previously been reported (Sulikowski & Burke, 2014). In Experiment 1 no such differences were observed. The sample size was relatively small, however, and the targets were not depicted wielded. In the 'not held' conditions of Experiment 2 (with its larger sample size), men tended to locate the weapons more accurately than did women, located the guns (but not the weapon knives) more quickly than did women, and tended to exhibit more caution when searching for guns than did women. When the weapons were depicted wielded in Experiment 2, however, more robust sex differences emerged, consistent with those reported by Sulikowski and Burke (2014). Men located both weapon targets more quickly, and with more caution than did women, and did so more accurately for the weapon knives (though not for the guns). Although sex differences when searching for weapons depicted not held likely exist (several findings tended in favour of men, and none in favour of women in the current study, and such findings were reported by Sulikowski & Burke, 2014), this effect is more robust and reliable when the weapons are depicted held. As such, this sex difference seems as strongly linked to cues of interpersonal aggression as it is to the weapons themselves. Whether other cues of interpersonal aggression would also trigger sex differences in attention and decision-making ought to be explored.

Depicting weapons and venomous creatures in hands was intended to increase the levels of immediate danger implied (relative to depicting those targets not held). For weapons, this context introduces cues of animation and intent. For venomous snakes and spiders, it is meant to imply that the animal is in immediate peri-personal space, and so within striking range for a bite. Caution scores for venomous spiders increase when those spiders are depicted on hands (Sulikowski, 2012; and Experiment 2 of the current study) and the same is true for weapons depicted wielded (Sulikowski & Burke, 2014; and Experiment 2 of the current study). No prior analyses of caution scores, however, have involved snakes depicted held. In the current study caution actually decreased when snakes were depicted held. It may be that pictures of a snake being held implied that the snake was safe to hold, and was therefore not venomous. Informal participant feedback suggested this as a possibility. In the 'held' conditions reaction times were still faster for snakes than lizards. This is consistent with people exhibiting perceptual and attentive sensitivities to a coiled snake shape, that is largely independent of any cognitive evaluation of the threat the snake poses, and drives fast reaction times to such stimuli (LoBue & DeLoache, 2011). It is also consistent with the caution score being primarily sensitive to the potential costs (in this case danger) of failing to detect a present target (Sulikowski, 2012), and relatively insensitive to shape and feature cues that drive fast response times.

Prior studies (for example, Blanchette, 2006; Brosch & Sharma, 2005) reporting threat superiority effects have confounded distractors across conditions, a design flaw rectified in the current study (as explained in the Introduction). Consequently, participants in the current study reported on the absence or presence of an a priori identified target, whereas in prior studies participants only reported as to whether or not a visual display contained a categorically discrepant image (target) among otherwise homogenous distractors. Such methodological differences however, are unlikely to jeopardise comparisons between the threat superiority effects reported here and those reported elsewhere for two reasons. Firstly, even though prior studies did not explicitly tell participants the identity of the potentially discrepant image, in the majority of cases, threatening targets were presented only among benign distractors and vice versa. Participants therefore learnt very quickly that when an array of flowers or mushrooms appeared on the screen, the potential target would be either a snake or a spider. Therefore, participants in such studies were generally aware of the threat status of the discrepant image in each trial prior to locating it. Secondly, Lobue and Matthews (2014) directly compared threat superiority effects observed with random trial order (so that the discrepant image's identity was not known until it was located) with those observed from trials blocked by target identity (in which participants therefore knew the potential discrepant image's identity for the full duration of each block). Other than a small reaction time advantage observed for all targets in the blocked design, the magnitude of the threat superiority effects observed were similar across both designs. Based on these considerations, it is unlikely that our participants' a priori knowledge of their targets' identities has systematically increased or decreased the threat superiority effects observed.

In the present study we tested the theory that the shared evolutionary history between humans and venomous animals has produced in people developmentally innate visual sensitivities to these animals' defining characteristics, promoting faster response times to locate these targets than can be supported by learned visual sensitivities toward man-made weapons. The totality of data do not support this theory. While the data from experiment 1 were consistent with it, experiment 2 suggested that a more parsimonious explanation is available. The faster response times, and more accurate and cautious search exhibited toward the natural, compared to the man-made targets is most likely due to the latter's inanimate status. When all targets were depicted held, or wielded, there were no consistent effects of target origin. While the Australian participants in this study showed similar sized threat-superiority effects irrespective of target origin, other studies using European participants have reported advantages for man-made over natural threats. More targeted comparisons between participants from environments varying in the frequency of violent crime and snake and spider bites, is needed to determine whether differences in participants' respective environments can account for these discrepancies.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2021.08.003.

References

Abbott, K. R., & Sherratt, T. N. (2013). Optimal sampling and signal detection: Unifying models of attention and speed-accuracy trade-offs. *Behavioral Ecology, 24*, 605–616.

Baldwin, J. M. (1902). *Development and evolution*. London: MacMillan Co.

Blanchette, I. (2006). Snakes, spiders, guns and syringes: How specific are evolutionary constraints on the detection of threatening stimuli? *Quarterly Journal of Experimental Psychology, 59*, 1484–1504.

Brosch, T., Sander, D., Pourtois, & Scherer, K. R. (2008). Beyond fear: Rapid spatial orienting toward positive emotional stimuli. *Psychological Science, 19*, 362–370.

Brosch, T., & Sharma, D. (2005). The role of fear-relevant stimuli in visual search: A comparison of phylogenetic and ontogenetic stimuli. *Emotion, 5*, 360–364.

Chun, M. M., & Wolfe, J. M. (1996). Just say no: How are visual searches terminated when there is no target present? *Cognitive Psychology, 30*, 39–78.

Crispo, E. (2007). The Baldwin effect and genetic assimilation: Revisiting two mechanisms of evolutionary change mediated by phenotypic plasticity. *Evolution: International Journal of Organic Evolution, 61*, 2469–2479.

Dukas, R., & Kamil, A. C. (2001). Limited attention: The constraint underlying search image. *Behavioral Ecology, 12*, 192–199.

Duncan, J., & Humphries, G. W. (1989). Visual search and stimulus similarity. *Psychological Review, 96*, 433–458.

Flykt, A. (2005). Visual search with biological threat stimuli: Accuracy, reaction times, and heart rate changes. *Emotion, 5*, 349–353.

Fox, E., Griggs, L., & Mouchlianitis, E. (2007). The detection of fear-relevant stimuli: Are guns noticed as quickly as snakes? *Emotion, 7*, 691–696.

Gearhardt, A. N., Treat, T. A., Hollingworth, A., & Corbin, W. R. (2012). The relationship between eating-related individual differences and visual attention to foods high in added fat and sugar. *Eating Behaviors, 13*, 371–374.

Koranyi, N., & Rothermund, K. (2012). When the grass on the other side of the fence doesn't matter: Reciprocal romantic interest neutralizes attentional bias towards attractive alternatives. *Journal of Experimental Social Psychology, 48*, 186–191.

LoBue, V. (2010a). What's so scary about needles and knives? Examining the role of experience in threat detection. *Cognition and Emotion, 24*, 80–87.

LoBue, V. (2010b). And along came a spider: An attentional bias for the detection of spiders in young children and adults. *Journal of Experimental Child Psychology, 107*, 59–66.

LoBue, V. (2012). Perceptual biases for threat. *Psychology of Bias*, 37–52.

LoBue, V., & Matthews, K. (2014). The snake in the grass revisited: An experimental comparison of threat detection paradigms. *Cognition & emotion, 28*(1), 22–35.

LoBue, V., & DeLoache, J. S. (2010). Superior detection of threat-relevant stimuli in infancy. *Developmental Science, 13*, 221–228.

LoBue, V., & DeLoache, J. S. (2011). What's so special about slithering serpents? Children and adults rapidly detect snakes based on their simple features. *Visual Cognition, 19*, 129–143.

LoBue, V., Rakison, D. H., & DeLoache, J. S. (2010). Threat perception across the life span: Evidence for multiple converging pathways. *Current Directions in Psychological Science, 19*, 375–379.

Love, H. J., & Sulikowski, D. (2018). Of meat and men: Sex differences in implicit and explicit attitudes toward meat. *Frontiers in psychology: Evolutionary Psychology, 9*, 559. https://doi.org/10.3389/fpsyg.2018.00559.

Miller, C. T., & Bee, M. A. (2012). Receiver psychology turns 20: Is it time for a broader approach? *Animal Behaviour, 83*, 331–343.

Moore, D. S. (2001). *The dependent gene: The fallacy of "nature vs. nurture."*. New York: Freeman.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*, 466–478.

Quinlan, P. T. (2013). The visual detection of threat: A cautionary tale. *Psychonomic Bulletin Review, 20*, 1080–1101.

Rakison, D. H., & Derringer, J. (2008). Do infants possess an evolved spider-detection mechanism? *Cognition, 107*, 381–393.

Sankar, J., Nabeel, R., Sankar, M. J., Priyambada, L., & Mahadevan, S. (2013). Factors affecting outcome in children with snake envenomation: A prospective observational study. *Archives of Disease in Childhood, 98*, 596–601.

Schneider, S. M. (2007). The tangled tale of genes and environment: Moore's the dependent gene: The fallacy of "nature vs. nurture". *The Behavior Analyst, 30*, 91–105.

Subra, B., Muller, D., Fourgassie, L., Chauvin, A., & Alexopoulos, T. (2018). Of guns and snakes: Testing a modern threat superiority effect. *Cognition and Emotion, 32*, 81–91.

Sulikowski, D. (2012). Venom, speed and caution: Effects on performance in a visual search task. *Evolution and Human Behavior, 33*, 365–377.

Sulikowski, D., & Burke, D. (2014). Threat is in the sex of the beholder: Men find weapons faster than do women. *Evolutionary Psychology, 12*(5) (147470491401200505).

Young, S. G., Brown, C. M., & Ambady, N. (2012). Priming a natural or human-made environment directs attention to context-congruent threatening stimuli. *Cognition & Emotion, 26*, 927–933.