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Original Article

Adaptive attention: how preference for animacy impacts change detection☆

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ABSTRACT

The selective nature of visual attention prioritizes objects in a scene that are most perceptually salient, those relevant to personal goals, and animate objects. Here we present data from two intentional change detection studies designed to determine the extent to which animals in a scene distract from other changes. Our stimuli depicted camouflaged animals in their natural habitats. We compared participants' responses to changing animals and inanimate objects selected from the same pictures, thus improving on other methodologies studying this effect. Experiment 1 results suggest that animals are noticed rapidly and accurately, even when they share bottom-up features with the rest of the scene. Additionally, the unchanging presence of camouflaged animals distract from detecting inanimate changes. Experiment 2 employed signal detection theory (SDT) to measure the sensitivity (d') and response bias (β) related to changing animate versus inanimate stimuli. Experiment 2 outcomes indicate that participants tend to adopt a liberal response bias and are most sensitive to animate changes. Presence of an animal in a scene also influences sensitivity (d') when participants had to attend to and notice inanimate changes. Our findings are interpreted as additional support for the animate-monitoring hypothesis which suggests that early detection of animacy may have endowed our hunter-gather ancestors with survival advantages.

1. Introduction

Attention is often studied as a domain-general mechanism. Perspectives in evolutionary psychology deviate from this interpretation, suggesting that attention is better understood as a set of specialized systems designed to solve particular adaptive problems (Tooby & Cosmides, 2005). The animate monitoring hypothesis, proposed by New, Cosmides, and Tooby (2007), suggests that domain-specific mechanisms prioritize and monitor animate stimuli in the environment. A logical consequence of allocating attention to monitor animate stimuli is that inanimate stimuli become less salient when animals are present. The following paper presents the use of a unique methodological approach designed to determine if animate stimuli are continually monitored by the human attention systems. We explore how perceptual sensitivities and biases toward the animate hamper the detection of inanimate objects in the presence of animate distractors.

1.1. Theory and background

Within the workings of the visual attention system, not all elements of a visual scene are attended to equally (Simons & Levin, 1997). When objects are incongruent, or do not fit into the surrounding landscape (e.g. a fire hydrant in the living room) people notice the odd-ball objects faster and with greater accuracy (Hollingworth & Henderson, 2000). When something near the ‘interesting’ portion of a scene-changes, we focus our attention on those details first (Rensink, O'Regan, & Clark, 1997). Similarly, greater experience in a particular domain leads to fast detection of familiar objects as they change (Werner & Thies, 2000).

Animate features of a scene are given higher priority during attention tasks, suggesting that making distinctions between animate and inanimate stimuli is particularly relevant to human cognition. In its rudimentary form, this ability appears almost immediately after birth (see Opfer & Gelman, 2011) and serves as one of the foundations for social and cognitive development. Human and nonhuman animals have agency (Spelke, Phillips, & Woodward, 1995) and provide socially relevant information (Baron-Cohen, 1995). Brain architecture also reflects the importance of our capacity for distinguishing animate from inanimate information. Dedicated domain-specific neural networks govern this ability and their disruption is associated with debilitating deficits in verbal expression and concept formation (Caramazza & Shelton, 1998). Distinguishing animate from inanimate

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is so critical that it is one of the longest-preserved cognitive functions in patients with neuro-degenerative disorders (Hodges, Graham, & Patterson, 1995).

Caramazza and Shelton (1998) proposed that these animacy-honed brain networks evolved in response to selection pressures encountered by our species. Animate stimuli are directly relevant to survival (Tooby & Cosmides, 2005), and contain perceptual features that have remained consistent throughout hominid evolution. Human and non-human animals have specific characteristics (e.g. eyes, faces, fur, teeth, claws), and create recognizable stereotypical motion that quickly captures attention (Cavanagh, Labianca, & Thornton, 2001; Cutting & Kozlowski, 1977; Pratt, Radulescu, Guo, & Abrams, 2010).

Animate agents can be food or foe. As such, it is probable that we evolved capacities for perceiving predators and prey in our environment (Barrett, 2005). Participants viewing arrays of human faces orient to facial features associated with threat and anger (Hansen & Hansen, 1988; Lundqvist & Ohman, 2005). Preferential attention is given to fear inducing non-human stimuli (e.g. snakes and spiders) compared to inanimate objects (Lipp, Derakshan, Waters, & Logies, 2004; Ohman, Flykt, & Esteves, 2001). Taken together, evidence suggests that stimuli relevant to threat are prioritized in visual search tasks.

Early and accurate detection of nonthreatening animate agents also likely provided increased opportunity to mate or cooperate. Preferential attention is directed to attractive distractor faces, which interferes with completion of other tasks (Sui & Liu, 2009). Even with limited information, familiar biological motion can be identified as belonging to a friend (Cutting & Kozlowski, 1977) or an animal (Pavlova, Kragloh-Mann, Sokolov, & Birbaumer, 2001). Broadly, perspectives in evolutionary psychology argue for the presence of domain-specific systems that process animals with mnemonic, attentional, and learning circuitry that operates concordantly depending on task demands (Tooby & Cosmides, 2005).

New et al. (2007) hypothesized that the human attention system evolved category-specific selection criteria to prioritize and frequently monitor animate stimuli. Using a modified version of the flicker-task paradigm (Rensink et al., 1997), the authors demonstrated how our attention systems preferentially detect animals and humans in visual scenes. When compared to familiar inanimate objects (e.g., coffee mugs and telephones) changes to animals and people were noticed faster and with greater accuracy. This effect remained even when animate changes were very small and when vehicles (i.e., objects that are equally familiar, spatially/temporally sensitive, and potentially dangerous, but not part of our ancestral past) were included among the comparisons.

The animate monitoring hypothesis, as proposed by New et al. (2007), also predicts that attention systems actively monitor animate information in a visual scene. Thus, it stands to reason that prioritizing and keeping track of the animate also leads to interference with the processing of inanimate information. The stimuli and methodology used by New et al. (2007), however, are not sufficient for testing this complimentary research question.

New et al. (2007, 2010) presented participants with 70 unique images and asked them to detect visual changes in the pictures. Scene-changes were evenly divided into 5 categories, corresponding to the levels of the independent variable (i.e., scenes with appearing/disappearing animals, people, fixed objects, movable objects, and plants), but presence of animate distractors was not controlled, infusing a potential confound. One or more non-target animate objects were depicted in 64% of scenes portraying inanimate movable-object changes, in 28% of scenes portraying inanimate plant changes, and in 50% of scenes portraying inanimate fixed-object changes. Some of these animate distractors were quite prominent and centrally located in the scenes. Also, 14% of scenes illustrating animate human changes and 42% of scenes illustrating animate non-human changes showed animate non-targets.

This uneven distribution of animate non-targets across the five experimental conditions presents a threat to internal validity. New et al. (2007, 2010) went to great lengths when equating their 70 scenes to control for stimulus salience, color, luminance, and contrast, but the content within each scene varied. When comparisons were made, they were ultimately comparisons of participants' responses to different images.

We agree with New et al.'s (2007) animate monitoring hypothesis and have designed our experiments to test a logical follow-up question. If animate stimuli receive attentional priority and are continually monitored, will inanimate change-detection be hampered by the presence of animate objects? This paper presents a cleaner methodology looking at whether presence of animate distractors in a scene will interfere with participants' ability to detect inanimate change.

2. Experiment 1

Experiment 1 was designed to further examine the cognitive process that assigns preferential attention to animate features of a changing visual scene. This study presents a refinement of the Flicker Task used by New et al. (2007, 2010). The aim was to extend prior findings by controlling for previously unaccounted for confounds including the potential impact of animate distractors. Experiment 1 serves as a more stringent investigation of humans' apparent attentional bias for animate objects.

We hypothesized that scene-changes would be noticed with greater speed and accuracy when animate objects changed in a scene. Secondly, we predicted a reduction in participants' ability to notice inanimate scene-changes while animate objects were visible. We hypothesized that animals would act as distractors in situations where inanimate changes had to be detected. We expected attention to prioritize animate objects, even when that animate object was not the target. Subsequently; detection of inanimate objects would be deprioritized, impacting response time and accuracy, any time an animal was also visible in the scene.

Lastly, we hypothesized that the physical distance (cm) between the animate and inanimate objects would be related to the ease of change detection. Flickering inanimate objects should be noticed more rapidly, and with a higher degree of accuracy, the closer their proximity to the animate distractors. If human cognition prioritizes animacy, and animals are attended to first, then we expected it should be easier to detect targets (i.e., inanimate) that were closest to the animate non-target.

2.1. Method

2.1.1. Participants

Participants were self-referred college students who volunteered as part of fulfilling their undergraduate course requirements. All students with normal or corrected-to-normal vision, and no prior history of attention difficulties, were offered a chance to participate. Trained undergraduate research assistants completed informed consent and debriefing procedures with all participants.

Thirty-six undergraduate student volunteers were recruited to facilitate researchers' standardization of task stimuli. Data collected from these 36 participants were not used or considered part of the actual experiment.

One-hundred and five ($N = 105$) undergraduate students (73 F) were recruited to participate in the actual study with a mean age of 19.04 years.

2.1.2. Materials and apparatus

Researchers selected thirty-seven digital pictures from a Google image search, using the following search terms: "camouflaged animals" and "animals hiding in plain sight." Permission to use these pictures in experimental paradigms was obtained from all copyright holders. Three additional pictures were selected from the collection used by