Cognition 158 (2017) 215–223

Contents lists available at ScienceDirect

Cognition

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

Original Articles

The functional consequences of social distraction: Attention and memory for complex scenes

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ARTICLE INFO

Article history:
Received 13 November 2015
Revised 12 October 2016
Accepted 26 October 2016
Available online 12 November 2016

Keywords:
Social distraction
Visual attention
Memory
Social anxiety

ABSTRACT

Cognitive scientists have long proposed that social stimuli attract visual attention even when task irrelevant, but the consequences of this privileged status for memory are unknown. To address this, we combined computational approaches, eye-tracking methodology, and individual-differences measures. Participants searched for targets in scenes containing social or non-social distractors equated for low-level visual salience. Subsequent memory precision for target locations was tested. Individual differences in autistic traits and social anxiety were also measured. Eye-tracking revealed significantly more attentional capture to social compared to non-social distractors. Critically, memory precision for target locations was poorer for social scenes. This effect was moderated by social anxiety, with anxious individuals remembering target locations better under conditions of social distraction. These findings shed further light onto the privileged attentional status of social stimuli and its functional consequences on memory across individuals.

1. Introduction

Decades of research have suggested that faces and social stimuli hold a privileged processing status in human cognition. Studies have shown increased perceptual sensitivity to faces in newborn babies, which led to the proposal that infants are born with an innate structural representation of faces (Morton & Johnson, 1991). Neuroimaging has extended these findings to show brain areas (e.g. Puce, Allison, Asgari, Gore, & McCarthy, 1996) as well as single cells (e.g. Perrett, Hietanen, Oram, & Benson, 1992) specialized for processing faces (although see Gauthier & Tarr, 1997 for evidence of perceptual sensitivity to non-faces after extensive training). In addition to perceptual sensitivity, faces also show a special role in selective attention (Vuilleumier, 2000; Vuilleumier, Armony, Driver, & Dolan, 2001), including in change-detection tasks (Ro, Russell, & Lavie, 2001) and cueing tasks (Langton & Bruce, 1999).

A less commonly used alternative to investigate how social stimuli affect selective attention is the case of social *distraction* when people are *not* the targets of attention. Distractor faces show interference effects in visual search even under high perceptual load, suggesting mandatory processing (Lavie, Ro, & Russell, 2003). Additionally, neurotypical adults and children take longer to detect a target in a simple search paradigm with a face as a distractor than when there is no face distractor (Langton, Law, Burton, & Schweinberger, 2008; Riby, Brown, Jones, & Hanley, 2012). Interestingly, this effect does not extend to autistic children (Riby et al., 2012), whose reduced attention to faces and people is thought to demonstrate the absence of a privileged status for social stimuli (Klin, Jones, Schultz, & Volkmar, 2003).

Surprisingly, and critically, the effects of such distraction have not been investigated beyond selective attention within perceptual tasks. Social distraction is likely to have downstream consequences, influencing how well individuals remember information encountered during visual search. Studies showing poorer memory due to general distraction at encoding are numerous, spanning both working memory (e.g. Awh & Vogel, 2008) and long-term memory (e.g. Foerde, Knowlton, & Poldrack, 2006). However, no studies have investigated the effect of *social distraction* on longer-term memory (see de Fockert, Rees, Frith, & Lavie, 2001; Mano et al., 2013 for working memory examples with distraction during maintenance), nor have they used search in naturalistic scenes instead of simple visual search. The current study addresses this important gap in the literature by investigating the consequences of social distraction during visual search in naturalistic scenes on the quality of subsequent memories.

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http://dx.doi.org/10.1016/j.cognition.2016.10.015
0010-0277/© 2016 Published by Elsevier B.V.

We developed a task using natural scenes, which enabled us to contrast distraction caused by social stimuli vs. other, well-controlled stimuli that were matched for low-level visual properties. People are salient not just in terms of their social valence, but also with regards to low-level visual properties, including color and contrast. Although researchers often utilize scrambled or inverted faces, these control stimuli are less naturalistic and may pop out in natural scenes. The current study takes a novel approach to these problems, by using a graph-based visual saliency algorithm (Harel, Koch, & Perona, 2006) to ensure that the physical salience of social vs. non-social distractor items embedded within scenes is matched.

Finally, if social distraction does indeed have functional consequences, an individual's degree of bias towards social stimuli may play a moderating role. A large literature suggests a relationship between general anxiety and attentional bias towards threatening stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Bishop, Duncan, Brett, & Lawrence, 2004), and this relationship has been shown specifically for social anxiety and emotional faces in both clinical and typical populations. (e.g. Bradley, Mogg, White, Groom, & de Bono, 1999). In contrast to highly socially anxious individuals, as mentioned above, there is ample evidence that autistic individuals are less engaged by social stimuli in general, and more specifically do not demonstrate social distraction in simple visual search. We took advantage of these well-characterized individual differences, by including scales that tap into hypersensitivity to social stimuli (social anxiety) versus insensitivity to social stimuli and social distraction (autistic traits) [however, please see Senju & Johnson, 2009 for competing theories of hypo- versus hyper-arousal to social stimuli in autism spectrum disorders (ASD)].

In order to understand the consequences of social distraction for attention and subsequent memory, we posed three complementary questions: (1) Will the previously documented social distraction effect extend to visual search in natural scenes and when compared to distraction from items that are matched for visual salience? (2) Will social distraction influence later memory performance, such that memory will be poorer for social scenes? (3) Will these relationships be moderated by individual differences in social anxiety or autistic traits?

2. Materials and methods

2.1. Participants

This research was approved by the University of Oxford Central University Research Ethics Committee (CUREC). Thirty-seven healthy adult volunteers participated (aged 19–33, 21 female). All had normal or corrected-to-normal vision. Six other participants were tested but excluded—four due to age outside of our range of interest (18–35), one due to eye-tracker malfunction, and one due to lack of English proficiency to understand task instruction. Sample size was determined by the desire to at least double the size of previous studies, which had sample sizes of 16 (Patai, Doallo, & Nobre, 2012; e.g. Stokes, Atherton, Patai, & Nobre, 2012), in order to detect individual differences. Our stopping rule was to stop testing when our sample size was a multiple of four, due to the number of counterbalanced groups (see below). All participants provided written informed consent and were paid for their participation or received course credit.

2.2. Stimulus design and visual salience computation

Eighty natural indoor and outdoor scenes were prepared from photographs taken by the experimenter or acquired from the Internet with permission (1000×750 pixel resolution in 32-bit color, under the experimental conditions spanning 37.05 by 22.34 degrees of visual angle). Target objects were photographs of objects including tools, toys, fruits, etc., sized to approximately 1.09 by 1.09 degrees of visual angle. Social distractor stimuli were prepared from photographs of people standing upright taken by the experimenter (BD). Non-Social distractors were objects chosen to be similar to social distractors in terms of color and contrast (e.g. deck umbrella, ornamental plant, coat stand, etc.). They were also chosen to fit naturally into the scene such that they did not appear odd. All distractors were 9.03 degrees of visual angle in height.

Matching 'social' and 'non-social' versions of each scene were created using GIMP 2.8.10 image manipulation software with: (1) a social distractor (person) edited into a natural location or (2) a non-social distractor edited into the same location. Every scene had a unique target object placed within it. Target objects were superimposed on scenes during the visual search task through the stimulus presentation program.

Presentation of social and non-social scenes was counterbalanced across participants, so that half saw the same 40 scenes as social and the other 40 scenes as non-social, while the other half of the participants saw the reverse. In addition, each scene had two target locations that were counterbalanced across participants: one on the same side and the other on the opposite side of the distractor. These locations were balanced such that any one participant saw equal numbers of targets in the four visual quadrants. Finally, distractor position and gender of social distractors were also balanced (Fig. 1). Target location and distractor counterbalancing resulted in four participant groups: distractor group 1 location 1, distractor group 1 location 2, distractor group 2 location 1, distractor group 2 location 2.

To ensure that social and non-social distractors were equally salient with regards to low-level visual properties (color, contrast, etc.), salience values were calculated using a bottom-up visual saliency algorithm based off of the original Itti and Koch algorithm (Harel et al., 2006). For both target locations, paired samples t-tests comparing social and non-social versions of all scenes revealed no significant differences in salience between: (1) social/non-social distractors identified with hand-drawn AOIs ($p > 0.250$), (2) social/non-social scenes overall ($p > 0.250$), and (3) social/non-social scene target objects in the target locations identified with circular AOIs ($p > 0.250$) (Fig. 2).

2.3. Procedure

2.3.1. Visual search

Participants sat 75 cm away from a 1680 by 1050 resolution monitor (spanning 37.05 by 22.34 degrees of visual angle) with their chin on a chin rest. They were directed to look for target objects in 80 scenes over three blocks (Fig. 2). During search, gaze position was recorded from both eyes at 500 Hz using an Eyelink 1000 infrared camera following a 9-point calibration and validation. For each trial, participants saw: (1) a fixation square for 1000–1500 ms, (2) the object alone (1.61 by 1.61 degrees of visual angle) for 3000 ms, (3) the scene and embedded object, and (4) feedback for 1000 ms ("Object not found" or "Object found" on blank screen). Maximum search time was 20 s in the first block and decreased by 4 s each subsequent block. Participants observed all 80 scenes in random order during each of three blocks. They were instructed to press the spacebar when they found the object to reveal the cursor and then click on the object (Fig. 2). Accuracy in locating the target was defined as clicking on the object within a 0.54 degrees of visual angle buffer.