Why we Should Not Forget About the Non-social World: Subjective Preferences, Exploratory Eye-movements, and Individual Differences

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Abstract

We investigated both subjective and objective differences in viewing non-social versus social scenes. Specifically, we examined four related questions: 1) Do participants prefer non-social or social scenes? 2) Are there differences in subjective exploration of non-social and social scenes? 3) Are there differences in objective exploration of these scenes? 4) Does a non-social trait – connection to nature – influence the extent of non-social scene exploration? Experiment 1 found, surprisingly, that participants prefer non-social over social scenes, and correspondingly, they reported exploring these scenes more. Experiment 2 used eye-tracking to test the validity of this introspection and confirmed that participants explore non-social scenes more than social scenes. We also discovered that connection to nature selectively modulates exploration of non-social scenes, demonstrating a critical interaction between observer and scene characteristics in the deployment of spatial attention.

Keywords: eye-tracking; exploration; attention; individual differences; subjective experience.

Introduction

The desire to understand how attention is guided in the real social world has increased the use of eye movement tracking in complex natural environments. Accordingly, there has been a growing interest in the role that social stimuli play in the allocation of human attention and eye movements (for a recent review see Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012). However, this leaves a pertinent question unanswered: what role, if any, do non-social stimuli play in the allocation of attention in real world scenes?

Recent evidence indicates that when social and non-social scenes are put in direct competition, there is a distinct preference to look at social scenes, and particularly, at the eyes of the people in the social scenes (Fletcher-Watson, Findlay, Leekam, & Benson, 2008; Birmingham, Bischof, & Kingstone, 2008). Given that attention operates largely in service of an individual's goals and intentions, and that looking behaviour is positively correlated with reward (Sullivan, Johnson, Rothkopf, Ballard, & Hayhoe, 2012), a straight-forward prediction is that a selection bias for social stimuli over non-social stimuli reflects a *subjective preference*. However, an alternative possibility is that eye movements towards the social content of scenes (particularly the eyes of the people in the scenes) is being driven by a low-level neural system that is preferentially biased to process biologically relevant information (Laidlaw, Risko, & Kingstone, 2012). In this case, one's subjective preference of the stimuli is not necessarily driving gaze behaviour. The aim of Experiment 1 was to determine whether subjective preference may be driving attention towards social stimuli.

Participants were asked to subjectively rate their liking for non-social scenes and social scenes. Importantly, previous research has shown that the social scenes used in the present study attract fixations to the eyes of the people in the scenes (Birmingham et al., 2008). We also asked participants to introspect on how much they thought they had explored the social and non-social scenes. We did this to investigate the accuracy of subjective intuition as to how one looks at scenes. Because our past work has shown that there is a marked tendency for participants to fixate onto the eyes of people in the scenes, we predicted that participants would report they had explored social scenes less than non-social scenes.

Experiment 1

Methods

Participants Sixteen students from the University of British Columbia participated in the 30-minute experiment in exchange for course credit.

Stimuli Participants viewed a slideshow of 51 unique images at their own pace. Of interest were 6 interior and 6 landscape scenes from Foulsham, Kingstone, and Underwood (2008), as well as 7 social scenes from Birmingham et al. (2008) that have been shown to trigger rapid and sustained eye movements to the eyes of the individuals in the scenes. The social scenes either depicted 1 person alone, or 3 people interacting. Only these scenes were analyzed for the purposes of this study because they were used directly in Experiment 2.[1] Exploratory eye movements are potentially affected by the saliency distribution of the stimuli (Itti, Koch, & Niebur, 1998). For example, stimuli with widely distributed salient locations could lead to a distributed eye movement pattern, and stimuli with salient locations concentrated in a small area could lead to a concentrated pattern. For this reason, we ensured that the image areas spanned by the most salient points were matched across image types.[2]

Questionnaires Participants were asked to rate, on a 5-point Likert-type scale, how much they liked the scenes, and how much they explored the scenes.

Data Analysis A one-way repeated-measures analysis of variance (ANOVA) was used to compare the average preference and exploration ratings of the interior, landscape, and social scenes.

Results

There was a main effect of scene type on the average preference ratings, $F(2, 30) = 46.94$, $MSE = 8.95$, $p < .001$. Post-hoc, Bonferonni-corrected t-tests revealed that participants significantly preferred landscapes over interiors, $t(15) = 5.60$, $p < .001$, and social scenes, $t(15) = 8.59$, $p < .001$. See Figure 1.

There was a main effect of scene type on the exploration ratings, $F(2, 30) = 12.00$, $MSE = 1.14$, $p < .001$. Post-hoc, Bonferonni-corrected t-tests revealed that participants reported greater exploration of the interior and landscape scenes compared to the social scenes (interiors: $t(15) = 3.56$, $p = .003$; landscapes $t(15) = 4.32$, $p = .001$). There were no significant differences in exploration ratings between interiors and landscapes, p > .10. See Figure 2.

[1] The remaining slideshow images were used in different experiments not reported here. They included other social, interior, and landscape scenes from the same stimuli sets, in addition to other scenes from a different stimuli set (Foulsham & Kingstone, 2010). When all images from the current stimuli set are analyzed, the same results are obtained.

[2] We computed saliency maps for each scene using the Saliency Toolbox (Walther, 2012) and determined the location of the most salient locations (defined as the set of locations with a saliency value of at least 50% of the maximum saliency in the scene). We then calculated the image area spanned by these locations (i.e., their convex hulls). A comparison of all scene types showed that there were no significant differences in the image areas between the scenes.

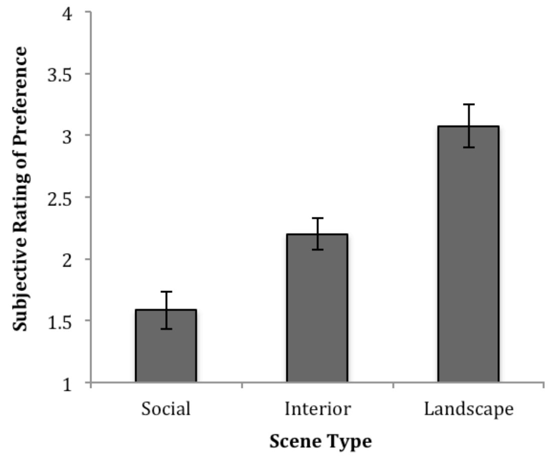

Figure 1: Average ratings of how much participants liked each scene type. Participants significantly rated landscapes highest and social scenes lowest (all *p*'s < .001). Error bars represent the standard error of the individual means.

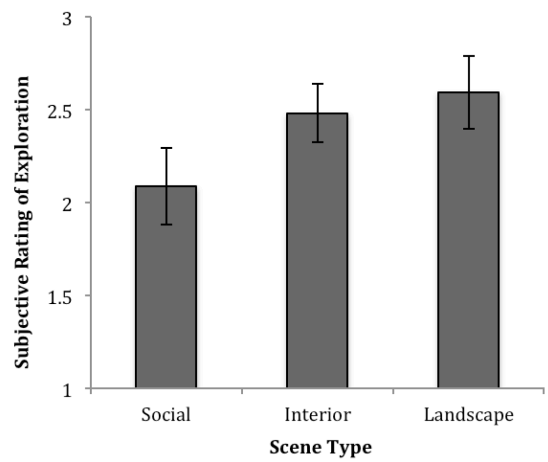

Figure 2: Average ratings of how much participants explored each scene type. Participants significantly rated landscapes (*p* = .001) and interiors (*p* = .003) above social scenes. Error bars represent the standard error of the individual means.

Discussion

In Experiment 1 we found that participants preferred the non-social landscape scenes and interior scenes over the social scenes. Given that our previous work using the current social stimuli has demonstrated a marked looking preference for social versus non-social stimuli, and that this finding has been confirmed by other researchers (Fletcher-Watson et al. 2008), it was reasonable to predict that this preference in looking behaviour would reflect a subjective preference for social over non-social stimuli. However, in contrast to reward theory, the data appears to support the notion that selection bias towards social stimuli is driven by something other than subjective preference.

In addition, subjects showed the strongest preference towards landscape scenes. This finding supports the idea that people have a unique preference for nature (Grinde & Patil, 2009; Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2011; Schultz & Tabanico, 2007).

Consistent with past work indicating that people tend to 'lock' their eyes on people in social scenes, our study found that participants rated their exploration of the non-social scenes to be significantly greater than the social scenes. This finding seems to validate the accuracy of subjective intuition about how one allocates attention. Nevertheless, research has demonstrated that individuals can be very poor at judging whether their eyes have moved or not (e.g., Belopolsky, Kramer, & Theeuwes, 2008). Even when individuals do realize their eyes have moved, they can be notoriously poor at judging where they may have looked (Foulsham & Kingstone, 2013). Thus we thought that it was important to objectively confirm the validity of participants' subjective reports, by testing subjects' exploratory looking behaviour with the same stimuli.

In addition, and in light of our recent work that an individual difference trait in visual curiosity can influence visual exploration (Risko, Anderson, Lanthier & Kingstone, 2012), we took this opportunity to investigate the intriguing hypothesis that a non-social trait may selectively predict how one looks at non-social content. To test this idea we used the Connectedness to Nature Scale (CNS; Mayer & Frantz, 2004). Connectedness to nature has been demonstrated to be implicitly part of an individual's identity, that is, how the natural world is included in one's representation of self (Schultz & Tabanico, 2007).

In a sense, connection to nature can be seen as an antithesis of scales that measure social traits. While scales like the Autism Quotient (AQ) measure one's connection to the social world (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), the CNS measures one's connection to the non-social world. Thus, if autism spectrum disorders and social skills scores on the AQ are predictive of how people look at social content (Chen & Yoon, 2011; Freeth, Foulsham, & Kingstone, 2013), it is plausible that CNS may be predictive of how people look at non-social content.

In Experiment 2, participants performed a free-viewing task of interior, landscape, and social scenes while being eye-tracked, and then completed the CNS. We looked at how exploration may be different across scene types, and whether CNS scores were related to these exploratory eye movements (Risko et al., 2012). Following the results of Experiment 1, we predicted that exploration should be equal for interiors and landscapes, and significantly less in social scenes.

Experiment 2

Methods

Participants Twenty-three participants from the University of British Columbia were given course credit, or paid $5, to participate in the 30 minute study.

Stimuli The same scenes were used as the ones analyzed in Experiment 1. The scenes were 1024 x 768 pixels, and corresponded to a horizontal visual angle approximately 42°, and a vertical visual angle approximately 33°.

Questionnaires Each participant was asked to provide demographic information, and to complete the CNS. The CNS is a 14-item questionnaire with a 5-point Likert-type scale, used to measure participants' trait levels of feeling emotionally connected to the natural environment (Mayer & Frantz, 2004). This inventory has acceptable internal reliability ($\alpha = .84$; Mayer & Frantz, 2004).

Apparatus An SR Research Eyelink 1000 eye-tracking system, recorded participants' eye movements at 1000 Hz. Stimuli were presented to participants on a 23" monitor. Scenes and eye movements were also presented to the experimenter on an adjacent monitor located in the testing room, relaying real-time feedback on system accuracy.

Procedure Participants were seated 60 cm from the computer monitor, with their heads positioned in a chin rest. Participants were told to view each image as they would normally do. Scenes were presented for 10 s. Participants viewed the images before being asked to complete the questionnaire.

Data Analysis An 8 x 8 grid was created for each image, yielding 64 interest areas that were invisible to participants. Each region subtended approximately 5.25° horizontal visual angle, and 4.13° vertical visual angle. We quantified participants' exploratory eye movement behaviour using an exploratory index (EI). This index is the ratio between the number of unique regions visited in a scene, and the total number of fixations in that scene (i.e., the number of regions visited with the number of fixations normalized). We believe the EI measure gives a more accurate quantification of exploratory strategy. A raw count of regions visited is easily biased by the total fixations a participant makes: the greater the total number of fixations, the greater number of regions that would be visited simply by chance. This is reflected in the data as a raw count of regions visited correlates highly with the total number of fixations in non-social scenes: $r = .73$, $p < .001$, and social scenes: $r = .67$, $p < .001$, whereas our EI measure does not, both p's > .22.[3] By normalizing for the number of fixations, the EI measure assesses how participants spatially allocate their attention given the same constraints (number of fixations).

It is arguable that this EI value misses within-region exploration, and reversing the ratio (number of fixations over regions visited) would better capture exploration.

[3] Using raw counts of regions visited instead of EI also gives us different results. Interiors had the greatest counts, with landscapes in the middle, and social scenes garnering the least. In addition, raw counts did not correlate with CNS in social or non-social scenes.

However, this value would be unable to distinguish whether participants are simply repeatedly looking at the same features within a region. Given the size of the regions, it is likely only one attractive feature (e.g., eyes) is contained within it. While it is true that a participant who attends these features more can be said to have "explored" them more, it is inconsistent with our operational definition of exploration. We are interested in exploration in the sense of spatial distribution of attention, not exploration in the sense of focus toward one specific feature.

A repeated-measures ANOVA was conducted between the average EI values of each scene type. Pearson's correlations were conducted separately between the EI mean for non-social scenes and CNS scores, and the EI for social scenes and CNS scores. Pearson correlations were also conducted between CNS scores and other eye movement measures (total fixations and fixation durations), to see if the trait was related uniquely to exploration.

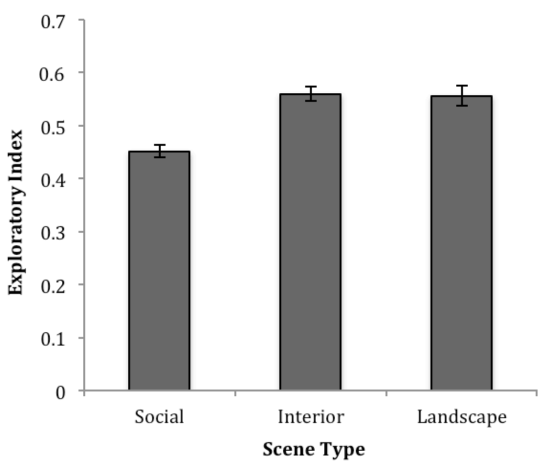

Figure 3: Average exploratory index values of participants viewing social, interior, or landscape scenes. Participant's significantly explored non-social scenes significantly more than social scenes (both *p*'s < .001). Error bars represent the standard errors of the individual means.

Results

There was a main effect of scene type on EI values, $F(2,44) = 31.67$, $MSE = 0.88$, $p < .001$. Post-hoc repeated-measure, Bonferonni-corrected, t-tests revealed that participants did not differ in exploring interiors and landscapes, but explored both significantly more than social scenes (interiors: $t(22) = 10.62$, $p < .001$; landscapes: $t(22) = 6.26$, $p < .001$). See Figure 3.

The correlations between CNS scores and EI measures are shown in Table 1. The correlation between CNS scores and EI for non-human scenes was significant, $r = .43$, $p = .04$. However, CNS scores were not correlated with EI for social scenes, nor for any of the other eye movement measures.

Table 1: Correlations between scores on the Connectedness to Nature Scale (CNS), and EI values, total fixations, and fixation durations in non-social and social scenes. Value bolded indicates $p < .05$.

Measure	CNS
Non-social:	
EI	**.43**
Fixation count	-.05
Duration	-.03
Social:	
EI	.08
Fixation count	-.02
Duration	-.07

Discussion

The results of Experiment 2 confirm our findings in Experiment 1. Participants explored the non-social scenes far more than the social scenes, in keeping with the subjective reports in Experiment 1. Equally remarkable, we found that a non-social trait, connectedness to nature, predicted the variation in exploratory eye movements. This power to predict scene exploration was specific to the non-social scenes.

General Discussion

We began our work by asking the following question: In light of the field's growing interest in social attention, what important role, if any, do non-social stimuli play in the allocation of attention in real world scenes? Our work has provided at least four new insights.

First, in Experiment 1, we found that participants preferred non-social scenes – whether they are outdoor scenes or interior scenes – significantly more than social scenes. This finding suggests that subjective preference and reward mechanisms are not responsible for the preferential bias to look toward social stimuli rather than non-social stimuli.

Second, in Experiment 1 we found that participants provided a subjective report that they explored non-social scenes (both landscapes and interiors) more than social scenes. Despite good reason to question the accuracy of this self-assessment, Experiment 2 found that people did explore non-social scenes far more than social scenes.

This finding in turn revealed that people are in fact accurate at subjectively gauging the extent to which they move their eyes through different scene types.

Finally, in Experiment 2, we discovered that a non-social trait, one's connectedness to nature, was selectively related to exploratory eye-movements in non-social scenes. In other words, non-social traits can selectively influence attention in certain scene types. This finding demonstrates the importance of using non-social scenes in exploring the influence of trait differences on attention. After all, if we had only used social scenes we would have missed the effect. It is also noteworthy that our work extends the work of Risko et al. (2012) to include a new individual trait related to exploratory eye movement behaviour – connectedness to nature.

Yet why was connectedness to nature not related to exploration in social scenes? There are at least three possibilities, all worthy of future investigation. First, it may be that there is an overwhelming pull to attend to human stimuli such that any differences in attention that might be influenced by individual traits are over-ridden. Highly attractive features that capture attention, like eyes and faces, may lead to failure of an exploratory viewing bias. This possibility suggests social EI and non-social EI are not distinct constructs. CNS would be related to both social and non-social EI if not for the overwhelming pull of eyes and faces. Alternatively, human content may produce a viewing strategy itself (e.g., making sense of the scene; Birmingham et al., 2008), and this strategy is prioritized over exploratory behaviour. Such an explanation has important implications for researchers wanting to study individual differences in areas related to attentional exploration, such as inspiration, creativity, and curiosity (Fredrickson & Anderson, 1999; Kasof, 1997; McCoy & Evans, 2002; Risko et al., 2012; Schlewitt-Haynes, Earthman, & Burns, 2002). The third possibility is that the CNS is not related to human connectedness. There may be 'connectedness to human' traits that could be related to human content. As mentioned previously, there is evidence that AQ scores are predictive of how people look at social content (Chen & Yoon, 2011; Freeth et al., 2013), as well as evidence of other traits like social anxiety related to attention to social stimuli (Mansell, Clark, Ehlers, & Chen, 1999). This would suggest that social EI and non-social EI are distinct constructs, and that different traits would relate independently to each scene type. Further study will be needed to examine these three possibilities.

In addition to stable characteristics like personality (Risko et al., 2012), our findings raise the possibility that factors like attitudes and feelings may also influence one's eye movements, and thus be embodied in eye movement behaviour. For example, connection to nature relates positively to pro-social and outward looking values, but negatively to inward looking values (Weinstein, Przybylski, & Ryan, 2009). Might these attitudes be embodied in broadness or narrowness of attentional focus (see Chua, Boland, & Nisbett, 2005, for a similar hypothesis)? Since the current study was purely correlational, inferences about such a possibility cannot be made. In the future, we hope to investigate the direction of this relationship.

Results from our two experiments combined support the possibility that the bias to look at social stimuli is sub-served not by one's subjective preferences for social versus non-social stimuli. If one wishes to maintain that these eye movements to social stimuli are due to reward mechanisms (Sullivan et al., 2012) then one must abandon the assumption that the reward system is related to preference. However, if that is true, then perhaps the notion of reward itself needs to be reconceptulaized. Perhaps a better account for our results comes from recent evidence of a primitive low-level neural system that automatically drives attention and eye movements toward biologically relevant information, such as the eyes of others (Laidlaw et al., 2012; Levy, Foulsham & Kingstone 2012).

On a more practical level, our investigation provides an example of the validity of using subjective reports, in addition to measuring objective variables. The fact that the subjective results in Experiment 1 were mirrored by the objective results in Experiment 2 mitigates some of the concerns cognitive scientists may have about doing subjective experience research (for a review, see Kingstone, Smilek, & Eastwood, 2008). For example, we show that subjective reports are reliable and replicable across individuals. We also show that attentional exploration does not operate below conscious awareness since participants' subjective reports were consistent with looking behaviour (cf. Nisbett & Wilson, 1977). Our study gives empirical backing to the validity, and necessity, of using subjective experiences in addition to objective measures (Kingstone et al., 2008).

Overall, our results suggest that the use of non-social stimuli in studying real-world attention should not be overlooked. Non-social stimuli offers participants a chance to avoid the overwhelming pull of social stimuli. As such, factors like individual traits and subjective preferences that affect eye-movement behaviour may be buried when using social stimuli. On a more theoretical level, our study contributes to a burgeoning field that seeks to uncover how psychological aspects of one's identity are intimately linked to the lowest levels of one's underlying physiology (Chua et al., 2005; Dodd et al., 2012; Dodd, Hibbing & Smith, 2011; Risko et al., 2012). Continuing to identify these subjective aspects will surely lead to interesting and important knowledge about how different individuals uniquely select, perceive, and ultimately act towards different stimuli.

Acknowledgements

This work was funded by grants to WFB and AK from the Natural Sciences and Engineering Council of Canada.

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