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Being watched: The effect of social self-focus on interoceptive and exteroceptive somatosensory perception

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Abstract

We become aware of our bodies interoceptively, by processing signals arising from within the body, and exteroceptively, by processing signals arising on or outside the body. Recent research highlights the importance of the interaction of exteroceptive and interoceptive signals in modulating bodily self-consciousness. The current study investigated the effect of social self-focus, manipulated via a video camera that was facing the participants and that was either switched on or off, on interoceptive sensitivity (using a heartbeat perception task) and on tactile perception (using the Somatic Signal Detection Task (SSDT)). The results indicated a significant effect of self-focus on SSDT performance, but not on interoception. SSDT performance was not moderated by interoceptive sensitivity, although interoceptive sensitivity scores were positively correlated with false alarms, independently of self-focus. Together with previous research, our results suggest that self-focus may exert different effects on body perception depending on its mode (private versus social). While interoception has been previously shown to be enhanced by private self-focus, the current study failed to find an effect of social self-focus on interoceptive sensitivity, instead demonstrating that social self-focus improves exteroceptive somatosensory processing.

Keywords: Interoception; Exteroception; Heartbeat perception; Somatic signal detection; Self-focus

1. Introduction

Considerable research evidence supports the multi-level model of body perception and body awareness (Berlucchi & Aglioti, 2010). In order for us to be aware of, and have an accurate perception of our bodies we must co-perceive various sensory inputs, including interoceptive, exteroceptive, proprioceptive, vestibular, tactile, and visual signals (Neisser, 1993). For a large part, we become aware of our bodies interoceptively, by processing signals arising from within the body (e.g., heart beats, respiration, gastrointestinal functions), and exteroceptively by processing signals arising on (e.g., touch), or outside the body (e.g., vision). While research on multisensory integration delineates how exteroceptive signals are combined and then impact body-awareness (e.g., vision and touch, or vision and audition; see Tsakiris, 2010 for a review), little is known about the integration of signals across interoceptive and exteroceptive somatosensory modalities. Even though interoceptive and exteroceptive signals are processed separately in the brain (e.g., Farb, Segal, & Anderson, 2013; Hurliman, Nagode, & Pardo, 2005) the two modes of bodily perception are highly interconnected (Simmons et al., 2012) and need to be integrated to bring about body awareness (Craig, 2009). Recent empirical investigations demonstrate that combined interoceptive-exteroceptive signals can significantly alter ownership of a virtual hand (Suzuki, Garfinkel, Critchley, & Seth, 2013), as well as awareness of one's body in space (Aspell et al., 2013), providing behavioral evidence to suggest that interoceptive and exteroceptive signals are integrated to jointly shape body awareness and perception.

As body perception ultimately relies on the online integration of sensory signals across different modalities—a dynamic process strongly modulated by attention (e.g., Talsma & Woldorff, 2005)—state-dependent fluctuations in both interoceptive and exteroceptive somatosensory perception as a function of varying modes and degrees of attention to the self could be expected. Distinct modes of self-focus enhance aspects of the self directly related to the given focus-mode—for example, mirrors have been found to elicit a more private self-focus, by directing individuals' attention to inner aspects of the self, whereas video cameras have been found to elicit a more social self-focus by drawing individuals' attention to the external, observable to others aspects of the self (Carver & Scheier, 1981; Davies, 2005). Private self-focus has been found to enhance interoceptive sensitivity, as reflected by higher heartbeat perception accuracy when attending to pictures of self, self-referential words (Ainley, Maister, Brokfeld, Farmer, & Tsakiris, 2013) or reflection of self in a mirror (Ainley, Tajadura-Jimenez, Fotopoulou, & Tsakiris, 2012; Weisz, Balazs, & Adam, 1988). The way in which private self-focus affects exteroceptive somatosensory perception is less clear than in the case of interoception. A recent study by Mirams, Poliakoff, Brown, and Lloyd (2013) shows that body-scan meditation practice, in which participants are trained to attend to selective areas of the body one at a time while taking the time to notice any somatic sensations in a non-evaluative manner, is followed by an increase in sensitivity and decrease in false alarm rates on a tactile perception task, suggesting enhanced tactile perception following the meditation practice. The authors point out that their results contradict the findings from their previous study (Mirams, Poliakoff, Brown, & Lloyd, 2012) examining the effects of interoceptive versus exteroceptive attention on somatosensory processing, which found that interoceptive attention increases an individual's propensity to report feeling a tactile stimulus regardless of whether it has occurred or not. They conclude that bodily self-focus might have differential effects on somatosensory processing depending on the mode of attention (localized, non-mindful interoceptive attention versus generalized, mindful body-scan meditation). Consequently, further research is necessary to delineate the way in which self-focus affects interoceptive and exteroceptive somatosensory processing.

While several studies have investigated effects of various modes of private self-focus on body perception, no study to date has examined how processing of bodily signals, both interoceptive and exteroceptive in nature, is affected by social self-focus. Social self-focus has been successfully elicited in experimental settings with a turned on video camera facing the participant as if s/he is being filmed (e.g., Burgio, Merluzzi, & Pryor, 1986; Duval & Lalwani, 1999). As there is evidence that private self-focus and social self-focus can have distinct cognitive effects (Davies, 2005), it is possible that social self-focus might impact body awareness in a different manner than private self-focus. The aim of the present study was to investigate whether social self-focus evoked by a turned on video camera (self-focus condition: camera turned on and facing the participant; non self-focus condition: camera turned off and facing away from the participant) would affect interoceptive and/or exteroceptive somatosensory processing.

We assessed interoceptive somatosensory processing by measuring cardiac interoceptive sensitivity (IS), which is commonly quantified as an individual's heartbeat perception accuracy score, calculated by comparing the number of heartbeats the individual reports to the number of heartbeats that actually occurred in a given time interval, with better heart beat perception accuracy reflecting higher interoceptive sensitivity (Schandry, 1981). In order to measure exteroceptive somatosensory processing we used a modified Somatic Signal Detection Task (SSDT; Lloyd, Mason, Brown, & Poliakoff, 2008). The SSDT involves detecting the presence of a near-threshold tactile stimulus presented on 50% of the trials, while a simultaneous visual stimulus, such as an LED, also flashes on 50% of the trials, resulting in an increase in participants' hit rate and false alarm rate due to the flashing LED (Lloyd et al., 2008). A signal detection analysis is used to establish whether any observed change in responses is due to an effect of the manipulation on tactile sensitivity (i.e., ability to tell apart signal from noise), response criterion (i.e., propensity to report feeling a tactile stimulus), or both. Overall, higher sensitivity, higher hit rate, and lower false alarm rate suggest higher exteroceptive/tactile awareness of the body. We hypothesized that the self-focus condition would be associated with enhanced somatosensory processing. We predicted that the self-focus condition would bring about an increase in interoceptive sensitivity as reflected by better heartbeat perception accuracy in the ‘‘camera on’’ as opposed to ‘‘camera off’’ condition. We further hypothesized that the ‘‘camera on’’ condition would be associated with improved tactile perception and that this would be reflected by increased sensitivity on the SSDT, driven by increased hit rate and decreased false alarm rate in the ‘‘camera on’’ as opposed to the ‘‘camera off’’ condition. As significant differences in emotional and cognitive processing based on individuals' interoceptive sensitivity level have been found—for example, in regards to emotional experience (e.g., Pollatos, Herbert, Matthias, & Schandry, 2007), decision-making (e.g., Werner, Jung, Duschek, & Schandry, 2009), and memory performance (e.g., Werner, Peres, Duschek, & Schandry, 2010)—we have also aimed to investigate potential modulation of SSDT performance by IS level. We expected individuals with higher IS to display more accurate tactile perception, as reflected by higher sensitivity, higher hit rate, and lower false alarm rate. Lastly, we also wanted to examine whether the effect of social self-focus on interoceptive and/or exteroceptive somatosensory processing would be moderated by IS level.

2. Material and methods

2.1 Participants

Fifty-seven (48 female; Mean age = 18.67 years; SD = .93 years) undergraduate psychology students at Royal Holloway, University of London took part in the experiment in compensation for course credit.

2.2 Experimental design

The experiment was a fully counterbalanced within-subject design. Participants completed the interoceptive sensitivity (IS) task and the Somatic Signal Detection Task (SSDT) two times each—one time with the video camera turned on and facing the participant (i.e., social self-focus condition), and one time with the video camera turned off and facing away from the participant (i.e., non-self-focus condition). The order of ‘‘camera on’’/‘‘camera off’’ conditions was counterbalanced across participants. The order of IS task and SSDT within each condition (‘‘camera on’’, and ‘‘camera off’’) was also counterbalanced across participants. Together, there were 8 possible orders. The order in which a given participant completed the tasks was randomized.

2.3 Experimental Set-up

Participant was seated at a desk-chair about 1 m away from the wall. A black screen with a 10 mm red LED in the middle was attached directly to the wall. The LED was at eye-level of the seated participant and directly in front of him or her. A video camera was mounted on a tripod and placed about 75 cm directly in front of the participant. The LED was about 25 cm behind the video camera. The camera was slightly below eye-level of the participant in order not to interfere with the participant’s vision of the LED. However, when turned on and facing the participant, the camera lens was turned slightly upwards in order to capture participant’s face. When the camera was turned off and the lens was facing away from the participant, the tripod and the camera remained in the same position in front of the participant. Fig. 1 illustrates the experimental set up.

Insert Figure 1

During the experiment, the lab was dark; a spotlight placed above the participant illuminated the area in which the participant was seated. The spotlight did not directly illuminate the wall on which the LED was situated in order not to reduce visibility of the flashing light during the SSDT.

2.4 Interoceptive sensitivity task

Interoceptive sensitivity was assessed via heartbeat perception, using the Mental Tracking Method (Schandry, 1981). Participants were instructed to mentally count their heartbeats from the moment they received an audio computer-generated cue signaling the start of the trial, until they received an otherwise identical cue signaling the end of the trial, and then to verbally report to the experimenter the number of heartbeats they had counted. Every participant was first presented with a 10-s training trial (during the first assessment only), and then with a block of 25-s, 35-s, and 45-s trials presented in a random order. During the whole duration of the task, participants' true heart rate was monitored using a piezo-electric pulse transducer attached to the participant's right index finger (PowerLab 26T, AD Instruments, UK). Throughout the assessment, participants were not permitted to take their pulse, or to use any other strategy such as holding their breath. No information regarding the length of the individual trials or feedback regarding participants' performance was given. The task was programmed using Presentation software (Neurobehavioral Systems: http://www.neurobs.com).

2.5 Somatic Signal Detection Task

The Somatic Signal Detection Task (SSDT; Lloyd et al., 2008) measures somatic sensitivity and response bias in detecting whether a tactile stimulus at threshold intensity is present or absent, while an irrelevant LED flashes (at the same time as the occurrence of tactile stimulation) or not. The dependent variable is the participant's response: ‘‘definitely yes,’’ ‘‘maybe yes,’’ ‘‘maybe no,’’ ‘‘definitely no’’. It should be noted that in order to adapt the SSDT paradigm to the present investigation, we modified some aspects of the procedure. Specifically, we delivered the tactile stimuli to the cheek, as opposed to the hand as in the original paradigm. This adjustment was made to ensure that tactile stimulation occurred at a body-site that is the focus of attention during the video-camera manipulation—the face—as opposed to the hand, which is peripheral to the focus of attention during the manipulation. As we moved the site of tactile stimulation, we also needed to adjust the location of the LED. The light was positioned on eye-level, a meter away from the participant, in his or her central visual field, and slightly behind the video-camera to ensure that the light remained close enough to be salient, yet not too close as to interfere with the salience of the camera manipulation.

Tactile stimuli were delivered through a constant current electrical stimulator (DS7A, Digitimer). One couple of surface electrodes, placed on the participants' right cheek approximately 1 cm apart, delivered a single constant voltage rectangular monophasic pulse. The beginning of each trial was signaled by two brief audio tones. Then, a stimulus period of 1020 ms followed. In the tactile-present trials a 0.05 ms tactile stimulus was presented after 500 ms. In tactile-absent trials an empty 1020 ms period took place. A single audio tone signaled the end of the trial, at which point participants were asked to report whether they perceived a tactile stimulus on their cheek or not. First, a staircase procedure was used to establish a threshold for each participant—the point at which participant reported feeling the tactile stimulus on 40–60% of the tactile-present trials. The threshold protocol consisted of 5 tactile-present and 5 tactile-absent trials, and the participant was asked to give a verbal response of ‘‘yes’’ or ‘‘no’’ to each trial. The thresholding procedure was repeated as many times as needed in order to establish the threshold, before the main experimental trials could take place.

The main experiment consisted of 2 blocks of 80 trials, with 20 trials for each of the four conditions (tactile present-light present, tactile present-light absent, tactile absent-light present, tactile absent-light absent) presented per block in a random order. In the light-present trials the LED was illuminated for 20 ms with a delay of 500 ms on either side. The light was either simultaneous with the tactile pulse (in the tactile present-light present trials) or occurred on its own (in the tactile absent-light present trials). Participants had to report whether they felt the tactile stimulus during the trial period by pressing one of four buttons on the response pad: ‘‘definitely yes,’’ ‘‘maybe yes’’, ‘‘maybe no,’’ ‘‘definitely no’’ (the order of the response buttons was also reversed and random half of the participants responded in the above order, while the other half responded in the reverse order of: ‘‘definitely no,’’ ‘‘maybe no,’’ ‘‘maybe yes,’’ ‘‘definitely yes’’). Participants were unaware of the significance of the light stimulus and were asked to report solely whether they felt a tactile stimulus. The stimuli were controlled via a PC running NI LabVIEW 2011 software, which was also used to record the responses. In between the two blocks, the thresholding procedure was repeated in order to re-establish the threshold before the second experimental block.

2.6 Procedure

Upon arrival to the lab participants were given information about the study that was essential to provide informed consent, but that did not reveal the real objectives of the experiment. After participants signed the informed consent form the experiment begun. Participants were seated at the desk-chair and 2 electrodes were attached to their right cheek with the use of surgical tape. Participants then completed the IS task and the SSDT in the ‘‘camera on’’ and ‘‘camera off’’ conditions (see ‘Experimental design’ section for information on counterbalancing of task order). Upon completion of the experiment participants were fully debriefed and informed about the real purpose of the study.

2.7 Data analysis

2.7.1 Interoceptive sensitivity scores

Interoceptive sensitivity scores were calculated using the following formula:

$1/3 \Sigma (1-(| \text{actual heartbeats} – \text{reported heartbeats} |) / \text{actual heartbeats})$.

Individuals were categorized as high or low in IS using a median split on the camera off IS score (median = .590). The sample consisted of 29 low IS individuals (mean IS = .487, SD = .078), and 28 high IS individuals (mean IS = .794, SD = .125).

2.7.2 Somatic Signal Detection Task data

In accordance with the original SSDT paradigm (Lloyd et al., 2008), responses “definitely” and “maybe” were combined, and grouped into ‘yes’ and ‘no’ responses, which were then categorized as hits, misses, false alarms, and correct rejections. Hit rate and false alarm rate were calculated using the following formulas:

Hit rate = hits / (hits + misses)

False alarm rate = false alarms / (false alarms + correct rejections)

Sensitivity *(d’)* and response criterion (c) statistics were calculated using Statilite software (Version 1.05 developed by Chris Rorden: http://www.mccauslandcenter.sc.edu/mricro/stats/index.html). Where false alarms were equal to zero, 1 was added to both false alarms and to correct rejections to calculate *d’* and *c* values.

3. Results

3.1 Association between IS and Somatic Signal Detection Task performance

Interoceptive sensitivity scores (across all participants) were correlated with SSDT outcome variables of hit rate, false alarm rate, sensitivity, and response criterion for the non-self-focus condition. As IS scores in this condition were not normally distributed, Spearman's ρ correlation coefficients were computed. IS scores were positively correlated with overall false alarms in the camera off condition (ρ = .299, p = .024), which was driven by the significant positive association between IS and false alarms in the light present condition (ρ = .266, p = .046), and a marginally significant positive relationship between IS and false alarms in the light absent condition (ρ = .239, p = .073). IS scores were not significantly correlated with any other outcome measures on the SSDT in the camera off condition.

3.2 Interoceptive sensitivity

As interoceptive sensitivity scores in the non-self-focus condition were not normally distributed, non-parametric test statistics were used to investigate whether the camera manipulation had an effect on IS. A Wilcoxon Signed Rank Test revealed that interoceptive sensitivity scores did not differ between self-focus ("camera on") and non-self-focus ("camera off") conditions (Z = -1.148, p = .251). No effect of camera remained when separately examining the low IS group (Z = -.876, p = .381) or the high IS group (Z = -.638, p = .524). There were no differences in heart rate between camera conditions (t (56) = -1.517, p = .135).

3.3 Somatic Signal Detection Task Results

Sensitivity (*d'*), hit rate, and response criterion (*c*) were each submitted to a 2 x 2 x 2 x 4 x 2 ANOVA with within subject factors of Light (present or absent) and Camera (on or off), and between subjects factors of Camera order (camera first or camera second), Task order (4 possible orders) and IS group (higher IS, lower IS). As there were no main effects of Camera order on sensitivity (F (1, 41) = .095, p = .760), hit rate (F (1, 41) = .012, p = .913), or response criterion (F (1, 41) = .004, p = .950), and of Task order on sensitivity (F (3, 41) = .990, p = .407), hit rate (F (3, 41) = .678, p = .571), or response criterion (F (3, 41) = .286, p = .835) these factors were removed from final analyses, and the dependent variables were analyzed in 2 (light) x 2 (camera) x 2 (IS group) ANOVAs. As false alarms were not normally distributed, non-parametric test statistics were used to test for differences between groups and within conditions. A series of Mann-Whitney U tests and Kruskal-Wallis H tests revealed no group differences in any of the false alarm measures based on the between-subjects factors of Camera order and Task order, respectively—all values were above the significance level of α = .05. Table 1 contains descriptive statistics for each outcome measure in each light condition.

Insert Table 1

Sensitivity (*d')* was higher in the self-focus condition than in the non-self-focus condition (F (1, 55) = 5.866 p = .019, η^2_p = .096). There was a significant main effect of light on sensitivity (F (1, 55) = 34.430 p <.001, η^2_p = .385) with *d'* being significantly higher in light present trials than in light absent trials. There was no interaction effect of camera and light on *d'*. There was no main effect of IS group on *d'*, nor interaction of IS group with camera or light on *d'*. In order to investigate the components of the increase in sensitivity, hit rate and false alarms across conditions were examined next.

Hit rate was analyzed in a 2 x 2 x 2 ANOVA, revealing a significant main effect of light (F (1, 55) = 87.801, $p < .001$, $\eta^2_p = .615$), with hit rate being significantly higher in light-present than in light-absent trials, and a significant main effect of camera (F (1, 55) = 4.276, $p = .043$, $\eta^2_p = .072$), with hit rate being significantly higher in camera-present trials than in camera-absent trials. There was a significant interaction of light and camera on hit rate (F (1, 55) = 4.304, $p = .043$, $\eta^2_p = .073$). In order to probe the interaction, pairwise t-tests comparing hit rate in both camera conditions were conducted for each of the light conditions separately. The results revealed that the effect of camera on hit rate was driven by the difference in hit rate across camera conditions in light-absent trials (t (56) = -2.816, $p = .007$, Cohen's $d = -.753$), as there was no difference in hit rate across camera conditions in light-present trials (t (56) = 2.096, $p = .400$). To see whether the light had a smaller effect on hit rate in the self-focus condition—when the camera was on—than in the non-self-focus condition—when the camera was off—difference scores (hit rate light-present – hit rate light-absent) in each condition were compared. The light had a significantly smaller effect on hit rate in the self-focus condition (mean difference = 8.59 (SD = 12.01)) than in the non-self-focus condition (mean difference = 13.25 (SD = 12.21)), t (56) = 2.096, $p = .041$, Cohen's $d = .56$. Figure 2 illustrates the effect of light and camera on hit rate. There was no main effect of IS group on hit rate, nor interaction of IS group with camera or light on hit rate.

Insert Figure 2

As false alarms were not normally distributed, non-parametric test statistics were used to examine for significant differences in false alarms between conditions. A Wilcoxon Signed Rank Test showed a main effect of light on false alarm rates ($Z = -2.739$, $p = .006$) with false alarm rates being higher in light-present than in light-absent trials, but no main effect of camera on false alarm rates ($Z = -1.001$, $p = .317$). The main effect of light on false alarms was driven by the "camera off" condition where false alarms were higher in light-present trials ($Z = -2.557$, $p = .011$), as opposed to the "camera on" condition where false alarms did not significantly differ between light-present and light-absent trials ($Z = -1.699$, $p = .089$). However, the effect of light on false alarm rate in each condition, as compared using mean difference scores (false alarm rate light-present – false alarm rate light-absent), did not differ ($Z = -.436$, $p = .663$). Figure 3 illustrates the effect of light and camera on false alarm rate. Although the number of false alarms was higher in the high IS group than in the low IS group, the effect of IS group on false alarm rate was not statistically significant indicated by significance level values above .05 on a series of Mann-Whitney U tests investigating group differences in false alarm rates based on the between-subjects factor of IS group.

Insert Figure 3

Response criterion (*c*) was not affected by presence of the camera (F (1, 55) = 2.076, $p = .155$), and there was only a main effect of light (F (1, 55) = 87.990 $p < .001$, $\eta^2_p = .615$), with a significantly more liberal response criterion in light-present trials as opposed to light-absent trials. There was no interaction effect of camera and light on the response criterion. There was no main effect of IS group, nor interaction of IS group with camera or light on the response criterion.

4. Discussion

The current study investigated interoceptive and exteroceptive somatosory perception under two conditions: self-focus and non-self-focus, as manipulated with a video camera being turned on or turned off, respectively. Contrary to our predictions, interoceptive somatosensation, as measured with a heartbeat perception accuracy task, was not significantly affected by the self-focus manipulation. However, exteroceptive somatosensation, measured with the Somatic Signal Detection Task (SSDT), differed significantly between the two self-focus conditions. In order to investigate our research question we needed to modify certain aspects of the SSDT paradigm—namely, the site of tactile stimulation, and respective position of the light in relation to the stimulated body part. Due to the strong automatic integration of visual and tactile sensory modalities, the light in our modified version of the SSDT, which, importantly, was in the central visual field of the participant, retained its salience, and as expected, and in accordance with the SSDT paradigm, in both conditions light occurrence enhanced tactile perception, as reflected by increased sensitivity and hit rate in light-present trials. Light presence also increased false alarm rate in the ‘‘camera off’’ condition and made participants more likely to report feeling a stimulus (as reflected by a more liberal response criterion in light-present as opposed to light-absent trials). Importantly, the presence of a switched on camera also enhanced tactile perception, as reflected by increased sensitivity and higher hit rate in the ‘‘camera on’’, as opposed to ‘‘camera off’’ condition. Further, in the ‘‘camera on’’ condition, the light did not have an effect on false alarm rate as it did in the ‘‘camera off’’ condition, nor did the light increase hit rate as much in the ‘‘camera on’’ condition as it did in the ‘‘camera off’’ condition. Heartbeat perception accuracy was not a significant moderator of SSDT performance. The only significant association between heartbeat perception accuracy and SSDT measures was observed between heartbeat perception accuracy and false alarm rate in the ‘‘camera off’’, non-self-focus condition.

To summarize, when the video camera was turned on, tactile perception was enhanced, as reflected by increased sensitivity and hit rate. Moreover, when it was turned on and recording, there was a lesser impact of light presence on hit rate and no effect of light on false alarm rate. The fact that the presence of the light improved hit rate to a larger degree when the camera was off than when the camera was on, as well as significantly increased false alarm rate only when the camera was off and not when it was on, suggests that the self-focus condition during which the camera was on was powerful enough to override the effect of light on tactile perception. Importantly, the self-focus condition with the camera turned on did not affect the response criterion, consequently eliminating the possibility that differences in performance on the SSDT were due to mere change in tendency to report feeling a tactile stimulus, instead likely reflecting an actual change in sensitivity due to the camera manipulation. It should be noted that the ‘‘camera on’’ condition might have diminished the effect of the light more easily as a result of an already weakened link between the visual and tactile sensory modalities (as compared to the original SSDT paradigm) brought about by a greater spatial distance between the sources of tactile and visual stimulation.

As false alarm rates were smaller in the present study than in the original SSDT paradigm, it is indeed likely that the magnitude of the light effect on tactile perception was smaller in the present study than in the original SSDT study by Lloyd et al. (2008). Nevertheless, it should be noted that multisensory integration is not narrowly constrained by spatial correspondence and there is a large body of research demonstrating crossmodal integration also when the sensory stimulation from the two modalities occurs in distinct locations (see Spence, 2013 for a review). Overall, the light in our manipulation elicited the expected effect on tactile perception and the fact that this effect was diminished in the presence of the camera can be explained by the increase in tactile sensitivity due to heightened self-focus brought about by the turned on video camera. In interpreting our results, we suggest that the ‘‘camera on’’ condition evoked a cognitive shift from first to third person perspective in participants who, as a result of the ‘‘camera on’’ manipulation, were primed with a third person representation of the self as if one sees oneself from the outside, and particularly their face (which was the focus of the camera), which, consequently, might have contributed to the enhancement of tactile perception on the face. The visual enhancement of touch (VET) effect is a well-studied phenomenon, which demonstrates that viewing a given body region improves tactile perception in that skin region (e.g., Kennett, Taylor-Clarke, & Haggard, 2001), by influencing processing in the early somatosensory cortex (e.g., Fiorio & Haggard, 2005). While participants in the present study did not actually view their face, the video-camera being turned on might have primed thoughts of the face being viewed from the third person perspective (being previously told that the video recording of them performing the task could be watched by a third party), consequently, increasing sensitivity in detecting tactile stimuli in the ‘‘camera on’’, but not the ‘‘camera off’’ condition through a mental imagery effect analogous to the VET.

Contrary to our predictions, the video-camera manipulation did not affect interoceptive somatosensory perception, as there was no difference in interoceptive sensitivity between the ‘‘camera on’’ and ‘‘camera off’’ conditions. Past research experiments by Ainley et al. (2012, 2013) have found an increase in interoceptive sensitivity during both mirror, and still photograph self-observation—also used to increase self-focus. Of course, it is possible that interoceptive sensitivity was affected by mere presence of the video camera, which automatically enhanced self-focus, without much further difference between ‘‘camera on’’ and ‘‘camera off’’ conditions. The design of the present study, however, limits the conclusions we can draw from the data, as we did not have a third condition in which the camera would be absent, or an independent baseline measure, which would allow us to make such a comparison. Another possibility might be that the video camera manipulation did not elicit self-focus sufficiently to increase interoceptive sensitivity. We did not ask individuals whether they felt more focused on themselves, as we were not necessarily trying to evoke a conscious increase in self-focus, and the video camera is likely to increase self-focus in a way that the individual is not explicitly conscious of. Also, we assume our manipulation was potent as it did have a significant effect on tactile perception, as we anticipated. Consequently, we propose that a lack of an observed effect in the interoceptive domain is likely due to the mode of self-focus elicited by our manipulation, which was social rather than private in nature. While mirror presence has been found to direct individual’s attention to inner aspects of the self, video camera manipulations have been found to draw attention to external, or social aspects of one’s self that are observable to others (Carver & Scheier, 1981). Accordingly, while mirror presence can enhance an individual’s awareness of his or her inner body—a very private aspect of the self—a turned on video camera, on the other hand, might more selectively enhance tactile perception, which is the sensory modality through which individuals interact with the external world, hence, a sensory modality that is given a stronger weighting in the context of the social self-focus manipulation, thereby enhancing information processing associated with that modality.

Finally, we investigated the relationship between interoceptive and exteroceptive somatosensory perception by examining our data for potential moderating effects of interoceptive sensitivity on SSDT performance, after splitting our participants into two groups: higher and lower heartbeat perception accuracy groups based on the sample median in the ‘‘camera off’’ condition. While we did not observe any modulation of tactile perceptual performance based on interoceptive sensitivity being higher or lower, it should be noted that our sample median was rather low, hence our groups did not represent individuals truly high and low in interoceptive sensitivity. Interestingly, we observed a positive correlation between interoceptive sensitivity and false alarm rate in the ‘‘camera off ’’ condition. This relationship was not reflected in the independent sample comparison results—most likely due to the heavily skewed distribution of false alarms, which included many values of zero, which necessitated the use of non-parametric statistical tests likely lacking in power to detect the difference.

It has been proposed that increased attention to interoceptive stimuli might contribute to the occurrence of false alarms by increasing sensory noise, thereby making it more difficult for an individual to distinguish between signal and noise (sensations originating outside and inside the body, respectively) when detecting a tactile stimulus (Mirams et al., 2013; Silvia & Gendolla, 2001). Mirams et al. (2012) found that directing individuals’ attention to pulse sensations in the fingertip increased individual propensity to report feeling a threshold tactile stimulus, nevertheless did not significantly affect sensitivity measures. Consequently, the results of that study suggest that interoceptive attention might bias individuals toward reporting tactile sensations in their absence, but do not entirely support the hypothesis that interoceptive attention contributes to individuals being less able to distinguish sensory noise from signal. It should be considered that in their experiment, Mirams et al. utilized an untypical interoceptive attention task in which they asked participants to focus their attention on pulse sensations in their fingertip. This methodology might account for an increased propensity to report having felt a tactile stimulus on the fingertip when completing the SSDT afterwards. Notably, in the present study, where we employed a classic version of the task, we did not find an effect of engaging in the heartbeat perception task on SSDT performance, as indicated by a lack of task order effects in our data. Importantly, while Mirams et al. investigated overall effects of interoceptive attention on SSDT performance, they left unexamined the question of whether inter-individual variability in baseline interoceptive sensitivity was related to tactile perception. While our results show that individuals with higher interoceptive sensitivity made more false alarms on the SSDT during the ‘‘camera off’’ condition, we did not observe any association between IS and sensitivity measures which would be more directly indicative of diminished ability to tell apart sensory signal from sensory noise. Even though false alarms on the SSDT have been associated with activity in the right insula and the anterior cingulate cortex (Poliakoff et al., in preparation, as cited in Mirams et al., 2013)—regions central to bodily attention and interoception (Craig, 2003; Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004)—more empirical evidence is needed to test whether increased interoceptive sensitivity interferes with exteroceptive processing of bodily signals—especially, given the evidence for the contrary, where individuals with higher interoceptive sensitivity have been shown to be less susceptible to the Rubber Hand Illusion (Tsakiris, Tajadura-Jimenez, & Constantini, 2011). The Tsakiris et al. study suggests that individuals with higher interoceptive sensitivity are less susceptible to interference from exteroceptive signals in their perceptual experience. Nevertheless, individuals with higher interoceptive sensitivity would then be expected to show enhanced exteroceptive somatosensory perception, and more specifically, increased sensitivity on the SSDT, which is also not supported by our data inasmuch as we did not observe any relationship between interoceptive sensitivity and tactile sensitivity measures. Consequently, further research is needed to establish the exact nature of the relationship between interoceptive and exteroceptive somatosensory processing.

4.1 Conclusions

To conclude, we investigated the effects of social self-focus on exteroceptive somatosensory processing, as measured with the Somatic Signal Detection Task, and interoceptive sensitivity, as measured with a heartbeat perception accuracy task. Our results show that when a video camera was turned on, it enhanced tactile perception, but did not affect heartbeat perception accuracy, relative to the ‘‘camera off’’ condition. Essentially, it can be concluded that social self-focus, as manipulated with a video camera being turned on or turned off, enhanced bodily perception in the exteroceptive tactile modality. Unlike mirrors, which have been found to evoke private self-focus by directing attention to private aspects of the self, video cameras have been found to direct attention to social aspects of the self that are external and observable to others (Davies, 2005). Therefore, the effect of social self-focus on tactile perception, and not on heartbeat perception, could be perhaps attributed to the inherently social aspect of tactile processing. Even though the effect of the switched on video camera on exteroceptive somatosensory processing was not modulated by interoceptive sensitivity, we observed heartbeat perception accuracy to be positively correlated with false alarms in the ‘‘camera off’’ condition. This finding is consistent with recent research showing that false alarm responses on the SSDT are associated with activity in the interoceptive centres of the brain—the right insula and the ACC (Poliakoff, in preparation, as cited in Mirams et al., 2013), nevertheless, our results do not shed further light on the nature of the relationship between interoceptive sensitivity and exteroceptive somatosensory processing such as tactile processing, as we failed to find significant correlations between heartbeat perception accuracy and any of the other SSDT outcome measures. Future research should delineate the relationship between interoceptive sensitivity and exteroceptive somatosensory processing, by taking into account the potential for modulating effects of various modes of attention to self on the way in which somatosensory processing of internally and externally originating bodily signals interacts in shaping body awareness and perception.

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Tables and Figures

Table 1.

Mean sensitivity and response criterion in each camera and light condition.

		Camera condition	
Variable	Light condition	“Camera off” (NSF)	“Camera on” (SF)
d'	No light	1.72 (.51)	2.01 (.50)
	Light	1.91 (.50)	2.13 (.52)
	Overall	1.86 (.46)	2.02 (.47)
c	No light	.87 (.28)	.66 (.26)
	Light	.78 (.26)	.65 (.27)
	Overall	.77 (.24)	.72 (.24)

Note: NSF = non self-focus; SF = self-focus; *d’* = sensitivity, *c* = response criterion. Standard deviations in parentheses.

Figure 1.

Experimental set-up.

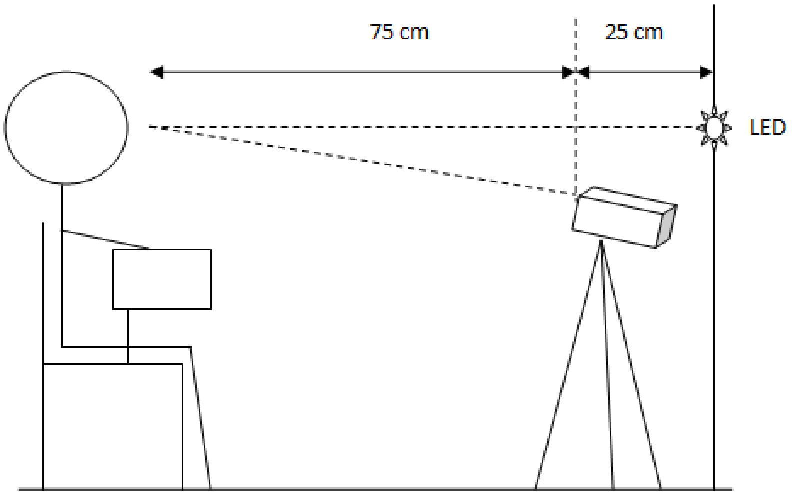
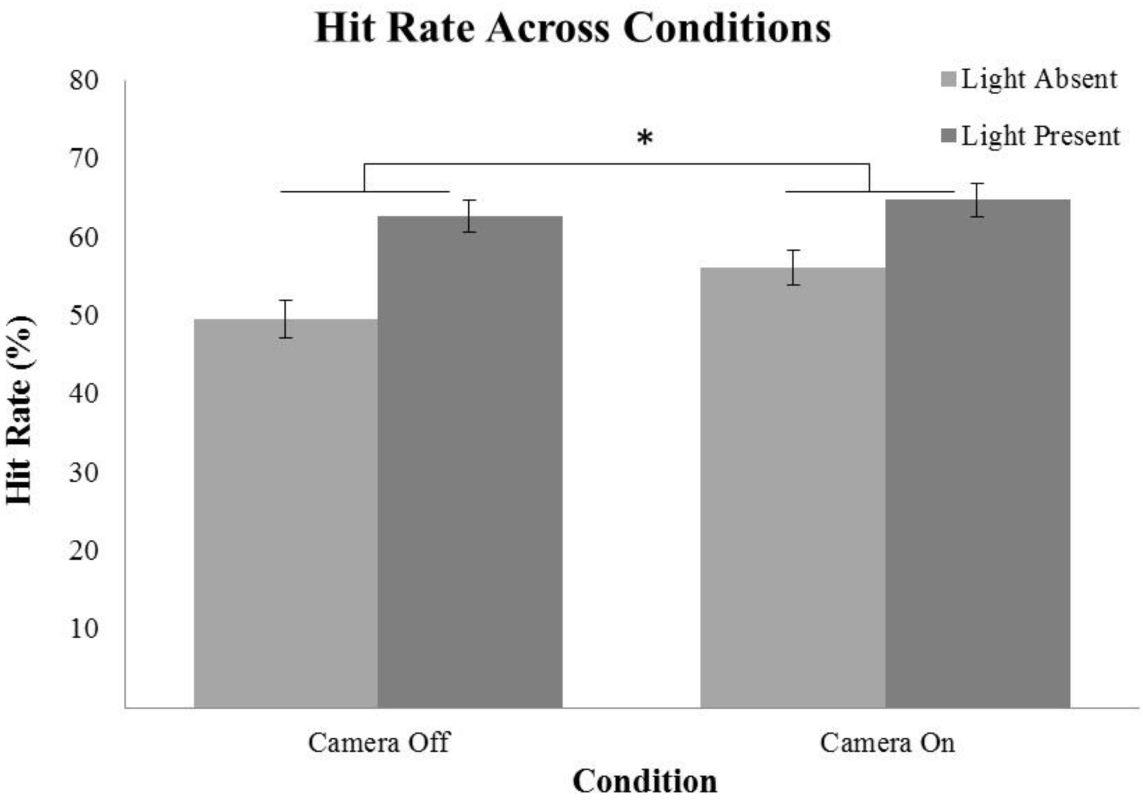


Figure 2.

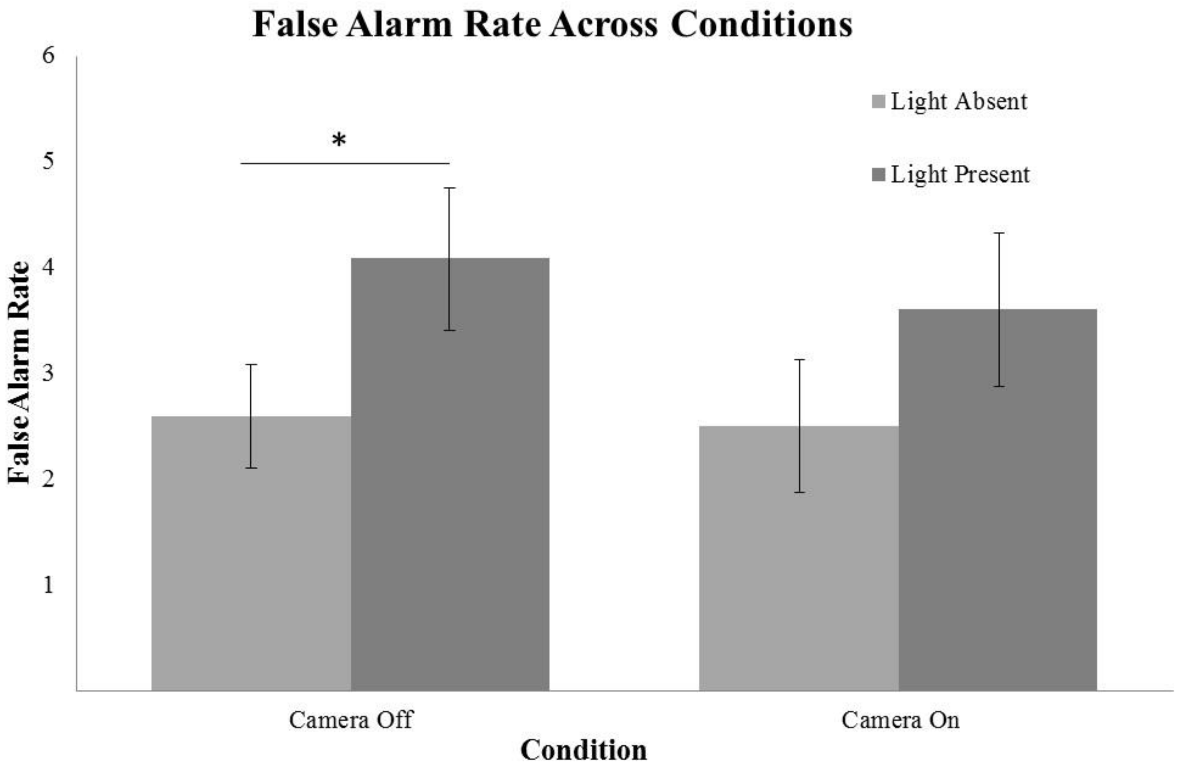
The effect of camera and light on hit rate.



Note: * $p < .05$

Figure 3.

The effect of camera and light on false alarm rate.



Note: * $p < .05$