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Samson, Lelia; Janssen, Erick

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**Introducing a Software-Based Method to Assess and Manipulate Visual Attention:
Feasibility and Initial Validation**

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Lelia Samson^{1, 3} and Erick Janssen²

¹Wee Kim Wee School of Communication and Information, Nanyang Technological University,
Singapore

²The Kinsey Institute for Research in Sex, Gender, and Reproduction, Indiana University,
Bloomington, Indiana

³To whom correspondence should be addressed at the Wee Kim Wee School of Communication
and Information, NTU, 31 Nanyang Link, Singapore, 637718. Email: LESamson@ntu.edu.sg

Abstract

A new software-based method to assess and manipulate visual attention (VA) is introduced. The method uses circular, transparent outlines ('bubbles') that move over visual stimuli. To evaluate the method's feasibility and validity, 50 men watched same- and opposite-sex erotica in self-directed and manipulated VA conditions while their psychophysiological responses were recorded. Participants were instructed to select a bubble by using a computer-mouse which kept selected content visible while darkening the rest of the screen. Only one bubble was available during the manipulated VA conditions. Findings revealed that participants could successfully perform the experimental task and that their spontaneous VA was consistent with predictions. Furthermore, the method successfully manipulated VA. The benefits of this application include the ability to measure and direct VA in multiple participants simultaneously, its ease of use, as well as its provision of relatively noise-free data. Advantages of using this method in social/behavioral science research are discussed.

Keywords: visual attention, stimulus processing, attention manipulation, method development, psychophysiology

Introducing a Software-Based Method to Assess and Manipulate Visual Attention: Feasibility and Initial Validation

In the contemporary western world, where electronic and other media are omnipresent, a seemingly infinite number of stimuli compete for our limited attention (Broadbent, 1958; Lang, 2000; Lennie, 2003; Neisser, 1967). Psychologists, computer and cognitive scientists, as well as experts in media and marketing research have made substantial contributions to our understanding of the mechanisms that are responsible for the allocation of attentional resources, including those relevant to visual stimulus processing (Brasel & Gips, 2008; Egeth & Yantis, 1997; Geiger & Reeves, 1993; Itti & Koch, 2000; 2001; Lang, 1990; Lang, Zhou, Schwartz, Bolls, & Potter, 2000; Moran & Desimone, 1985; Öhman, Hamm, & Hugdahl, 2000; Parkhurst, Law, & Niebur, 2002; Verma & McOwan, 2009; Wolfe & Horowitz, 2004; Yarbus, 1967; Yegiyan & Lang, 2010). The theoretical and empirical literature on the topic of visual attention has grown considerably over the last 25 years (Carrasco, 2011; Egeth & Yantis, 1997). However, this scientific progress is not matched to a similar degree by methodological innovation: The assessment of visual attention still largely relies on the use of elaborate experimental procedures (Barth, Dorr, Böhme, Gegenfurtner, & Martinetz, 2006; Breitmeyer, 1984; Cheal & Lyon, 1991; Eriksen & Collins, 1969; Eriksen & Rohrbaugh, 1970; Gosselin & Schyns, 2001; Jiang, Costello, Fang, Huang, & He, 2006; Kahneman, 1968; Nakayama & Mackeben, 1989; Wenger & Townsend, 2006) or on the use of relatively obtrusive, difficult to calibrate and expensive devices (e.g., eye-trackers).

The current study presents a new, software-based approach to the measurement of visual attention; one that, at the same time, allows for the *manipulation* of attention. As an initial test, we applied the newly developed method to the study of the role of visual attention in men's

responses to same- and opposite-sex stimuli. The paper is organized as follows. We begin with a short introduction to the topic of visual attention. Next, we describe existing methods for measuring visual focus, in particular those allowing for the assessment of eye-gaze. Then, we describe our new approach to assess and direct visual attention, and evaluate its feasibility and validation through an initial experimental test. The feasibility of the method was first tested through an assessment of participants' performance on tasks that require their attention to be directed to specific stimuli. Second, to examine whether the method validly assesses participants' interests in specific stimulus content, we tested whether spontaneous (or self-directed) visual focus is consistent, as has been found in previous psychophysiological and viewing-time studies, with men's self-reported sexual orientation. Last, as an additional test of its validity, we examined whether the manipulation of visual attention to different aspects of the stimulus translates into predictably different psychophysiological response patterns.

Existing Methods to Assess Visual Attention and Eye Gaze

Going back to the days of Hermann von Helmholtz (1866) and William James (1890), scientists have for many years studied concepts like visual attention, eye-gaze, and Point Of Regard (POR). This research has aimed to improve our understanding of the cognitive mechanisms that connect attention (an internal process) to objects of interest in our external environment. Visual attention, which will be used interchangeably with visual focus, refers to the processes by which some objects or locations within the visual field are selected for further processing while others are ignored (Carrasco, 2011; Findlay & Gilchrist, 2003; Yantis, 1998). In the eye-tracking literature, visual attention is conceptualized as Point of Regard (POR) – “a point in *space* where a person is looking” (Poole & Ball, 2006, p. 219) – and operationally defined as eye gaze.

Thus, the eye tracking literature has culminated in the notion that attention is closely related to eye gaze and that humans generally are interested in what they are looking at – at least when engaged in spontaneous or task-relevant visual explorations (Barber & Legge, 1976; Bolt, 1984; Brasel & Gips, 2008; Duck, Gregson, Jones, Noble, & Noy, 1988; Giordano, McElree, & Carrasco, 2009; Henderson & Hollingworth, 1998; Kahneman, 1973; Land & Hayhoe, 2001; Ling, Liu, & Carrasco, 2009; Moran & Desimone, 1985; Parkhurst et al., 2002; Rayner & Pollatsek, 1992; Sperling & Melchner, 1978; Theeuwes, 1993; Ware & Mikaelian, 1987; Yabus, 1967; Yeghyan & Lang, 2010).

Methodological developments in the field of attention research have been dominated by approaches to the measurement of eye-gaze (mostly defined in terms of “the sum of all fixation durations,” Poole & Ball, 2006, p. 213). Starting in the 1950s, researchers have explored various ways to capture movement and focus of the eyes (Buquet, Charlier, & Paris, 1988, for a review, see Duchowski, 2002; 2007). One of the very first attempts involves the external assessment, by independent observers, of the degree to which viewers direct their ‘eyes to the screen’ (Duck et al., 1988; Lorch & Anderson, 1979). Another method, also introduced many years ago, uses electrooculography (EOG), or the recording of electric potential differences through electrodes placed around the eyes (Oster & Stern, 1980). However, this method assesses eye movements and eye position relative to the position of the head and is therefore not suitable to identify POR, or the object of interest, unless the head position is also tracked.

More recently, hardware measurement tools have been introduced that are commonly known as eye-trackers. These include technologies such as EyeCatchers (Chamberlain, 2007; Duchowski, 2007; Fjeld, Ironmonger, Voorhorst, Bichsel, & Rauterberg, 1999), Photo-OculoGraphy, Video-OculoGraphy (Chamberlain, 2007; Duchowski, 2007; Duchowski &

Vertegaal, 2000; Hansen & Ji, 2010; Morimoto & Mimica, 2005; Shahzad & Mehmood, 2010; Stephane, 2011; Villanueva, Cabeza, Goni, & Echeto, 2004), videographic eye trackers (Böhme, Dorr, Krause, Martinetz, & Barth, 2006; Vig, Dorr, & Barth, 2009), etc. These systems have in common that they allow the orientation and movements of the eyes to be tracked using cameras. Although widely used and well-validated, these methods require the use of desk-mounted or wearable cameras, are relatively expensive, and they can be used in only one subject at a time. Also, they require sophisticated calibration procedures, which can lose accuracy and require recalibration, even within a single experimental session.

The most precise method to measure the orientation and movement of the eyes involves the use of search coils, or sclera contact lenses. As the name suggests, this method involves mounting a wire coil on a large contact lens, which is placed directly on the surface of the eye. The wire coil is used to transmit information about eye position and movement. This method, while highly accurate, is also the most intrusive and uncomfortable of all available options. Beyond the evident drawback of the discomfort associated with wearing this device, the method assesses eye-position and -movement independent from head position. This limitation renders it, like the EOG, unsuitable to measure Point of Regard (POR), researchers' ultimate focus of interest.

More recently, less cumbersome and less intrusive methods have been introduced, such as video-based and table-mounted eye trackers (corneal reflections), that allow for the assessment of eye gaze from a distance (Duchowski, 2007; Duchowski, Cournia, & Murphy, 2004; Vertegaal, Mamuji, Sohn, & Cheng, 2005). These so-called "4th generation" eye-trackers include enhancements such as auto-focusing and self-calibrating digital cameras, digital optics, and increasingly easy to use image-processing software. They employ digital optics, coupled

with on-chip Digital Signal Processors to accurately identify head-and-eye position, to compute and synchronize POR within the visual field in real time. Whereas these new devices have undeniably brought about significant improvement to the assessment of visual attention, challenges related to their calibration and usability have persisted, as reported by researchers using them (Duchowski, 2007; Duchowski et al., 2004; Vertegaal et al., 2005). Also, other limitations remain, including their relatively high cost and processing needs (associated with the large quantities of data they provide) and, as is true for other methods, the fact that they allow the assessment of only one person's visual attention at a time.

Some attempts have been made to measure visual attention using software-based techniques (Chen, Anderson & Sohn, 2001; Gosselin & Schyns, 2001). Chen and colleagues measured mouse-cursor movements and position during web browsing, as evidence supports a strong relationship between eye-gaze and mouse-cursor position (Chen et al., 2001). Gosselin and Schyns (2001) used a technique for visual recognition and categorization of photographed faces that makes most of the visual information unavailable: a gray screen is punctuated by several Gaussian-shaped 'windows' displaying parts of the visual stimuli. In addition, some research has attempted to direct visual attention through elaborate experimental procedures by precueing target stimuli (Cheal & Lyon, 1991; Eriksen & Collins, 1969; Eriksen & Rohrbaugh, 1970; Kinchla, 1992; Kröse & Julesz, 1989; Müller & Rabbitt, 1989; Nakayama & Mackeben, 1989). For example, eye gaze has been guided by means of adding formal features (e.g., red dots) to visual stimuli (Barth et al., 2006). However, this approach unavoidably alters the visual information presented, which can be problematic in media and communication studies.

Introducing a New Method

We present a new, software-based method to assess and manipulate visual attention that can be used in more than one participant at any given time (each research subject using their own screen and mouse). The software application is used to create and superimpose circular transparent outlines (or ‘bubbles’) on a computer screen, on top of the video clips, websites, or other visual stimuli. The circular transparent outlines move continuously on top of the videos, making their content available while darkening the rest of the clips. Viewers select their point of regard (POR) by keeping a computer cursor inside one of the available bubbles, thus allowing their visual attention to be tracked (in terms of selected bubble and ‘time-in-bubble’) unobtrusively. In addition, participants’ attention can be directed (and task adherence can be evaluated) by asking them to focus on the content of a specific bubble.

To test the feasibility and validity of this new approach, we conducted a study that focused on the processing of orientation-congruent and -incongruent sexual stimuli in men (for more information on the conceptual background of this research and for other analyses, see Samson & Janssen, 2014). Psychophysiological and viewing time studies have consistently shown that men’s sexual responses, and viewing times, are orientation-congruent, or consistent with their self-reported sexual orientation. This is in contrast to women, where such ‘category specificity’ has not been found (Chivers, Reiger, Latty, & Bailey, 2004; Chivers, Seto, Lalumière, Laan, & Grimbos, 2010; Ebsworth & Lalumière, 2012; Israel & Strassberg, 2009; Mavissakalian, Blanchard, Abel, & Barlow, 1975; Peterson, Janssen, & Laan, 2009; Rullo, Strassberg, & Israel, 2010; Sakheim, Barlow, Beck, & Abrahamson, 1985; Tollison, Adams, & Tollison, 1979).

Hence, if our method successfully assesses spontaneous or self-directed visual attention, previously reported findings should be replicated using the new method for self-directed

attention. Using the novel software, two transparent outlines (bubbles) were superimposed on the videos: one bubble moving over sexual, one moving over the nonsexual mediated content. It is predicted that men will focus on the orientation-congruent sexual stimuli more than on the orientation-incongruent sexual stimuli by keeping the mouse cursor inside the sexual bubble during the orientation-congruent videos for longer than during the orientation-incongruent videos. If the method successfully captures visual focus, then men's time-in-bubble should match 'category specific' viewing time and sexual response findings. Moreover, men's genital responses are expected to provide evidence for the notion that the viewed content is actually processed, which is supported by stronger genital responses during the presentation of orientation-congruent versus orientation-incongruent sexual content.

Manipulating visual attention. In addition to examining spontaneous attention, the current study examined the feasibility and effectiveness of our newly developed method in *directing* visual attention. Research on the determinants of sexual response suggests that whereas attention may not be a prerequisite for the initial activation of sexual responses (e.g., Janssen, Everaerd, Spiering, & Janssen, 2000; Ponsetti & Bosinski, 2010), attention is central to the establishment and maintenance of more substantial response levels (e.g., Barlow, 1986; Geer, Lapor, & Jackson, 1993). Thus, this approach allows for the validation of our software-based method that goes beyond the assessment of task adherence (keeping a mouse inside a bubble, as a measure of eye gaze): It allows us to test whether the stimulus is actually processed, by examining psychophysiological response patterns during conditions that experimentally manipulate the focus of visual attention.

In order to direct visual focus, the software was used to superimpose only *one* bubble on video content and participants were asked to keep the mouse cursor inside the bubble. Visual

attention was directed towards sexual content, when the bubble moving on top of the sexual content was the only one available, and towards nonsexual content, when the bubble moving on top of the nonsexual content was the only one available. It is expected that directing visual focus towards sexual stimulus content will result in increased sexual responses. It is also predicted that sexual responses during the manipulations of visual attention conditions will vary over time. Specifically, it is expected that genital responses will increase over time when visual focus is directed towards sexual stimuli—which depict increasingly explicit sexual behaviors—as compared to nonsexual video content.

Method

Participants

A total of fifty men (28 heterosexual, 22 homosexual) participated in this study. They were recruited through flyers and online announcements. Recruitment materials invited heterosexual or homosexual men, aged 21-35, to participate in an experiment about how men process sexual stimuli. The materials directed men to a brief online screening questionnaire, which included questions about age, sexual orientation, and possible histories of sexual problems. Eligible and interested participants were scheduled for an experimental session and received a link to a larger set of questionnaires, which collected demographics as well as information on sexual attitudes and behaviors. Subjects were compensated \$15 for their participation. Study approval was obtained from the Human Research Protection Program (HRPP) of the university IRB.

Stimuli

Participants were presented with a series of 3-minute excerpts from commercially available sexually explicit films as well as nonsexual, neutral excerpts, taken from documentaries

about animals (e.g., cats, turtles). The first neutral clip lasted eight minutes and was used to determine physiological baseline levels. The subsequent neutral film excerpts were used for 3-minute return-to-baseline intervals. Sexual film excerpts consisted of three videos depicting homosexual (two men engaged in same-sex with one-another) and three videos depicting heterosexual (a man and a woman engaged in sex) activity. All sexual clips depicted actors engaged in petting, fondling, kissing, oral-genital sex, and sexual intercourse. The auditory channel presented background music but no sexual content.

Attention Manipulation and Assessment

The manipulation and measurement of visual focus was accomplished through use of a software application that allows for the presentation of circular transparent outlines ('bubbles') which move on top of visual stimuli (in the current study, video excerpts), making their content available while darkening everything else (see Figure 1). Movement and placement of the bubbles can be controlled by the program (for random conditions), by entering the coordinates of the bubbles over time or by recording movements of the mouse over targeted content. The size and number of bubbles can vary according to experimental needs and screen size. For the purpose of the present study, one (for manipulated attention) and two (for self-directed attention) circular transparent outlines equal in size (about $1/8^{\text{th}}$ of the available visual display) were used. For the current research, bubbles were superimposed on the video stimuli by the researchers. After identifying the screen location of sexual and nonsexual content frame by frame, the first author moved the mouse cursor over sexual/nonsexual content to control and record the movement of the bubbles.

--Insert Figure 1 here--

For the purpose of the current experiment, participants were asked to use a computer mouse to keep its cursor inside either a self-selected or a prescribed bubble, depending on the instruction. An invitation to “hover your mouse-cursor over a bubble” appeared on top of the screen when no bubble was selected (see Figure 1, left panel). To minimize awareness and sensitization to the research topic, as well as to reduce response biases, participants were not informed prior to study completion that the time they spent inside bubbles would be recorded.

For self-directed visual attention (Condition 1), not one but two transparent outlines moved freely within the screen, and participants were told that they could select either one and move from one to the other whenever they wanted, by keeping the mouse cursor inside the chosen bubble. One of the two bubbles moved over sexual content (e.g., genitals), the other over nonsexual content (e.g., background, hair). Thus, in Condition 1, the participants could choose to focus on sexual or nonsexual content. For the other two conditions, participants’ visual attention was directed towards sexual (Condition 2) or towards nonsexual content (Condition 3). Self-directed attention (Condition 1) was assessed prior to the manipulation of visual focus (Conditions 2 and 3). Thus, participants were first presented with videos presenting two bubbles and were allowed to select either the sexual or the nonsexual bubble. During the second and third conditions, only sexual or nonsexual content was available. The videos and these two conditions were presented in three, randomly selected, fixed orders.

At the end of the experimental session, the data generated by each participant was saved in a text document (in ASCII format) which contained a detailed account of which bubble the subject hovered over at what time, as well as information about time spent in and out of the bubbles.

Measures

Self-directed visual attention. Self-directed visual focus was operationalized as the time participants spent in one of the two available bubbles during Condition 1 (in seconds, out of a maximum of 180 seconds). Self-directed visual attention towards sexual content was measured as time in the sexual bubble and visual attention away from sexual content was assessed as the time they spent in the nonsexual bubble.

Genital response. Erectile responses were monitored using a RigiScan device (Timm Medical Technologies). This instrument measures penile circumference at 15 sec intervals and penile rigidity at 30 sec intervals once circumference has increased by 20%. For a discussion of the reliability and validity of the RigiScan, see Janssen (2002) and Janssen, Prause, & Geer (2007). Genital responses were reported as the maximum penile rigidity (%) measured at the base of the penis (cf. Janssen, 2002; Janssen, Vorst, Finn, & Bancroft, 2002) for analyses on the main effects of experimental conditions. The analyses over time used penile circumference, the difference scores from baseline measured at 15 sec intervals (cf. Janssen, 2002; Janssen et al., 2002).

Procedure

Upon arrival to the lab, participants, who were tested individually, entered a room furnished with an armchair, a desk, a mouse with mouse-pad and 42-inch LCD television monitor. They were seated at a viewing distance of 80 inches (Hatada, Sakata & Kusaka, 1980; Reeves, Lang, Kim & Tatar, 1999; Sakamoto, Aoyama, Asahara, Yamashita, & Okada, 2008). An experimenter explained the procedures and showed the measurement devices. After the participant read and signed the informed consent form, the experimenter left the room and the participant put the RigiScan in place and a disposable sheet and towel on his lap, a procedure commonly used in studies of this kind (e.g., Janssen, Goodrich, Petrocelli, & Bancroft, 2009).

After the device was put in place, the experimenter started a 15-minute adaptation period. During the adaptation period, the participant was asked to practice the experimental task by trying to keep the mouse-cursor inside bubbles placed on top of a practice film. At completion of the practice task, participants were presented with an 8-minute neutral film. This was followed by presentation of the sexual and nonsexual clips. At the end of the testing session, payment arrangements were made and participants were debriefed regarding the purpose of the study. Testing sessions took approximately 90 min.

Data Analysis

Analyses were conducted using MANOVAs (McCall & Appelbaum, 1973; O'Brien & Kaiser, 1985). They were performed using two factors: Sexual Stimulus (2) and Attention Manipulation (2). Sexual Stimulus consisted of video clips depicting Orientation-Congruent and -Incongruent sexual activity. The Attention Manipulation factor was created using the following two manipulations: (1) visual attention directed towards Sexual Content (e.g., genitals), and (2) towards Nonsexual Content (e.g., furniture, arms). MANOVA was also used to perform analysis over time using penile circumference difference scores, as measured at 15 sec intervals). SPSS 19 for Windows and SPSS 11 for Mac OS X were used for all analyses.

The data from one heterosexual participant were excluded from all analyses because of nonparticipation in the experiment (he fell asleep during the study). In addition, the data from one homosexual and one heterosexual participant were excluded from the analyses on sexual arousal because their RigiScan recording was unusable (experimenter error). Thus, the final sample consisted of 47 men (26 heterosexual; mean age = 23.9, $SD = 3.2$; 21 homosexual, mean age = 23.2, $SD = 2.9$).

Results

Task adherence. Analyses revealed that, in general, participants successfully executed the experimental task. Participants kept the cursor inside a bubble for more than 95% of the time (approximately 174 seconds out of a total of 180 seconds for each film excerpt).

For self-directed visual attention (Condition 1), when two transparent outlines were available, men maintained their visual focus on one of the two (either sexual or nonsexual) bubbles for about 176 seconds (98%) for homosexual and 175 seconds (97%) for heterosexual stimuli. The participants also adhered to the experimental task when only one bubble was available (Condition 2 and 3). Participants kept the cursor inside the sexual bubble, when instructed to do so, for an average of 175 seconds ($SD = 7.9$) during homosexual stimuli and for 172 seconds ($SD = 10.4$) during heterosexual stimuli (Condition 2). Similarly, men kept the cursor inside the nonsexual bubble for an average of 174 seconds ($SD = 10.1$) during homosexual stimuli and for 173 seconds ($SD = 9.8$) during heterosexual stimuli (Condition 3).

Validity to assess the object of interest. To assess whether the newly developed method successfully captures self-directed visual attention, men's time-in-bubble (during Condition 1) for sexual content was examined. Consistent with findings from previous psychophysiological and viewing-time studies, we predicted that self-directed visual attention to sexual content would be higher for orientation-congruent stimuli. To test this prediction, a 2 (Sexual Stimulus: Orientation-Congruent, Orientation-Incongruent) MANOVA was performed on attention for sexual content (time-in-sexual-bubble). We found a significant effect of Sexual Stimulus, Wilks' $\lambda = .58$, $F(1, 48) = 34.32$, $p < .001$, $\eta_p^2 = .42$. The participants focused longer on the sexual content of orientation-congruent ($M = 162.76$, $SE = 3.8$) than orientation-incongruent ($M = 100.56$, $SE = 10.31$) stimuli.

To test whether the viewed content was actually processed, a 2 (Sexual Stimulus: Orientation-Congruent, Orientation-Incongruent) MANOVA was performed on men's genital responses during the self-directed visual attention condition (Condition 1). There was a significant effect of Sexual Stimulus, Wilks' $\lambda = .67$, $F(1, 46) = 22.25$, $p < .001$, $\eta_p^2 = .33$. The participants had stronger genital responses when viewing orientation-congruent sexual content ($M = 39.19$, $SE = 4.51$) than when viewing orientation-incongruent sexual content ($M = 12.38$, $SE = 3.12$).

Manipulating visual attention. It was predicted that directing visual attention towards sexual – versus nonsexual – content (during Conditions 2 and 3) would lead to increased genital responses, regardless of whether the stimuli were orientation-congruent or not. To test this prediction, a 2 (Attention Manipulation: Sexual Content, Nonsexual Content) MANOVA was performed on men's genital responses. There was a significant effect for Attention Manipulation, Wilks' $\lambda = .65$, $F(1, 46) = 24.73$, $p < .001$, $\eta_p^2 = .35$. Directing visual attention towards sexual content resulted in stronger genital responses ($M = 25.51$, $SE = 3.3$) than when visual attention was directed towards nonsexual content ($M = 15.53$, $SE = 2.5$).

It was also predicted that sexual responses during the manipulations of visual attention conditions would vary over time. The longer participants' visual focus was directed towards sexual content (Condition 2), the more the genital responses were expected to increase, as compared to the condition during which visual focus was directed towards nonsexual content (Condition 3). To test this prediction, a 2 (Attention Manipulation: Sexual Content, Nonsexual Content) X 12 (Time) MANOVA was performed on men's genital responses using penile circumference difference scores. The MANOVA revealed a significant main effects of Attention Manipulation, Wilks' $\lambda = .63$, $F(1, 46) = 26.63$, $p < .001$, $\eta_p^2 = .37$; and of Time, Wilks' $\lambda = .28$,

$F(11, 36) = 8.76, p < .001, \eta_p^2 = .73$. In addition, a significant interaction of Attention Manipulation by Time was found, Wilks' $\lambda = .43, F(11, 36) = 4.49, p < .001, \eta_p^2 = .58$. As can be seen in Figure 2, directing visual attention towards sexual content resulted in stronger genital responses over time as compared to the condition during which visual focus was directed towards nonsexual content.

--Insert Figure 2 here--

Discussion

The study described in this article presents a newly-developed software application for the assessment and manipulation of visual attention. The feasibility and initial validation of this new method was examined by measuring men's responses to orientation-congruent and -incongruent sexual stimuli, an area of strong empirical support for "target specificity". The method's feasibility was tested through the assessment of participants' task adherence. The results provide empirical evidence that participants could perform the experimental task, as they successfully kept the cursor inside a bubble for more than 95% of the time.

To examine whether the method successfully captured participants' interests in specific stimulus content, we tested whether spontaneous or self-directed visual focus is consistent with men's self-reported sexual orientation, as has consistently been found in psychophysiological and viewing time studies. Analyses revealed that participants spent more time focusing on the sexual content of orientation-congruent than that of orientation-incongruent stimuli. Consistent with our predictions, these findings suggest that the method successfully assesses spontaneous visual focus.

As an additional validity test, we examined whether the manipulation of visual attention to different aspects of the stimulus would translate into different psychophysiological response

patterns, consistent with previous research findings. Our results indicate that directing visual attention towards sexual content resulted in higher levels of genital response as compared to the condition during which visual focus was directed towards nonsexual content. Moreover, sexual responses significantly increased over time, when visual focus was directed towards sexual as compared to nonsexual content. This provides further empirical support for the idea that our method successfully manipulates visual attention: Time in bubble reflects choice of content, but does not guarantee that the content was actually processed – the psychophysiological findings, however, do provide support for this.

Testing for consistency with predictions, for calibration and replication of extensive existing empirical support in this field, the present study empirically illustrates the feasibility and initial validity of this newly developed method to assess and manipulate visual attention (for additional findings, see Samson & Janssen, 2014). Beyond our theoretically driven predictions, it also points to several advantages, including its ease of use, its provision of relatively noise-free data, and the possibility to measure and direct visual focus in multiple participants at a time. Furthermore, our software-based approach to measuring and manipulating visual attention brings methodological enhancements to its operationalization. For example, in eye-tracking studies, eye gaze represents the operationalization for POR. It is measured separately and matching it with POR can be challenging because the position of the head is not always measured, known, or fixed. With the present method, Point of Regard (the object of interest within the visual field) and eye gaze actually overlap. That is, since viewers need to look at the cursor in order to control it, it can be safely assumed that the selected bubble area represents POR. Eye-trackers can only be used to measure overt visual focus (shifts in spatial attention with eye movements), which is to a large degree a top-down mechanism (Findlay & Gilchrist, 2003; Hunt & Kingstone, 2003)

and is arguably less applicable to ordinary media consumption. The method presented here is capable to capture visual attention that is allocated overtly as well as covertly (shifts in spatial attention without eye movements), although it cannot differentiate between the two.

Some limitations of the study should be mentioned. The assessment and manipulation of visual focus is enabled through the use of bubbles that require participants to follow them using a computer mouse. This exposure context hence involves a more active engagement with visual content. The findings generalize to such active viewing situations and should not be assumed to apply to more passive ones. It should also be mentioned that the current method requires participants to allocate cognitive resources to the measurement task itself. This does not confound the findings on visual focus since the cognitive resources required by the measurement task are the same across all research conditions and the method allows researchers to assess which stimulus content (i.e. selected bubble), compared to other content (i.e., other bubbles), is most likely to capture a viewer's visual attention. Moreover, the psychophysiological results (especially those involving effects over time) provide further support for the idea that the experimental task, and the cognitive resources it requires, do not distract participants from processing the mediated content. Second, although our study provides some initial validation of this novel approach to the assessment and manipulation of attention, we cannot be certain that it fully captures the intricate nature of visual attention. That is, we acknowledge the possibility that participants may, in varying degrees, have managed to keep the mouse cursor inside bubbles by focusing on the cursor itself, while ignoring or filtering out the rest of the content. Yet, even in such a case, peripheral or parafoveal vision – which involves automatic or involuntary processes (cf. Holender, 1986) – would have been expected to lead to the processing of surrounding visual content. The psychophysiological results support this conclusion. Furthermore, our findings are

most relevant to the focus of visual attention and cannot differentiate between various aspects of the attention-allocation processes (such as those related to cognitive control, orienting response, cognitive withdrawal, between exogenous versus endogenous attention-allocation processes, between overt versus covert orienting, between serial versus parallel processing, and so on).

The findings of the current study demonstrate the feasibility of the newly developed method, and provide initial validation of this approach. Future investigations could advance our understanding while incorporating memory tests and other physiological measures. Testing its usability in other populations (including women, different age groups, etc.) or with other types of stimuli should also be considered in future research. Particularly, comparisons with existing methods such as eye-tracking would be valuable next steps in further establishing its benefits and shortcomings. Further research could also investigate the impact of the level of background dimness and the speed and shape of the bubbles. We believe, given the results of the study, that our method has value and may contribute to the literature in areas of research as varied as media and marketing research, computer-science, experimental psychology, other behavioral sciences. It could be used to test visual attention and responses to advertising, news, documentaries, movies, visual/graphic design, websites, etc. This is especially useful in examining which specific content is most likely to capture viewers' focus. These investigations seem overdue in the context of our contemporary mass media, which is dense with information, where webpages are inundated by various announcements and advertisements in all corners, and where television newscasts are oversaturated with stimuli: as the news screens jam-pack images of the anchor, of the reported events (including or excluding the reporter), of the news headlines, text boxes, the channel logo, a time clock and a constantly-crawling news ticker. The method presented here has

potential in allowing researchers to assess which of these mediated stimuli are more likely than the others to capture viewer visual focus.

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Figure 1. The assessment and manipulation of visual attention.

Figure 2. Genital responses (cm circumference change) over time with visual focus directed towards sexual and nonsexual content.