Abstract

Research on non-offending heterosexual participants has indicated that men's gaze allocation reflects their sexual preference. In this exploratory pilot study we investigated whether naturalistic gaze behaviour is sensitive to deviant sexual preferences. We compared gaze patterns of convicted heterosexual child sex offenders (n = 13) with female victims to heterosexual non-offending men (n = 13) in a task of free-viewing images of clothed male and female figures aged 10, 20 and 40 years old. Child sex offenders (CSO) dedicated more fixations to the upper-body of the female child than male child figures. The pattern was different for the control sample, whose gaze pattern to male and female figures could only be differentiated when viewing adult figures. CSO showed significantly greater difference in their gaze towards the upper-body of male and female children than non-offenders. Our findings provide preliminary evidence for eye-tracking as a potential method of assessing deviant sexual interest.

Introduction

The assessment of sexual preference is "a prerequisite to adequate research and clinical activity" (Wright & Adams, 1994, p.221). Currently the most commonly used method to assess sexual preference in forensic research is penile plethysmography (PPG). Although PPG is largely considered the 'gold standard' in the assessment of sex offenders (Kalmus & Beech, 2005), it has been criticised for its susceptibility to faking, intrusiveness and lack of standardisation (Flak, Beech, & Fisher, 2007; Kalmus & Beech, 2005; Laws, Hanson, Osborn, & Greenbaum, 2000; Marshall & Fernandez, 2000). In response to these criticisms, there has been a recent trend towards looking at alternative methods of assessment, with particular emphasis on cognitive measures (Thornton & Laws, 2009; Snowden, Craig & Grey, 2011).

Cognitive measures are typically attention-based tasks. These measures work on the premise that preferred sexual information is processed differently from non-sexual and non-preferred information (Geer & Bellard, 1996; Geer & Fuhr, 1976; Geer & Melton, 1997; Janssen, Everaerd, Spiering, & Janssen, 2000; Spiering, Everaerd, & Janssen, 2003); by measuring differences in processing we may obtain an insight into the observer's sexual motivation and interest. Several studies have shown that both explicit, consciously processed sexual stimuli (Geer & Bellard, 1996; Geer, Judice, & Jackson, 1994; Geer & McGlone, 1990) and implicit non-consciously processed sexual stimuli (Spiering et al, 2003; Spiering, Everaerd, Karsdorp, Both, & Brauer, 2006) have an interfering effect on information processing, which requires additional processing time and exerts attentional capture. Studying how sexual information is processed offers an insight into the cognitive processes that may accompany early sexual attraction thought processes, as well as potentially providing new methods to assess sexual preference in clinical and forensic settings.

Snowden et al. (2011) have recently reviewed the use of indirect cognitive measures of processing sexual stimuli among sexual offenders. Tasks such as the Emotional Stroop (Stroop, 1935), The Implicit Association Test (IAT; Greenwald, Mc Ghee, & Schwartz, 1998), Rapid Serial Visual Presentation (RSVP; Raymond, Shapiro, & Arnell, 1992), Choice Reaction Time (CRT; Giotakis, 2005), viewing time (Abel et al., 2004; Glasgow, Osborne, & Croxon, 2003; Gress 2005) have all indicated a difference in information processing of child stimuli between CSO and non-offenders. Given that eye movements are automatic, difficult to consciously alter, and reflect the observers motivation and preferences (Isaacowitz, 2006; Nummenmaa, Hyona, & Calvo, 2006), measuring gaze allocation in the viewing of human figures should advance our understanding of cognitive processing of sexual information and could be a useful measure of sexual preferences (Hall, Guo, & Hogue, 2011, 2012; Lykins, Meana, & Kambe, 2006; Lykins, Meana, & Strauss, 2008; Rupp & Wallen, 2007).

The ability of eye-tracking to elucidate differences in information processing of sexual stimuli has been under-researched, despite the fact that eye-movements are likely to be an integral part in some of these methods (such as VT and CRT). The extent to which eye movements can be controlled is, as yet, unknown. However, research by Nummenmaa, Hyona, & Calvo (2006) has shown that under instructions not to look at emotional stimuli participants still directed their eye-gaze towards these images, indicating initial gaze appears not to be under volitional control, Given that initial eye movements are automatic, difficult to completely control or altere consciously, and reflect the observers' motivation and preferences (Isaacowitz, 2006; Nummenmaa et al., 2006), measuring gaze allocation in the viewing of human figures should advance our understanding of cognitive processing of sexual information and could be a

useful measure of sexual preferences (Hall, Hogue, & Guo, 2011, 2012; Lykins, Meana, & Kambe, 2006; Lykins, Meana, & Strauss, 2008; Rupp & Wallen, 2007).

Several studies have investigated gaze patterns in non-forensic sexual research. Research has revealed a gender difference in gaze strategies to erotic and non-erotic images, with heterosexual men demonstrating a strong preference for viewing opposite sex figures (Lykins et al., 2008; Rupp & Wallen, 2007; Nummenmaa, Hietanen, Santiila, & Hyönä, 2012) , and specifically looking more at nude females chests (Nummenmaa et al., 2012). For men, this bias could start at the early stage of visual processing, with Fromberger et al. (2012a) demonstrating that when paired with non-preferred figures (girls, boys or men) heterosexual men dedicated the first fixation towards sexually preferred (adult women) and viewed these figures for longer than the non-preferred figures.

Eye-tracking has been used to develop a measure of stimulus attention within a Virtual Reality Simulator (Renaud, DéClarie, Gourd, Paquin, & Bouchard, 2003) indicating that pedophiles show a less stable, slower and more sexually oriented gaze pattern than control subjects (Renaud, et.al. 2013). One recent study (Fromberger et al., 2012b) compared eye movements of pedophiles and controls whilst they viewed an image of a child and adult presented simultaneously. Participants were asked to make a judgment as to which person they found more sexually attractive by clicking a mouse button whilst their eye-movements were tracked during the decision process. The images were selected from the Not-Real-People (Pacific Psychological Assessment Corporation, 2004) picture set and all images were nude. Measures of first fixation and fixation time showed that that pedophiles looked earlier and longer towards the child figure than the control groups, providing preliminary evidence that eye movements may be sensitive to pedophilic tendencies. However, it remains unclear which specific body regions are

attended to when CSOs gaze at figures without specific instruction (mimicking natural behaviour), and how this may differ as a function of the figure's age and sex. By exploring more explicit allocation of fixations we may gain further insight into CSOs early cognitive process when viewing children.

Further analysis of gaze distribution to body regions provides a unique insight into the information processing strategies associated with viewing clothed figures of different ages. Recently, Hall et al. (2011) systematically compared gaze patterns of young heterosexual men and women when viewing photos of plain-clothed male and female figures of various ages (baby, 10-, 20-, 40- & 60-year-olds). The results show that men displayed a distinctive gaze pattern only when viewing twenty-year-old female images. Specifically, men showed more fixations and longer viewing time to the upper-body and waist-hip region, indicating that gaze patterns may be sensitive to males preferred gender and age of sexual partner. In another study, Hall et al. (2012) found a clear role of sexual motivation in influencing men's gaze behaviour. Heterosexual men who reported more sexual compulsivity dedicated more gaze to the waist-hip region when viewing figures of their preferred sexual partner than men with less sexual compulsivity, suggesting gaze patterns may also be sensitive to individual differences in sexual motivation. It appears that for teleiophilic men, gaze patterns detect differences in information processing between sexually preferred and non-preferred stimuli.

To date, the extent to which gaze patterns may reflect deviant sexual interests remains largely un-investigated. Despite this, gaze patterns offer several potential advantages to existing cognitive measures of sexual interest. The processes underlying existing measures (e.g., VT, CRT, IAT, RSVP, Stroop) are unclear (Imhoff et al., 2010). For example, with all these methods longer latencies may possibly also reflect a general interest in children, independent of sexual

interest. In comparison, gaze patterns allow a measure of naturalisitic behaviour, which is difficult to control in initial viewing (Nummenmaa et al., 2006). Additionally, this method allows a specific insight into what information the observers are preferentially attending to, which may influence their later decision making and behaviour (Singer, 1984).

In this exploratory study we investigated whether naturalistic gaze patterns (free from instruction) in CSOs could be differentiated when viewing plain clothed figure images of male and female adults and children (10-year-olds, 20-year-olds, 40-year-olds), and compared their data to a non-offending sample.. We chose to focus our analysis on the upper-body and waist-hip regions, as previous research has demonstrated them to be the most effective in elucidating sexual preference (Hall et al., 2011, 2012). Evolutionary theorists consistently highlight the importance of assessing the upper-body and waist-hip regions in the attraction process (Singh, 1993a, 1993b; Henss, 2000), with both regions being thought to provide an observable marker of a female's age and fertility (Singh, 1995; Singh & Randall, 2007). In support of this, previous research has demonstrated that differences in waist-hip ratios and breast sizes influence attractiveness judgments (Connolly, Slaughter, & Mealey, 2004; Furnham, Swami, & Shah, 2006; Furnham, Tan, & McManus, 1997), which can also be evidenced by differences in gaze towards these regions. For example, Suschinksy, Eilas and Krupp (2007) found that men judged figures of a lower waist-to-hip ratio as more attractive, and also dedicated more gaze to the upper-body and waist-hip regions of these figures when compared to figures with higher waist-to-hip ratios, and Cornelissen, Hancock, Kiviniemi, George and Tovee (2009) showed that men and women tend to gaze at the stomach and chest region when making attractiveness judgments. On the basis of strong theoretical and research-supported evidence we chose to exclusively concentrate our analysis of the upper-body and waist-hip regions.

We hypothesised that CSOs with female only victims would show differential gaze behaviour when viewing male and female child figures, which would be manifested by how often (proportion of fixations) and how long (viewing time) they viewed the upper-body and waist-hip region. Specifically, we expected CSOs to show more gaze behaviour to these regions of the female child figures than the male child figures. The non-offenders were expected to only demonstrate this pattern when viewing figures of mature adults. In line with phallometric studies, we did not expect to find any difference in the gaze behaviour between CSO and non-offenders when viewing adult stimuli (e.g., Barbaree & Marshall, 1989).

Method

Participants

Two groups participated in this study, a sample of convicted CSO and non-offenders matched for age, gender orientation and ethnic origin. These three factors were measured through self-report. The final sample consisted of 13 CSOs and 13 matched non-offenders. The CSOs, ages ranged from 22 to 68 years-old (M = 43.46 years, SD = 14.22), offences ranged from downloading indecent images of children to full sexual intercourse, sentence length ranged from 1 to 8 years (M = 3.37 years, SD = 2.36), 2 offenders had indeterminate sentences for public protection, and victims ages ranged from 7 to 12 years (M = 10.46 years, SD = 1.85). None of the offenders had engaged in a sexual treatment programme. Non-offending participants were recruited by a researcher at a University; CSOs were recruited by the prison psychologist assistant. Both groups were informed that the research was investigating how we look at people.

The non-offending group consisted of 13 men recruited through a university, including undergraduates and both academic and non-academic staff members. Non-offenders ages ranged

from 20 to 55 years-old (M = 40.69 years, SD = 11.14), although the offending sample were slightly older than the non-offenders, a t-test revealed there was no significant difference between the two samples (p = .07). Non-offenders all reported white, British ethnic origin and heterosexual orientation and all reported a preference for sexual partners aged 20 or 40 years-old (assessed through self-report). All participants were informed the results would be anonymous, confidential and for research purposes only. The research project was approved by the university's departmental ethics committee and local prison processes.

The offending sample included an initial population of 27 men convicted for a child-related sexual offence and detained in a local prison with a vulnerable prisoner unit. Participants were only included if they fulfilled the following criteria:

1. They were males over 18-years-old
2. Reported preferential attraction to females
3. They had only been convicted of child-related sex crimes
4. They were white, British
5. Child victims were aged under 12-years-old
6. Not convicted / suspected of intra-familial offences

As this was an exploratory investigation, we chose these restricted criteria to control for any potential confounds in sexual interest that may result from sexuality, culture and familial relationship to the victim. Of the initial sample, 3 were excluded on the basis of ethnic origin, 1 for offences against boys, 3 for offences against adult women, 1 for eye-tracker failure, 2 for later admitting homosexual tendencies, and 4 for failing to complete the questionnaire, leaving the final sample of 13 CSOs.

Procedure

Digitized grey scale images were presented through a portable Tobii 1750 system and displayed on an integrated TFT flat panel gamma-corrected colour monitor (17 inches, 30cd/m^2 background luminance, 50Hz frame rate) with a resolution of 1024×768 pixels. At a viewing distance of 57cm the monitor subtended a visual angle of 40×30°. The Tobii system is a portable eye-tracker with built in camera.

Horizontal and vertical eye positions were measured with 50Hz sampling frequency and up to 0.5° accuracy, with a drift in calibration of less than 0.5°. The ClearView software computed horizontal and vertical eye displacement signals as a function of time to determine eye velocity and position in a free-viewing task.

The images consisted of 30 full-body figures of white ethnic origin and included three age groups: pre-pubescent children around 10-years-old, adults in their early twenties and adults in their late thirties or early forties were used (10 images per age category with equal proportion of sex in each). Images were obtained from internet fashion catalogues. All figures were plain-clothed in summer or sportswear and portrayed with either neutral or low-intensity happy facial expressions. The images were gamma-corrected and displayed once in a pseudo-random order at the centre of the screen. The original background of the figures was replaced with a homogeneous grey background with 5% Michelson contrast and all images were scaled to the same size (600×300 pixels, 22×11°).

In a previous study, all images were assessed for figure attractiveness on a seven-point Likert scale by non-offending 20-year-old heterosexual men and women (Hall et al., 2011). The five figures belonging to the same age and sex category were deemed equally attractive. Across

image categories, both men and women participants rated figures of their preferred age (20-year-olds) and sex as more attractive than the figures in other categories.

During the experiment the participant sat in a chair and viewed the display binocularly, with their head unrestrained. They were asked to keep their head as still as possible whilst viewing the pictures. To calibrate eye positions, participants followed 1 fixation point (FP) that was presented sequentially at one of nine locations across the screen (3×3 matrix). Calibrations were only accepted if the data was accurate for both eyes. After the calibration, the trial was started with a FP displayed on the centre of the monitor. During the free-viewing task participants were instructed to fixate on the FP for 1s (the initial central fixation was checked and confirmed with off-line analysis). After that, the FP disappeared and an image was then presented for 5s. The participant passively viewed the images with the task instruction of "viewing the pictures as you normally do". The inter-trial interval was set to 1.5s.

Data Analysis

While determining fixation location and viewing time allocation within images, we divided each body into two different feature regions: the upper body (from the base of the neck to the end of the rib cage), and the waist-hip region (including the stomach, hips and pubic region). We chose to focus our analysis on these two regions as previous research has demonstrated they are the most crucial for eliciting differences in sexual preference in heterosexual men. Specifically, men gaze sooner and longer at these regions when viewing adult female stimuli (Cornelissen et al., 2009; Dixson, Grimshaw, Linklater, & Dixson, 2011; Hewig et al., 2008). However, when viewing images of males there is no difference in gaze allocation to these regions (Hall et al., 2011, 2012).

Each fixation was then characterised by its location and its time of onset relative to the start of the trial. To calculate the proportion of fixation and viewing time allocated at each body region, two commonly used measurements in eye tracking studies to indicate the amount of interest and processed information by the viewers (Henderson, 2003), the number of fixations and associated viewing time (sum of individual fixation durations) directed at each body feature, was normalized to the total number of fixations and total viewing time sampled in that trial.

The analysis was conducted on data normalised to account for differences in region size between stimuli categories. For example, the breast region of a 20-year-old woman is likely to be larger than that of a 10-year-old girl. As such, observers may gaze more at this region for 20-year-old figures simply because the region is larger. To account for this, the proportion of the areas of a particular body feature relative to the whole image was subtracted from the proportion of fixations and viewing time directed at that body feature in a given trial. Any difference in fixation distribution and viewing time from zero means that this particular body feature attracted more or less fixations than predicted by a uniform viewing strategy (Guo, Tunnicliffe, & Roebuck, 2010; Hall et al., 2011, 2012). Thus, negative values demonstrate less viewing than predicted by region size, and positive values demonstrate more viewing than predicted by region size.

Unless specified in the results section, a series of repeated-measures Analysis of Variance (ANOVA) were used to compare fixation and viewing time allocation across the different types of figure images. The ANOVAs were conducted separately for the different image age groups (10-year-olds, 20-year-olds and 40-year-olds). For each ANOVA, depicted sex and body region were within-subjects variables, and offence status (CSOs *vs* non-offenders) was the between-

subjects variable. Follow-up tests were conducted in the form of planned comparisons to investigate significant interaction effects, with Bonferroni corrections where necessary.

We chose to conduct separate ANOVAs on the different aged images as child molesters are likely to demonstrate similar interest in adults as non-offenders (Chaplin, Rice, & Harris, 1995). As such, we would expect little difference between how the two groups viewed 20- and 40-year-old figures. As the purpose of this experiment was to investigate how CSOs view different age and sex figures and compare these findings to a non-offending sample, we considered this separate age analysis the most effective way to elucidate this information.

Results

Gaze patterns to sexually pre-pubescent children and mature adult figures

To ensure there were no significant differences in gaze patterns to the five figures within the same category (e.g., 10-year-old girls) we conducted multiple one-way ANOVAs for proportion of fixations and viewing time for each observer. No significant differences in gaze allocation to the two body regions were observed across the images (all *ps* > 0.9), indicating that the five images within the same category attracted a similar viewing pattern from individual observers.

We then examined whether figures of different sex and ages presented in the free-viewing task attracted a similar amount of fixations from offenders and non-offenders. Table 1 illustrates the total fixations to the displayed image and showed that CSOs allocated 8.8 – 9.3 fixations to explore different figures, of which at least 97% of fixations were located on the figures, and non-offenders allocated 9.5 – 11.2 fixations, of which at least 96% were allocated on the figures.

[INSERT TABLE 1 HERE]

To gain an understanding of how the fixations were distributed across the whole figure, we present proportion of fixations that CSOs and non-offenders showed to the four body regions (the face, upper-body, waist-hip and limbs) in Table 2. It looks like the different body regions attracted a similar proportion of fixations from CSOs and non-offenders, with the face and limbs receiving most number of fixations. However, a direct comparison of different body regions is not a reliable due to differences in region size. As previously mentioned, some body regions (e.g. limbs) may attract more fixations simply because they are larger in area than other body regions (e.g. waist-hip), which is a particularly pertinent issue when comparing gaze to the same body region from figures of varying sexual maturity (e.g. upper-body). For reasons stated in our data analysis plan ANOVAs were conducted on proportion of fixations and viewing time normalised to account for region size, and were focussed on the upper-body and waist-hip regions.

[INSERT TABLE 2 HERE]

We then examined whether CSOs and non-offenders showed a differential gaze strategy when viewing male and female figures of children (10-year-olds) or adults (20 and 40-year-olds). For each age group two 2 (CSOs *vs* non-offenders) × 2 (depicted sex) × 2 (body region) ANOVAs with proportion of normalised fixations and viewing time allocated at each figure region as dependent variables were conducted.

When viewing 20-year-old figures a main effect of depicted sex (fixation F (1, 24) = 33.69, $p < .001$, $\eta_p^2 = .58$; viewing time F (1, 24) = 31.36, $p < .001$, $\eta_p^2 = .85$) revealed that all participants showed more gaze to the upper-body and waist-hip region when viewing 20-year-old female than male figures. This finding is consistent with previous findings, and is thought to reflect heterosexual preference (Hall et al., 2011, 2012). Within this age category, a main effect

of body region (fixation F (1, 24) = 6.64, $p < .02$, $\eta_p^2 = .22$; viewing time F (1, 24) = 5.79, $p < .02$, $\eta_p^2 = .78$) demonstrated that the upper-body received more fixations and viewing time than the waist-hip region. The further interaction effect of body region × depicted sex (fixation F (1, 24) = 29.51, $p < .001$, $\eta_p^2 = .55$; viewing time F (1, 24) = 14.15, $p < .001$, $\eta_p^2 = .32$; Figure 1) revealed that the female upper-body received more gaze than the male upper-body (post-hoc *t*-tests *ps* < .001), and that the female upper-body was more likely to be viewed than the corresponding waist-hip region (post-hoc *t*-tests *ps* < .001). For male figures, gaze between the two regions was indistinguishable.

[INSERT FIGURE 1 HERE]

For the 40-year-old images a main effect of depicted sex (viewing time F (1, 24) = 7.51, $p < .01$, $\eta_p^2 = .24$) revealed that participants showed more fixations to the upper-body and waist-hip regions of the 40-year-old female (M = -8.04, SD = 1.4) than male (M = -10.83, SD = 0.7) figures, indicating some preference for participants to gaze more often at the sexual regions of the older female images than their male counterparts. For this age group no other comparisons reached significance, suggesting that in general gaze patterns to the older age images were not so clearly differentiated. For both of the adult age images (20 year-old and 40-year-old) there were no significant interactions with offence status (CSOs *vs* non-offenders). Clearly, CSOs and non-offenders viewed adult images in a similar manner.

For the 10-year-old images all main effects did not reach significance. However, interestingly a significant 3-way interaction between offence status × depicted sex × body region (fixation F (1, 24) = 8.94, $p < .01$, $\eta_p^2 = .27$; viewing time F (1, 24) = 6.14, $p < .02$, $\eta_p^2 = .20$) suggested that CSO and non-offenders view child figures in a different way.

Planned comparisons compared gaze behaviour within each participant group. For the measure of viewing time further comparisons did not reach significance. With reference to proportion of fixations, CSOs looked more often towards the upper-body of the female child than male child figure (*t*-test $p < .04$; Figure 2), whereas non-offenders showed no difference in gaze to this region when viewing male and female children ($p > .15$). However, further *t*-tests revealed no statistical difference between CSOs and non-offenders gaze to this region. For both participant groups (CSOs and non-offenders) there was no difference in gaze towards the waist-hip regions of male and female children. In line with our previous studies (Hall et al., 2012, 2014), no significant differences were observed in face and limb regions between male and female figures in the same age group (all ANOVAs; $F(1,24) = \leq .63$, all ps $\geq .31$).

[INSERT FIGURE 2 HERE]

Examining Difference Scores

The analysis indicated that CSOs may be motivated to gaze at differential body cues when viewing male and female child stimuli, however, this gaze pattern did not significantly differ to the gaze of non-offenders. As this was an exploratory study and we sought to fully explore any subtle differences in gaze patterns between CSOs and non-offenders we conducted further analysis to directly assess individuals' differences in gaze towards the body regions of male and female figures. To achieve this we created a 'difference measure' by subtracting gaze towards the male region from gaze towards the female region in figures of the same age for each of the two body regions. For example, proportions of fixations towards the 10-year-old female upper-body minus proportion of fixations towards the 10-year-old male upper-body. This was

conducted for both proportion of fixation and viewing time, with larger numbers indicating the observer showed more differentiation in their gaze between male and females. It was considered that these difference scores would best illuminate subtle differences in gaze patterns, particularly as previous research has shown differential gaze behaviour towards male and female to be a potential indicator of sexual preference (Hall et al., 2011; Hall et al., 2012). Similar to the previous analysis, repeated measures ANOVAs were conducted on these difference scores, with body region as the within-subjects variable and offence status (CSOs *vs* non-offenders) as the between-subjects variable.

The 2 (offenders *vs* non-offenders) × 2 (body region) ANOVAs conducted on proportions of fixations and viewing time to adult figures (20- and 40-year-old) revealed no significant difference between CSOs and non-offenders differential gaze scores. Nor was there any interaction between body region × offence status, indicating that both participant groups showed similar gaze strategies when viewing adult male and female figures. However, when viewing images of 10-year-olds, there was a significant interaction effect of region × offence status for proportion of fixations (F (1, 24) = 8.94, $p < .01$, $\eta_p^2 = .27$). Post-hoc *t*-tests revealed CSOs showed significantly greater difference scores when viewing male and female child upper-bodies than non-offenders ($p < .01$). As shown in the first analysis, CSOs looked more often at the upper-body of the female child than male child. No other comparisons reached significance (all *ps* > .18).

Discussion

Motivated by previous findings that men's gaze behaviour to human figures seem to show a distinct and sexual attraction assessment-related gaze pattern when viewing figures of

their preferred sexual interest, here we demonstrated that this gaze strategy is also sensitive to deviances in sexual age preferences. CSOs showed significantly more fixations towards the upper-body of 10-year-old girls than boys. Although further post-hoc analysis indicated no significant difference between CSOs and non-offenders fixations to the female child's upper-body, analysis of difference scores found CSOs showed significantly more difference in viewing the upper-body of male and female children than non-offenders. In contrast, when viewing images of mature adults (20- and 40-years old) the gaze pattern between CSOs and non-offenders could not be differentiated. The findings further suggest that the men's viewing strategies could be linked to their sexual preference, including interest in young children.

Current research on gaze behaviour to sexual stimuli has focused on gender differences in visual attention to same and opposite sex figures (Lykins et al., 2008; Rupp & Wallen, 2007), or focused specifically on viewing adult figures (Cornelissen et al., 2009; Dixson et al., 2011; Hewig et al., 2008; Lykins et al., 2006, 2006; Rupp & Wallen, 2007). In addition, most studies have concentrated on a heterosexual non-sexual offending population. The one study that did investigate a sexually offending sample (Fromberger et al., 2012b) did not explore exact fixation location; as such the extent to which gaze patterns may reflect deviant sexual preferences has been unexplored. Our pilot study is the first to show that child molesters show a differentiated gaze pattern in viewing male and female child figures, with this gaze being localised in a region crucial for sexual arousal and age assessment.

Previous research demonstrated that gaze patterns to these figure regions could not be accounted for by differences in local image structure (such as local contrast) thereby supporting the supposition that this gaze pattern reflects a sexual assessment process. To examine this, Hall et al. (2011) employed a saliency map to investigate whether gaze allocation to local figure

regions (e.g. upper-body region) was a result of differences in the image properties (such as more visual detail and intensity). They found that differences in the local properties of the images did not predict gaze distribution, suggesting that it is unlikely that the observers' gaze patterns could be explained by simple bottom-up visual process. Furthermore, the increased attention to the upper-body is consistent with evolutionary theory that postulates this region is important for sexual assessment.

Several recent studies have also noted a difference in cognitive and information processing in child and adult stimuli between child molesters and controls. For example, child molesters have been shown to demonstrate additional processing time to child stimuli than non-offenders (Beech et al., 2007), a shorter response latency for child-and-sex paired words or images than non-offenders (Gray, Brown, MacCulloch, Smith, & Snowden, 2005; Nunes et al., 2007; Van Leeuwen et al., 2009) and a longer viewing time to child stimuli than that considered normal by the Abel Assessment for Sexual Interest (Abel, Jordan, Hand, Holland, & Phipps, 2001; Letourneau, 2002). These studies all suggest a difference in the interest and perception of child stimuli. Our study demonstrates that this difference may even be evidenced at the level of spontaneous covert visual attention.

The findings of this study also support previous research indicating that child molesters still show interest in adult stimuli. Phallometric studies commonly report that CSOs also demonstrate arousal to adult stimuli (Barbaree & Marshall, 1989; Freund, Watson, & Dickey, 1991; Harris, Rice, Quinsey, Chapin, & Earls, 1992; Lykins et al., 2010). Likewise, in this study the offenders showed a visual sexual assessment-related process to the mature adult (20- and 40-year-old figures), similar to that shown by the controls. Additionally, the lack of statistically significant differences between CSOs and non-offenders when viewing child stimuli may reflect

previously reported findings that gynephilic men will show arousal to pubescent and prepubescent girls (Lykins et al., 2010). Their study, which included no child sexual offenders in the sample, demonstrated, that although gynephilic men will show greatest penile arousal to adult women, they will demonstrate significantly more arousal to prepubescent girls than to non-preferred erotic stimuli.

Interestingly, viewing time measurements did not appear to be as an effective measure of sexual interest in the offending population, with only proportion of fixations significantly differing when viewing under-age stimuli. Although both measures are considered to reflect interest (Henderson, 2003), it is possible that offenders may be drawn to viewing the body regions of the female child, but are conscious not to dwell viewing 'inappropriate' regions. It would seem very realistic to think that men who have sexually offended would not wish to be caught gazing at body regions, however, their initial orientation towards these regions (e.g. fixation counts) may be harder to control (see Nummenmaa, Hyona, & Calvo, 2006). Research indicates that visual information is processed very rapidly (Henderson, 2003) and the extent to which fixation duration reflects the observers interest is not so well studied in comparison to allocation of fixations (Castlehano, Mack, & Henderson, 2009; Castelhano & Rayner, 2008). Further research should investigate the use of viewing time measures in gaze patterns to stimuli in populations who may wish to conceal their intent/interest. Furthermore, offenders' gaze strategy to the waist-hip region did not differentiate between male and female child figures, suggesting that gaze to the upper-body region is potentially the most sensitive measure of CSOs sexual interest. A possible explanation for this lack of waist-hip effect in offenders may be that child molesters are not necessarily interested in the fertility of the female, of which the waist-hip ratio is arguably the best indicator (Singh 1993a; Singh & Randall, 2007), but are more

interested in the age and sexual maturity of the child, which can also be assessed through breast development. Alternatively, more pronounced differences may be found when using nude or more sexualised images, such as those used in studies with non-offending men and women (Lykins et al., 2006; 2008). However, we specifically wished to investigate gaze patterns to clothed figures that mimic the conditions under which most feelings of sexual attraction would typically occur. We also consider it more ethical to show clothed figures of children.

The results of this study need to be taken within the context of understanding sexual interest in child offender populations. We know that deviant sexual interest is a critical factor relating to sexual recidivism (Cortoni, 2009; Hanson & Morton-Bourgon, 2005) and a number of theories see deviant sexual interest as central to both assessing risk and understanding the development of offending behaviour. The Structured Assessment of Risk and Needs (Webster et al., 2007) identifies the first of four risk domains to be offence related sexual preferences and preoccupation. Theories of sexual offending stress the role of sexual interest. For example, Ward and Keenan's (1999) Implicit Theory, states that some sex offenders may hold the notion that children are sexual objects that seek sexual activity, leading them to misinterpret everyday behaviour as the child's desire for sex, while Finkelhor's Precondition Theory sees sexual interest in children as critical to the first step towards offending (Finkelhor, 1984). If the offenders' viewing to the upper-body does reflect sexual interest, this could be taken as direct evidence that child molesters literally view children as sexual beings. It might therefore be possible in the future to undertake physiological assessments of sexual interest without the inherent problems of directly measuring sexual arousal (Fernandez, 2009).

There are certain limitations to consider when interpreting the findings of this pilot study. Given the exploratory nature of this study we chose to control for potential confounds such as

sexuality, race, culture, and relationship to victim. Future studies could investigate potential difference in a varied population. Furthermore, although our sample size is not atypical for studies using a forensic/clinical population or for pilot data, our sample size was nevertheless small. The control group were non-offenders, offering an insight in to the differences between offending and non-offending men but not between different types of sex offenders. Although, given the unique gaze pattern CSOs showed only to child images we anticipate this reflecting sexual interest in children we cannot conclude that these differences are specific to CSOs. Further research should investigate sex offenders without child victims and may want to assess objective sexual preference with phallometry prior to the eye-tracking assessment . Our images were standardised to ensure that models were depicted with similar facial expressions, adopting similar poses and corrected for differences in luminance and contrast. However, they were not specifically designed and standardised stimuli such as that used in the Not-Real-People (Pacific Psychological Assessment Corporation, 2004), which may have influenced our results. Given that gaze patterns and attractiveness ratings did not differ across the five exemplars within each category (age and gender) we consider it unlikely that any subtle image differences would account for our findings. We also believe that our clothed images are particularly needed when studying early sexual attraction processes, considering that most individuals' first feelings of romantic attraction towards someone occur when the person is clothed (Lykins et al., 2008) and using clothed figures is more ethical than naked figures.

These findings are only intended to highlight the need for further research to establish the potential utility of this measure in forensic research. As such we would recommend that our findings are used to inform future research rather than make firm conclusions. Alongside testing a larger sample, further research would need to assess its psychometric properties including test-

re-test reliability, discriminative and concurrent validity, as well as the extent to which the measure is open to 'faking good' and susceptible to individual variables. Our current design does not allow a differentiation between bottom-up and top-down attentional control. Although gaze allocation at early stage of image viewing is unlikely to be altered consciously (Nummenmaa et al., 2006) future research may want to look in detail at early viewing time as at a later stage our participants could purposely avoid looking at certain body regions. This may partly explain the reduced fixation and viewing time directed at up-body of 10-year-olds in comparison with 20-year-olds by the offenders (Figure 1 and 2). However, the offenders still demonstrated the significant difference in fixation allocation at up–body between 10-year-old girls and boys, indicating eye-tracking can provide reliable assessment of sexual preference for this participant group.

Although any implications of this pilot study should be considered in-light of our sample size, the findings do suggest the potential of eye-tracking as a measure of detecting sexual preference in forensic settings. Eye-tracking is portable, relatively easy to use, and non-invasive. The findings so far indicate that even when viewing clothed figures, CSOs may not be able to conceal their interest in children. Unlike implicit measures (e.g., viewing time) the processes underlying eye-gaze to the upper-body and waist-hip region are unlikely to represent a general interest in children, and more likely to relate to specific sexual preference. Furthermore, if combined with phallometric assessment, eye-tracking may not only allow an insight into exactly what is causing a physiological arousal, but also may be used to assess any mental "switching off" that can occur doing this assessment (Beech et al., 2005).

Despite the noted limitations, this original study provides unique evidence that CSOs may show a sexual attraction assessment-related gaze strategy when viewing both adult and 10-year-old figures, suggesting that their gaze may reflect their sexual interest and be sensitive to their interest in under-age girls. These preliminary findings further indicate that gaze strategies to clothed figures appear to reflect sexual preference, and highlights the need for further research to assess whether eye-tracking may be a reliable and valid measure of paraphilic sexual interest in men.

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Table 1

Averaged Number of Fixations (Means) Offenders and Controls Dedicated to Female and Male Images for 10-year-old, 20-year-old, and 40-year-old Figures

Image Category	Offenders		Controls	
	Female Images	Male Images	Female Images	Male Images
10-year-olds	9.2 (2.7)	8.8 (3.2)	10.4 (2.9)	9.5 (3.8)
20-year-olds	9.1 (2.2)	9.0 (2.8)	11.2 (3.3)	9.9 (3.6)
40-year-olds	9.0 (2.2)	9.3 (2.5)	10.6 (3.5)	9.8 (3.3)

Note. Standard deviations of the mean are given in parentheses.

Table 2.

Averaged Proportion of Fixations Offenders and Controls Dedicated to different Figure Regions (Face, Upper Body, Waist-Hip and Limbs) for Female and Male Images

Figure Sex	Body Region	Child Sex Offenders	Non-Offenders
Female	Face	50.4 (5.1)	49.3 (10.0)
	Upper-Body	15.9 (5.1)	16.7 (7.0)
	Waist-Hip	10.4 (2.2)	9.7 (3.5)
	Limbs	22.4 (3.5)	22.8 (1.6)
Male	Face	54.0 (3.5)	54.0 (1.2)
	Upper-Body	12.0 (2.7)	13.1 (2.5)
	Waist-Hip	10.0 (0.4)	8.7 (2.4)
	Limbs	23.1 (1.6)	22.7 (4.6)

Note. Standard deviations of the mean are given in parentheses.