Studying ‘natural’ eye movements in an ‘unnatural’ social environment: The influence of social activity, framing, and sub-clinical traits on gaze aversion

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Abstract

Experimental psychologists frequently present participants with social stimuli (i.e. videos or pictures) and measure behavioural responses. Such designs are problematic in that they remove the potential for social interaction and inadvertently restrict our eyes multifaceted nature as a tool to both perceive and communicate with others. The aim of the current study was to develop a new paradigm within which we can easily, and reliably measure the influence of top-down processes (i.e. belief), social activity (i.e. talking and listening), and possible clinical traits (i.e. gaze anxiety, and social interaction difficulties) onto gaze behaviours. Participants were engaged in a 'real' or pre-recorded Skype conversation. Finding suggest that participants who believed they were engaging in a real conversation spent less time looking at the speaker's eyes, but no differences were found for dwell time onto the whole face. Within our non-clinical sample, higher levels of gaze anxiety resulted in reduced dwell time onto the whole face but not eyes, whilst social interaction difficulties produced reduced dwell time onto the eyes only. Finally, talking consistently produced reduced dwell time onto the whole face and eyes regardless of any other conditions.

Introduction

We spend much of our time interacting with others, and understanding the mechanisms that underpin these social interactions lies at the heart of human cognition. Social interactions rely on a finely tuned perceptual system that process facial information to make judgements about people's mental states, such as their desires and intentions. There have been huge advances in our understanding of these social attentional processes, and we are particularly sensitive towards other people's faces (Fletcher-Watson Findlay, Leekam, & Benson, 2008). For example, our attention is automatically drawn towards another person's eyes (Birmingham, Bischof, & Kingstone, 2008), and towards objects that are being looked at by others (Friesen, & Kingstone, 2003). Effective use of this social information is fundamental to any successful social interaction, and abnormalities in these social attentional processes are thought to play an important role in clinical disorders, such as anxiety (Shulze, Renneberg, & Lobmaier, 2013) and autism (Dawson et al, 2004).

Psychologists frequently study social cognition using the *"lone observer"* paradigm in which we present participants with "social stimuli" (i.e. picture or video of faces), and measure whether these displays modulate people's behavioural responses (i.e. eye movements, reaction times). The assumption here is that measures taken during these paradigms meaningfully relate to real-world social interaction, yet these "social stimuli" do not actively interact with the observer (Gobel, Kim & Richardson, 2015). Although such designs afford a high level of experimental control (Cole, Skarratt & Kuhn, 2016) they inadvertently create an invisible barrier between participants and the stimuli, and thus preclude any form of "real" interaction (Risko, Richardson, & Kingstone, 2016).

These paradigms do not encapsulate the complexities of real social interactions, and this failure becomes very prominent when we consider our eyes' multifaceted nature. We use our eyes both for selecting the relevant visual information (i.e. overt attention) and to communicate with others. Most "*lone observer*" paradigms simply focus on the former function, and they do not invite participants to directly communicate with the avatar. During real social interactions on the other hand, we use eye-contact to co-ordinate timing of speech responses (Kendon, 1967), indicate intentions to deceive (Mann et al, 2013) and misdirect others' attention (Kuhn, Tatler, & Cole, 2009). In fact, a study by Ho, Foulsham, and Kingstone (2015), suggests that speakers end their turn with a direct gaze towards the listener, and the listener begins talking with an averted gaze towards their target. Therefore, a full understanding of social attention requires us to move beyond the "*lone observer*" paradigm and towards studying attentional processes in situations that allow for real social interactions.

Several studies have illustrated that the potential for a real social interaction can change where people look. Thus, whilst *"lone observer"* paradigms produce increased fixations towards the eyes (Birmingham, & Kingstone, 2009 review), people often spend less time looking at a person's face when they are confronted with a real person. For example, Kuhn, Teszka, Tenaw, and Kingston (2016) asked participants to watch a magic trick that was either performed live (allowed for social interaction), or on video (did not allow for social interaction), whilst measuring overall eye movements. The results revealed that participants produce significantly fewer fixations towards a magician's head during a 'live', as compared to a video demonstration. Reduced frequency of fixations, with shorter durations, where also observed towards confederates who are physically present in a waiting room (Laidlaw, Foulsham, Kuhn, & Kingstone, 2011) or on the pavement (Foulsham, Walker, Kingston, 2011) as compared to a video condition.

Similarly, the same pattern of gaze behaviours can be observed when exposing participants to a 'live' video feed. Gregory et al (2015), presented participants with a dynamic social scene and informed participants that they were either watching a live (social), or pre-recorded (non-social group) video. Participants in the social condition allocated significantly fewer gaze behaviours towards the actors' heads and made less of an effort to follow their gaze, as compared to those in the non-social condition. Simply changing the thought process of what a participant believes they are watching influenced their visual attention. Moreover, whilst participants in the above studies were exposed to interactive stimuli (i.e. real people, or a live video feed), they were not actively encouraged to engage with the stimuli (see also Hesse et al., 2018). The only published study we are currently aware of that asked participants to actively engage with an interviewer revealed no significant differences between the 'live' (i.e. real interviewer) and video conditions. Moreover, the nature of the social activity plays an important role with participants fixating less towards the face when answering questions as compared to when listening to the interviewer (Freeth, Foulsham, & Kingstone, 2013).

Our eye's dual function also has important implications for our understanding of social attentional difficulties that underline several clinical conditions. Whilst many clinical models make strong predictions about atypicalities in social attentional processing, these findings often fail to be replicated under more controlled testing settings (Nation & Penny, 2008). This discrepancy between lab-based and clinical observations also prevents us from establishing specific social attentional dysfunction in clinical models. Until recently, very few experimental paradigms have studied social attentional processes in the context of real social interactions, and it is likely that our eye's communicative function plays a particularly important role.

Social anxiety disorder is characterised by an intense fear or avoidance of social situations in which an individual feels overly scrutinised or evaluated by others (American Psychiatric Association, 2013). Whilst most theories postulate that gaze aversion is a central construct in the development and maintenance of social anxiety, they are vague about the overall mechanisms involved (Hofmann, Heinrichs, & Moscovitch, 2004). Cognitive behavioural models postulate that gaze aversion is a safety mechanism behaviour that has possibly gone wrong. Thus, individuals with social anxiety initially use gaze aversion to avoid danger and display submissiveness towards others (Hoffman, 2007). However, over time this becomes unhelpful as it allows them to internalise their symptoms and stops them from picking up on important social cues (Stopa, & Clark, 2000; Beard, & Amir, 2009).

Whilst these theories explain how gaze aversion becomes problematic over time, they do little to explain how symptoms present during everyday interactions. For instance, do individuals with social anxiety avoid looking at the whole face or specifically the eyes? Does gaze aversion depend on genuine social interactions? And does the nature of social interactions influence the level of gaze aversion? Answers to these questions will provide valuable insights into the mechanisms underlying this behaviour. The "cognitive load theory" predicts that gaze aversion increases during high cognitive load, which suggests there should be higher gaze aversion when an individual is talking as compared to when they are listening to someone else talk (Doherty-Sneddon, Bruce, Bonner, & Longbotham 2002). This is because gaze aversion might reflect a shift in cognitive function in which a person is thinking of what to say, or withdrawing information from memory (Glenberg, Schroeder, & Robertson, 1998).

Most studies to date ignore these complexities and this might explain discrepancies in the literature. Thus, whilst some stringent lab-based studies using static stimuli of emotional faces observed increased gaze aversion in participants with high levels of anxiety (Horley, Williams, Gonsalvez, & Gordon, 2003), naturalistic observations using short structured conversations found no significant differences in the number of submissive and avoidant behaviours (i.e. gaze aversion) between high and low anxiety participants (Walters, & Hope, 1998). It is however important to note that these naturalistic observations were coded using an independent rater system with forced-choice decision at 10 seconds intervals. Moreover, no eye trackers were used and whilst the overall conversations were short, it is possible that anxiety influenced the overall nature of the interaction, and this could in turn influence overall eye movements. Thus, according to the cognitive load theory if someone with increased anxiety had very little to say during the conversation then they might display similar levels of eye contact as someone who was more talkative but less anxious. More recently, Hesse and colleagues (2018) developed a paradigm that allowed them to measure high precision eye movements whilst two individuals simply stared at each other. However, this study did not include genuine social interactions (i.e. talking and listening).

Discrepancies between lab-based findings and clinical observations also prevent us from establishing specific social attentional dysfunction in clinical models. For instance, Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterised by social communication and interaction difficulties that are also coupled with restrictive or repetitive behaviours (American Psychiatric Association, 2013). One of the earliest indicators of ASD is a developmental delay in initiating joint attention, and whilst many clinical models make strong predictions about atypicalities in social attentional processing, they are unsure of the underlying processes (Baron-Cohen et al, 1996; Nation & Penny, 2008). In fact, whilst early studies suggest that gaze may be avoided in children with ASD, recent reviews suggest that this does not replicate across ages and contexts (Rice, Morriuchi, Jone, & Klin, 2012; Guillon, Hadijkhani, Baduel, & Rogé, 2014). Moreover, a meta-analysis by Chita-Tegmark (2015), suggests that social attention difficulties within ASD are most prominent when stimuli contains high social content (i.e. multiple individuals).

Another possible reason for this lack of consistency for gaze behaviours within ASD is that most paradigms do not allow for genuine social interactions (see also Laidlaw et al, 2011). A recent study from von dem Hagen and Bright (2017) exposed participant to three experimental conditions which tried to encapsulate an online video conferencing interaction. In the first two passive conditions, participants were shown two videos, one of which was said to be ‘live’, and the other pre-recorded and they were simply asked to watch them. In the third condition, participants were asked to take part in a real-time social interaction with another experimenter over an actual video call. Participants spent significantly less time looking towards another person's eyes during the 'live' as compared to pre-recorded video conditions. However, differences between high and low autistic trait individuals were only picked up during the real-time interaction, and not during the two passive video screenings which included a 'live' condition (von dem Hagen, & Bright 2017).

Most methods discussed thus far have failed to find a balance between stimuli reliability and ecological validity. Thus, whilst more naturalistic studies account for the complexities of everyday interactions, they often fail to control for low-level perceptual differences in the stimuli presentation. Conversely, *'lone observer'* paradigms control for low-level reliability but fail to replicate the dynamic nature and the potential for real social interactions. This current study will attempt to develop a new paradigm that combines the best of both worlds. Advancements in communication technologies has meant that video conferencing is an integral part of everyday social interactions (Wang, 2004; Hall, 2013; Wolgemuth, 2008), and by using applications such as Skype we should be able to replicate the familiarity of having an everyday conversation whilst also maintaining a high level of experimental control.

The main aim of the current experiment was to develop a new paradigm to quickly, easily, and accurately measure gaze behaviours during naturalistic social interactions. Our new paradigm allows people to engage (listening and talking) within a highly controlled social situation, and we can measure their eye movements with a high resolution (spatial and temporal). A high spatial resolution is particularly important to distinguish between attention towards the eyes compared to other features of the face. Whilst high resolution eye tracking has been successfully employed in studies that involve the presentation of static images of faces, or videos, far less is known about subtle differences in oculomotor behaviour during "real" social interactions. Firstly, we aimed to explore whether instructing that a Skype conversation as being real (i.e. live) compared to pre-recorded (i.e. video) would impact people's oculomotor behaviour. We are unable to predict the direction of this effect, as few published studies have involved participants actively interacting with the social stimuli. Secondly, and in line with the cognitive load theory we predict reduced fixations towards the eyes and face during talking as compared to listening conditions.

Thirdly, we aimed to investigate whether our paradigm could pick up individual differences in gaze-aversion behaviour that are qualitatively reported within two clinical traits. Social Anxiety commonly involves gaze aversion, and this component can be measured in the normal population using the Gaze Anxiety Rating Scale (GARS; Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz. 2011). In fact, this self-report measure of avoidance and fear of eye contact has consistently been found to be associated with severity of social anxiety in both clinical and nonclinical samples (Schneier, et al. 2011, c.f. Jouni et al., 2016). Our main objective was to test whether our paradigm could pick up subtle differences in gaze aversion, and whether these differences correlate with self-reported measures of gaze aversion. In the current study, we simply measured GARS scores, rather than social anxiety, since they provide the most direct measure of self-reported gaze aversion. Understanding the nature of this gaze aversion, and being able to quantify it, has important methodological implications for future work on our understanding of social anxiety. As our study is the first to use highly interactive and social stimuli we can be unsure of the direction increased GARS will have onto gaze behaviours. This is because whilst lab-based studies displayed increase gaze aversion in social anxiety participants more naturalistic studies found no such differences (Horley et al, 2003; Walters, & Hope, 1998). Autism is diagnosed according to a dyad of impairments, and similarly these traits are also widely distributed in the general population. Since our paradigm involves measuring social attentional differences, and our participants consist of a non-clinical population, we will focus on the dimension that is most directly related to gaze aversion (social attentional dimension), as measured by the social interaction subscale in the AQ (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Again as our study is using highly interactive and social stimuli we predict that increased social interaction difficulties will produce reduced fixations towards the eyes and face. This is because studies using highly social and interactive stimuli where more likely to elicit social interaction difficulties (Chita-Tegmark, 2015; von Dem Hagen, & Bright, 2017).

Method

Participants

Sixty-eight psychology students participated in return for course credits. Most of our participants were female (n = 60) with an age range of 18-36 years old (M = 21, SD = 4.1). All participants had normal or corrected vision and were unaware of the aims of the study. The experiment was run in accordance to British Psychology Society and Goldsmith's University of London ethical standards.

Procedure

Upon arrival participants were asked to complete a general demographic survey coupled with an Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), and Gaze Aversion Rating Scale questionnaire (Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz, 2011). They were then presented with a false objective and were told that we are looking at the influence of anxiety, and pupil dilation onto everyday interactions. Participants were randomly allocated into either the Skype or video conditions. Participants in the Skype condition were told that they will be having a live Skype conversation with another student, whilst those in the video condition were told that this video was a pre-recorded call. All participants were informed that they will have a relatively structured conversation in which the conversant will talk about herself for two minutes and they will then have to talk about themselves for two minutes. To ensure the feeling of a real interaction, participants in the Skype condition were told that the first few minutes will be very structured. As such, they were not allowed to ask the person questions while she is talking, and she will not interrupt them whilst they are talking. However, once these four minutes are over then they can have a normal conversation.

Participants were then sat 70cm away from the screen and their eye movements were calibrated using a 9-point calibration procedure. Each condition began with a central fixation point which acted as a further calibration check, and all participants were presented with the same video, which emulated a typical Skype conversation. Screen capture software (Snagit 12) was used to record an actual Skype conversation with a female confederate. The video file was recorded using a standard mp4 format with a resolution of 720 by 576. It was 257sec in length, with the first 50sec being used to convince the participants that this was a real Skype call.

The experimenter started by placing a camera and microphone prop on the front right-hand side of the participants. Participants then saw the Skype call being activated and heard the typical Skype ringing sound. The female conversant answered the call (video and audio) but stated that she was unable to hear or see them. The experimenter proceeded with pushing the camera button to turn the microphone on and the fake camera was repositioned so that the confederate could see the participants. The female conversant then said, “that’s perfect I can hear and see you”. This short deceptive procedure (53 seconds) was intended to convince participants of the interactive nature of the conversation. The conversant then talked for 140 seconds about her education, work, hobbies, and future career goals (listening condition), after which she asked the listener to talk about his/her “future career goals” (talking condition). During this time the actor maintained a relatively direct gaze and remained silent throughout, but after 60 seconds she claimed that, “the call is cutting off a little bit” and the Skype call was abruptly ended, emulating a typical Skype crash. This abrupt ending ensured that the conversation could come to a natural conclusion without the need for a genuine interaction, and without revealing the fact that the conversation had been pre-recorded.

After the video ended, participants were asked to rate the extent to which they felt that this was a real-live interaction (1 Definitely Not - 5 Definitely Yes), and finally they were debriefed about our actual aims.

Individual differences measures

Gaze Anxiety Rating Scale (GARS; Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz. 2011)

Seventeen item self-report questionnaire that ascertains the level of avoidance and anxiety a person experiences, when having to make eye contact within a range of social situations (i.e. giving a speech or receiving a compliment). Respondents are asked to base their answers in relation to the last week, with fear and avoidance of making eye contact being rated on a 0 (no anxiety/avoidance) to 3 (severe anxiety/avoidance) Likert-scale. Overall scores are added to produce a fear subtotal, an avoidance subtotal and an overall total, with higher scores indicating increased social anxiety. This questionnaire was chosen because of its excellent reliability within undergraduate populations, with a Cronbach α coefficients of .90 for avoidance subscale, .88 for anxiety subscale, and .95 for the total scores (Schneier et al, 2011).

Adult Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001)

This fifty item self-report questionnaire provides us with a quantitative measure of autistic traits within a typically developing population. Participants are provided with statements and are asked to indicate on a 4 point Likert-scale (‘definitely agree’ to ‘definitely disagree’) how much each item applies to them. Questions are scored using a binary system, in which confirmation of autism is coded as +1, whilst the opposite responses are coded as 0. According to factor analysis studies by Hoekstra, Bartels, Cath, and Boomsma (2008), these fifty items can be divided into an attention to detail factor and a social interaction factor (which incorporates social skill, attention switching, social communication, and imagination subscales). As the current experiment was interested in social interaction subscales only the attention to detail factor was excluded. As such, scores are summed into a maximum of forty, with higher scores indicating increased social interaction difficulties. This specific subscale was chosen as it has good internal consistency α .84 and test-retest reliability *r* = .79 (Hoekstra et al, 2008).

Eye tracker and display

Eye movements were recorded using an SR-Research Eyelink 1000 eye tracker (500 Hz samples). Infrared remote eye tracking allowed participant to freely move their head whilst they were listening and talking. The Skype video call was displayed on a 21inch screen using Experiment Builder presentation software, which ensured accurate frame rate timings. Screen resolution was set at full screen, with an aspect ratio of 800 by 600, and a refresh rate of 120Hz. Two speakers were used to transmit the audio, and a specially designed camera was created to act as a microphone and camera prop.

Data Preparation

Eye movement analysis was carried out using Data Viewer version 2.4. Dynamic areas of interest were manually coded on a frame-by-frame basis and areas of interest were locked onto a specific location that was altered every time the target moved. The face area of interest covered the entire face, including eyes, whilst the eye area of interest consisted of a rectangle that covered the eyes only (see figure 1 and supplementary material for video containing dynamic interest areas and eye movements). We used Data Viewer (SR-Research) to calculate the proportion dwell time for each interest area, which represents the proportion of time participants spent fixating each of the areas of interest (excluding saccades and blinks), relative to the duration of the entire trial segment. Participants spent on average 88.6% of their time fixating the computer screen (excluding binks and saccades).

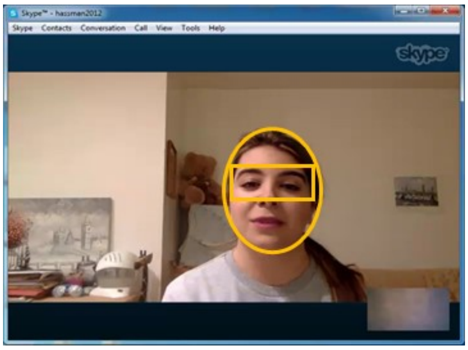


Figure 1. Stills of the Skype call with areas of interest outlined. The face consisted of an oval shape which covered the entire head (including the eyes), and the eyes are coded for via a rectangular shape.

Results

Data from 8 participants were removed due to tracker loss during the experiment (3 from the video condition, and 5 from the Skype condition).

1. Effect of instruction and social activity onto proportion dwell times towards the whole face and eyes.

The first set of analysis looked at whether instruction and social activity influenced dwell time towards the whole face (including the eyes) (See Figure 2). As with all subsequent analysis we calculated proportion dwell time and ran a mixed measures ANOVA with instructions (Skype vs Video) as between-participant, and activity (Listening or Talking) as within-participant variable. No significant main effect was observed for instruction $F(1,58) = 1.60$, $p = .21$, $\eta p^2 = .03$, but a significant main effect was found for social activity $F(1,58) = 160$, $p < .001$, $\eta p^2 = .73$, with listening producing increased dwell time towards the face than talking, in both the Skype $t(29) = 10.35$, $p < .001$, (95% CI; 0.22 - 0.33), and video $t(29) = 8.30$, $p < .001$, (95% CI; 0.25 - 0.41) conditions. No significant interaction was observed between instructions and social activity $F(1,58) = 1.40$, $p = .24$, $\eta p^2 = .02$.

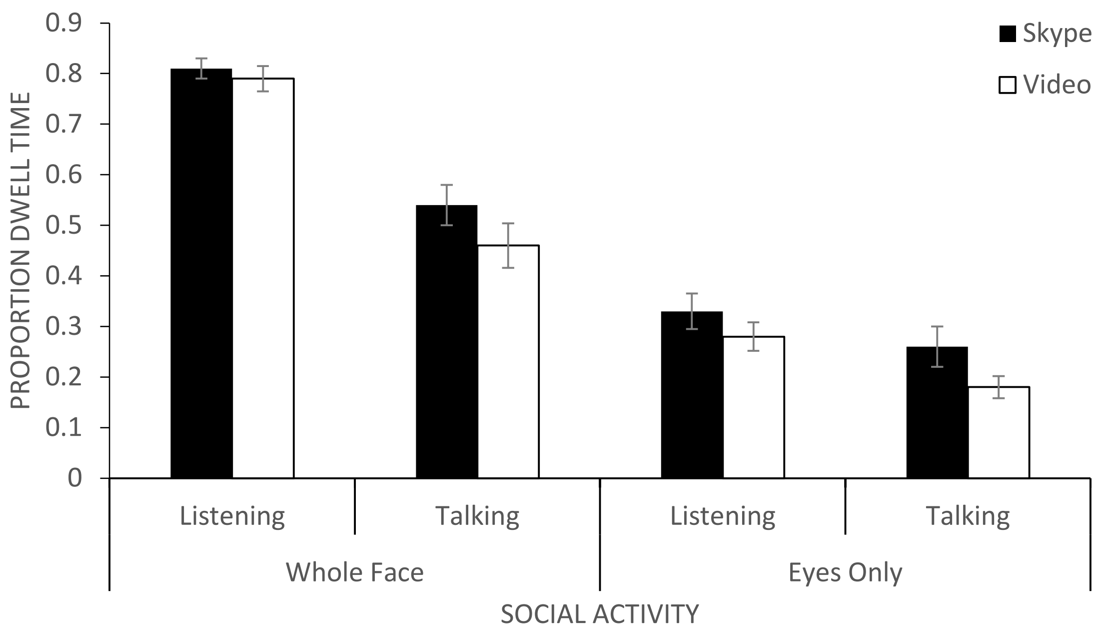


Figure 2. Bar graph displaying proportion dwell time towards whole face, or eyes as a function of instructions, and social activity with error bars denoting standard errors.

The second set of analysis looked at whether instructions and social activity influenced dwell time onto the eyes. Once again there was a significant main effect of social activity $F(1,58) = 14.1$, $p < .001$, $\eta p^2 = .2$, with listening producing increased dwell time in both the Skype $t(29) = 2.33$, $p = .027$, (95% CI; 0.01 - 0.12), and video $t(29) = 2.96$, $p = .006$, (95% CI; 0.03 - 0.16) conditions. However no significant main effect was found for instructions $F(1,58) = 2.09$, $p = .15$, $\eta p^2 = .035$, and no significant interaction was observed $F(1,58) = .49$, $p = .49$, $\eta p^2 = .008$.

2. Effect of belief in nature of the social interaction and social activity onto proportion dwell time towards the whole face and eyes.

One possible reason for the non-significant effect of instructions is that several participants were unsure whether our explicit instructions were genuine. Consequently, whilst participants in the Skype group were more convinced that this was a 'live' interaction (*M* = 3.5, *SD* = 1.4) as compared to the pre-recorded video group (M = 3, SD = 1.0), the overall group differences was not significant $t(58) = 1.66$, $p = .10$, (95% CI; -0.11 - 1.18). We therefore decided to split participants according to belief with those scoring 3 or below being placed in the 'Pre-Recorded' belief condition whilst those who scored 4 and above where placed in the 'Live' belief condition (See Figure 3). Three or below was chosen as a cut off as these participants were unsure whether it was a live interaction. With regards to dwell time onto the whole face, there was a significant main effect for social activity $F(1, 58) = 156$, $p < .001$, $\eta p^2 = .73$, but not for belief $F(1, 58) = .92$, $p = .34$, $\eta p^2 = .016$. No significant interaction was observed between social activity and belief $F(1, 58) = .61$, $p = .44$, ηp2= .01.

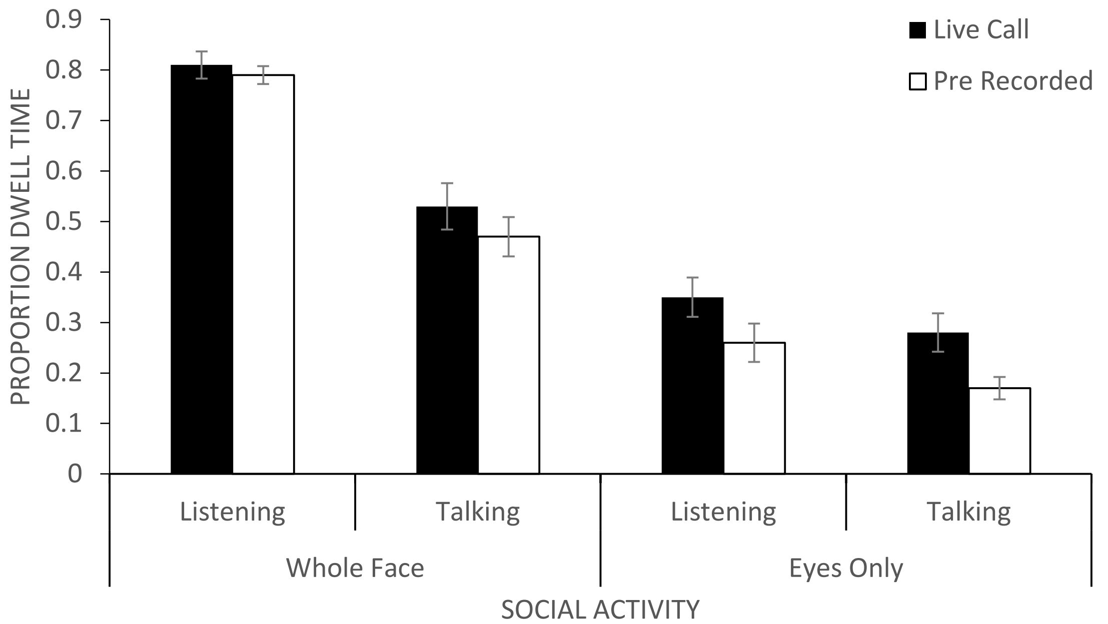


Figure 3. Bar graph displaying proportion dwell time towards whole face, or eyes as a function of belief, and social activity with error bars denoting standard errors.

Finally, we ran another mixed ANOVA analysis looking at dwell time onto the eyes (See Figure 3). There was a significant main effects for social activity $F(1,58)$ 13.8, $p < .001$, $\eta p^2 = .192$, and belief $F(1, 58) = 4.84$, $p = .032$, $\eta p^2 = .077$. With those who believed they were in the 'Live' condition making more of an effort to maintain eye contact as compared to the Pre-Recorded condition. However, no significant interaction was observed between social activity and belief $F(1,58) = .18$, $p = .67$, $\eta p^2 = .003$.

3. Effect of GARS, belief, and social activity onto proportion dwell time towards either the whole face or eyes.

	GARS			Social Interaction Difficulties			AQ		
Group	Score	Age	Gender	Score	Age	Gender	Score	Age	Gender
Low	21.2	21.1	3 = M; 32 = F	7.7	20.1	2 = M; 26 = F	12.2	21.1	3 = M; 27 = F
High	45.1	21.5	3 = M; 22 = F	17	22.3	4 = M; 25 = F	23.2	21.4	3 = M; 24 = F

Table 1: Group demographics

The first analysis looked at whether GARS, belief, or social activity had an influence on proportion dwell time towards the whole face. We initially focused on GARS with scores being summed and applying a median split (see table 1) to produce a high (M = 45.1, SD = 10.4) and low (M = 21.2, SD = 7) anxiety groups[1]. Proportion dwell time towards the whole face were calculated (See Figure 4) and a repeated ANOVA was conducted with GARS (High vs Low), and belief (Live vs Pre-recorded) as between-participants; and social activity (Listening and Talking) as within-participants variables. Significant main effects were found for GARS $F(1,56) = 7.05$, $p = .01$, $\eta p^2 = .112$, and social activity $F(1,56) = 174.9$, $p < .001$, $\eta p^2 = .757$; but not belief $F(1, 56) = 1.32$, $p = .255$, $\eta p^2 = .023$. No significant interactions were found for belief and GARS $F(1,56) = .206$, $p = .652$, $\eta p^2 = .004$, instructions and social activity $F(1,56) = 1.195$, $p = .279$, $\eta p^2 = .021$, or belief, GARS, and social activity $F(1,56) = .153$, $p = .697$, $\eta p^2 = .003$. However a significant interaction was observed between GARS, and social activity $F(1,56) = 6.63$, $p = .013$, $\eta p^2 = .106$. To investigate this further we conducted an independent samples t-tests using a Bonferroni adjusted alpha value of .025, which revealed no significant difference in dwell time on the face between the high and low GARS whilst listening $t(58) = 1.36$, $p = .178$, (95% CI; -0.02-0.11). However there was a significant difference when talking $t(58) = 2.81$, $p = .007$, (95% CI 0.05-0.27) with the high GARS group producing reduced dwell time towards the face than the low GARS group.

Table 2 shows the correlations between the GARS scores and our dwell time measures. As is clear form the table there were significant negative correlations between GARS scores and the time spent fixating the face, for both the listening and the talking condition, but the correlation was stronger for the latter.

[1] There was a significant difference between the two groups, $t(58) = 10.68$, $p < .001$

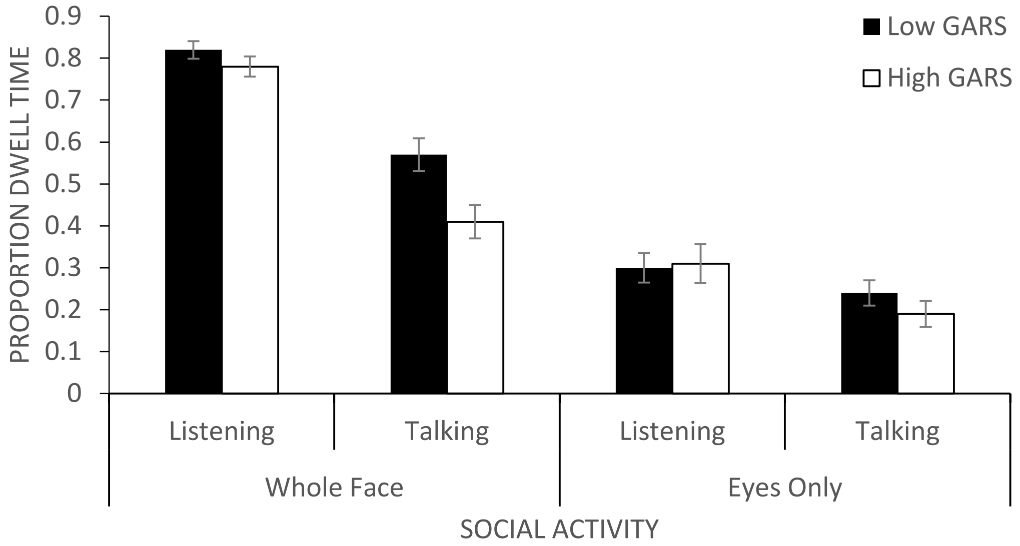


Figure 4. Bar graph displaying proportion dwell time towards whole face, or eyes as a function of GARS, and social activity with error bars denoting standard errors.

The second analysis looked at whether GARS, belief, and social activity influenced dwell time onto the eyes (See Figure 4). A significant main effect was found for social activity $F(1,56) = 15.9$, $p < .001$, $\eta p^2 = .221$, but not for belief $F(1,56) = 3.91$, $p = .053$, $\eta p^2 = .065$, or GARS $F(1,56) = .69$, $p = .409$, $\eta p^2 = .012$. No significant interactions were found for belief and GARS $F(1,56) = 3.53$, $p = .066$, $\eta p^2 = .059$, belief and social activity $F(1,56) = .5$, $p = .482$, $\eta p^2 = .009$, social activity and GARS $F(1,56) = 1.66$, $p = .202$, $\eta p^2 = .029$, or belief, GARS, and social activity $F(1,56) = 1.15$, $p = .289$, $\eta p^2 = .02$. As is apparent from table 2, whilst the correlations between dwell time on the eyes and GARS scores were negative, they were non-significant.

	Face		Eyes	
	Listening	Talking	Listening	Talking
GARS	**-.27***	**-.31***	-.11	-.20
Social Interaction Difficulties	-.086	-.031	**-.26***	-.25
AQ	-.093	.033	-.232	-.21

*Table 2: Pearson correlation coefficients between GARS- AQ - /Social Interaction scores and dwell time measures for eyes face and eyes as a function of social activity. * indicates significant correlation (p<.05, two-tailed).*

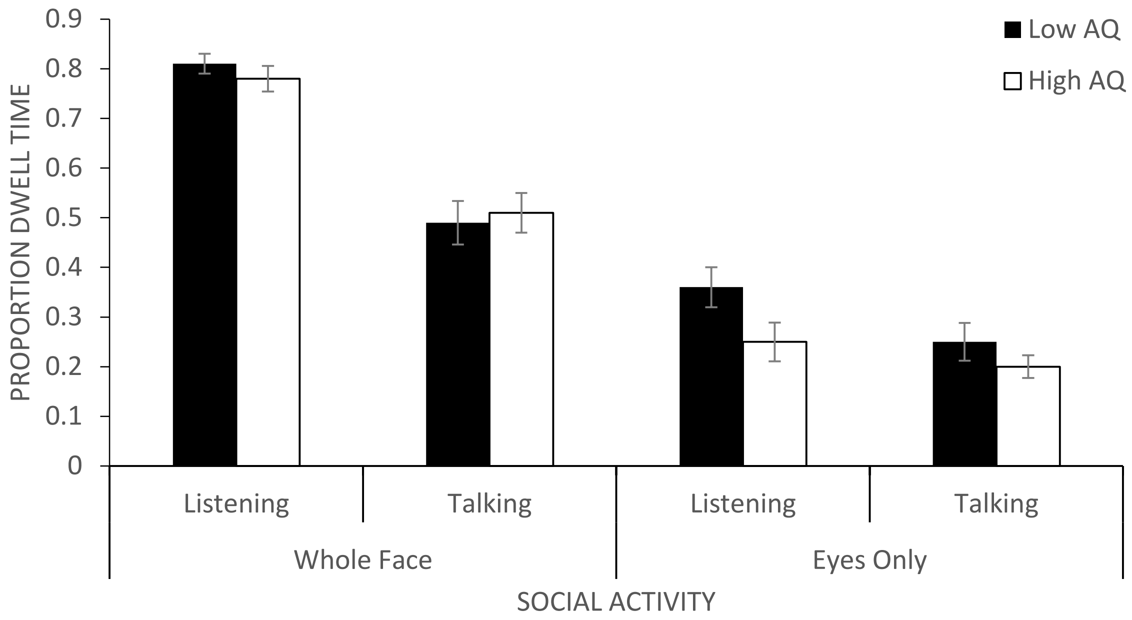
4. Effect of AQ/social interaction difficulties, belief, and social activity on dwell time towards either the whole face or eyes.

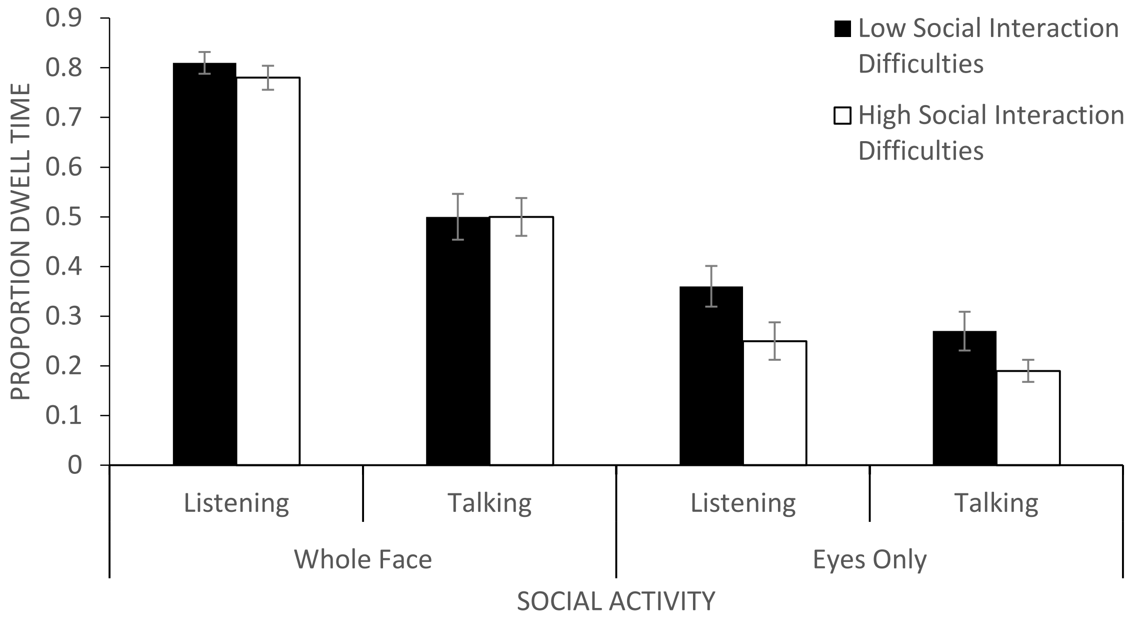
Our next analysis focused on the relationship AQ, and particularly social interaction difficulties, affected the time participants spent fixating the face. Whilst our main interest lay in the social interaction difficulties, we first report the analysis on the combined AQ scores.

The first analysis looked at whether differences in AQ, belief, or social activity influenced dwell times towards the whole face. AQ scores were summed, and participants were allocated via a median split into either a high or low AQ group (see table 1)[2]. Proportion dwell time towards the whole face where then calculated (See Figure 5), and a repeated measures ANOVA was conducted with AQ (High vs Low), and belief (Live vs Pre-Recorded) as between-participants and social activity (Listening or Talking) as within-participants variables. No significant main effects were found for AQ $F(1,53) = .006$, $p = .941$, $\eta p^2 = .000$, or belief $F(1,53) = 1. 1.54$, $p = .220$, $\eta p^2 = .028$, but a significant main effect was observed for social activity $F(1,53) = 180$, $p < .001$, $\eta p^2 = .772$. No significant interactions were observed for belief and AQ $F(1,53) = 1.56$, $p = . 217$, $\eta p^2 = .029$ belief and social activity $F(1,53) = 2.76$, $p = .105$, $\eta p^2 = .049$, AQ and social activity $F(1,53) = 1.35$, $p = .25$, $\eta p^2 = .025$, or belief, social activity, and social interaction difficulties $F(1,53) = 1.037$, $p = .313$, $\eta p^2 = .019$. Moreover, Table 2 shows that AQ does not correlate with dwell time on the face.

Next, we carried out the same analysis for the social interaction difficulties dimensions. Social interaction difficulties scores were summed, and participants were allocated via a median split into either a high or low social interaction group (see table 1)[3]. No significant main effects were found for social interaction difficulties $F(1,53) = .104$, $p = .749$, $\eta p^2 = .002$, or belief $F(1,53) = 1.717$, $p = .196$, $\eta p^2 = .031$, but a significant main effect was observed for social activity $F(1,53) = 179$, $p < .001$, $\eta p^2 = .771$. No significant interactions were observed for belief and social interaction difficulty $F(1,53) = 1.07$, $p = .306$, $\eta p^2 = .020$ belief and social activity $F(1,53) = 2.81$, $p = .099$, $\eta p^2 = .050$, social interaction difficulties and social activity $F(1,53) = .43$, $p = .515$, $\eta p^2 = .008$, or belief, social activity, and social interaction difficulties $F(1,53) = .902$, $p = .347$, $\eta p^2 = .017$. Moreover, Table 2 shows that social interaction difficulties do not correlate with dwell time on the face.

[2] There was a significant difference between the two groups, $t(42.9) = -10.58$, $p < .001$.
[3] There was a significant difference between the two groups, $t(46.9) = -9.25$, $p < .001$.


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PROPORTION DWELL TIME
Low AQ
High AQ
Listening
Talking
Listening
Talking
Whole Face
Eyes Only
SOCIAL ACTIVITY


0.9
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PROPORTION DWELL TIME
Low Social Interaction Difficulties
High Social Interaction Difficulties
Listening
Talking
Listening
Talking
Whole Face
Eyes Only
SOCIAL ACTIVITY

Figure 5. Bar graph displaying proportion dwell time towards the whole face, or eyes as a function of AQ (top) social interaction difficulty (bottom), and social activity with error bars denoting standard errors.

Finally, we looked at whether AQ and social interaction difficulties and social activity influenced dwell time onto the eyes (See Figure 5). We first report the analysis on the entire AQ score before focusing on the social interaction difficulties.

A significant main effect was found for social activity $F(1,53) = 13.37$, $p = .001$, $\eta p^2 = .201$, and belief $F(1,53) = 4.24$, $p = .044$, $\eta p^2 = .074$. However no significant main effect was found for AQ F(1,53) = 2.767, p = .102, ηp2= .05. Moreover, no interactions were found for belief and AQ $F(1,53) = .21$, $p = .648$, $\eta p^2 = .004$, belief and social activity $F(1,53) = 1.028$, $p = .315$, $\eta p^2 = .019$, AQ and social activity, $F(1,53) = 1.482$, $p = .229$, $\eta p^2 = .027$, or belief, social activity, and AQ $F(1,53) = .242$, $p = .625$, $\eta p^2 = .005$.

Next we report the results for the social interaction difficulties, which found a significant main effect was for social interaction difficulties $F(1,53) = 4.74$, $p = .034$, $\eta p^2 = .082$, showing that individuals with higher social interaction difficulties produced reduced dwell time towards the eyes[4]. There were also significant main effects of social activity $F(1,53) = 14.2$, $p < .001$, $\eta p^2 = .212$, and belief $F(1,53) = 4.48$, $p = .039$, $\eta p^2 = .078$. However no significant interactions were found for belief and social interaction difficulties $F(1,53) = .336$, $p = .565$, $\eta p^2 = .006$, belief and social activity $F(1,53) = 1.067$, $p = .306$, $\eta p^2 = .020$, social interaction difficulties and social activity, $F(1,53) = .618$, $p = .435$, $\eta p^2 = .012$, or belief, social activity, and social interaction difficulties $F(1,53) = 1.17$, $p = .285$, $\eta p^2 = .022$. Moreover, table 2 shows that there was a significantly negative correlation between social interaction difficulties and amount of time spent fixating the face whilst listening, and a negative, yet not significantly, correlation for the talking condition. It is interesting to note that by averaging across social activity, there is a significant negative correlation between dwell time on the eyes and social interaction difficulties (r = .28, p = .03).

Discussion

Most previous social cognition research has relied on the '*lone observer*' paradigm in which participants simply observe non-interactive social stimuli, and it is questionable whether these paradigms capture the full richness of social interactions. The aim of this paper was to develop, and test, a new way of studying social cognition that involves highly stringent experimental control, whilst also allowing for natural social interactions. By using relatively simple forms of deception we managed to convince most of our participants that their interaction with a pre-recorded person was genuine. Rather surprisingly, our explicit instructions were less effective than we had hoped for[5]. Several of the participant who were explicitly told that they were about to have a 'real' Skype conversation felt that the conversant

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[5] Since most of our participants were Psychology students, it is possible that they were more sceptical about our set-up than would be expected in the normal population.

was not real, but a similar number of the participants who were explicitly told that the conversation had been pre-recorded claimed they felt that it had been ‘real’.

The eye movement data revealed no difference in the extent to which participants prioritized the eyes and the face as a function of our explicit instructions. However, our subsequent analysis, which split participants according to their levels of belief (i.e. those who believed it was a ‘live’ call vs those who believed it was a pre-recorded call), showed that participants spent more time fixating the eyes when they felt that they were talking to a real person, compared to when they were interacting with a pre-recorded video. Therefore, instructions alone are not sufficient in eliciting a change in eye movement behaviours, because participants need to believe that they are having a real-live interaction for differences to be observed.

Our findings conflict with previous studies that have found reduced dwell time to the face (Kuhn et al, 2016; Laidlaw et al, 2011; Foulsham et al, 2011) when seeing a real person, compared to a recording of this person. It is important to note that our paradigm is fundamentally different in that our participants actively engage with the stimuli. Interestingly, the only other study we are aware of that involved active engagement with the stimuli found no significant difference between the ‘live’ and pre-recorded conditions (Freeth et al, 2013). However, Freeth et al (2013), did report that those in the ‘live’ conditions were more likely to follow the interviewers gaze. It is therefore likely that the increased gaze aversion (i.e. not looking at faces and eyes) is observed in social interactions where eye contact is not the social norm and thus less socially accepted. However, in situations where active interactions are required eye contact becomes the norm, and as shown in our study, people spend more, rather than less time fixating at another person’s eyes. One possible reason for this is that increased dwell time towards the eyes is normally a sign of general interest (Kleinke, 1986), friendship (Argyle, & Cook, 1976), and even increased liking towards others (Mason, Tatkow, and Macrae, 2005). Moreover, from the perspective of the person talking, increased dwell time during a conversation is normally taken as a sign of attention which can help dyads build a rapport (Duggan, & Parrott, 2001), and encourages intimate self-disclosure (Ellsworth, & Ross, 1975).

Our second aim was to develop a social attention paradigm that allowed us to investigate differences in eye movements during two fundamental aspects of any social interaction (listening vs talking). All our participants found it natural to talk to the person, even those who believed that they were watching a pre-recorded version of the conversation. Our most consistent finding was that participants spent significantly less time fixating the eyes and the face when talking as compared to listening. This effect also supports previous conclusions by Freeth et al (2013), and Doherty-Sneddon, and Phelps (2005), where participants used gaze aversion to reduce their cognitive load whilst thinking of answers to the previously asked questions. Similarly to Freeth et al.’s (2013) findings, this increased cognitive load effect was observed regardless of whether participants believed that they were in the ‘live’ or pre-recorded condition. One possible reason for this is that our explicit instructions had an alternative influence on the overall mental attributions associated with the task.

A recent study by Rice, and Redcay (2016), investigated whether mental attributions associated with an audio recording could also produce differences in neural responses. Findings suggest that simply believing that the audio recording was live is enough to produce increased activations in participants mentalising region (which is a neural network system associated with social cognition). It could be argued that our explicit instructions primed participants into thinking that they ultimately had to interact with the stimuli. Thus, simply by telling participants that they would have to engage in a talking condition might have been enough to influence overall mental attributions associated with both the listening and talking parts of the task. This also explains the same pattern of results reported by Freeth et al. (2013), wherein participants had to interact with the stimuli (i.e. answer questions). As such, gaze behaviours that are typically associated with everyday interactions might have been elicited regardless of whether participants believed that the stimulus was real or not. Another explanation might be that our cognitive load response which is typically associated with the talking condition is so strong that it overridden any effects that might have been observed regardless of whether the stimuli was believed to be real or not.

Being able to manipulate social activity also meant that we were able to pick up previously unobservable differences in gaze aversion mechanisms that might be typically associated with self-reported gaze aversion as measured using GARS scores. Our results are unique in that we observed different levels of gaze aversion as a function of social activity. Thus, gaze anxiety traits appear to reduce dwell time towards the whole face as opposed to specifically the eyes. Moreover, this effect was observed whilst talking but not listening, which is in line with the overall definition of social anxiety as a 'fear of being scrutinised or judged by others' (American Psychiatric Association, 2013). As such, if eye contact is seen as the social norm then a socially anxious individual might make more of an effort to maintain eye contact especially when they are listening. However, as the overall situation is still uncomfortable, participants with increased anxiety might compensate for this by simultaneously avoiding the whole face. Finally, if anxious individuals are afraid of both positive and negative evaluations (Weeks, & Howell, 2012), then it would also make sense for them to display increased gaze aversion during the talking as compared to the listening conditions. It is important to note that our study measured gaze aversion anxiety (GARS), rather than social anxiety more generally, and there has been some debate as to whether GARS forms a significant component of social anxiety in clinical populations (e.g. Jouni et al., 2016). Nevertheless, our high precision eye movement measurements taken whilst participants hold a natural conversation (talking and listening) have the potential to provide interesting insights into the potential mechanisms may underpin gaze aversion found in social anxiety.

Increased effort to produce eye contact could act as a mechanism by which socially anxious individuals display submissiveness and interest towards others (Gilbert, 2001). A study by Bavelas, Coates, and Johnson (2002), found that a gaze-window exists between the listener and the talker in which visual (i.e. nodding), auditory (i.e. saying hmm), and gaze (i.e. eye contact) behaviours are used in a collaborative manner to provide precise and non-verbal feedback. Similarly, findings by Ho et al (2002) suggest that gaze behaviours play a crucial role in regulating overall turn taking behaviours. This would explain why participants with high gaze anxiety traits feel obliged to maintain adequate levels of eye contact particularly when listening. Moreover, it could explain discrepancies within the literature where 'lone observer' paradigms present participants with static images that typically evoke no automatic social norms response. Therefore, anxious individuals can freely avoid eye contact because it is an uncomfortable and at times threatening situation i.e. pictures of angry/sad faces (Horley et al, 2003; Moukheiber et al, 2010). However, when exposed to more complex or real-life situations, then socially anxious participant might feel obliged to produce adequate levels of eye contact in the fear that they would otherwise appear rude, or uninterested (Walters, & Hope, 1998).

Previous research has also associated autism, and social interaction difficulties with reduced eye contact (Senju, & Johnson, 2009; Lord, Cook, Levental, & Amaral, 2000). Whist we did not find any significant differences relating to individual differences measured using the overall AQ score, the trends were in the predicted direction, and we assume that our study was simply underpowered to pick up these overall differences. However, our findings suggest that social interaction difficulties are associated with reduced dwell time towards the eyes but not the whole face. This in line with previous findings in which Dalton et al (2005), who observed that individuals with autism produced reduced dwell time towards the eyes, they did not produce significantly reduced dwell time towards the whole face. Moreover, by considering social activity we were able to uncover specific differences in the gaze mechanisms associated with social interaction difficulties and gaze anxiety traits. We show that increased gaze anxiety traits are associated with reduced fixations towards the whole face during the talking condition, whilst social interaction difficulties produced reduced dwell time towards the eyes regardless of social activity. This is more in line with the gaze indifference hypothesis in which social interaction difficulties are driven by general insensitive to the social cues that come from looking someone directly in the eyes during a social interaction (Senju, & Johnson, 2009).

Similar observations for the gaze indifference hypothesis have also been found in two-year-old children with ASD. A study by Moriuchi, Kllin, and Jones (2016) explored the role of explicit and implicit social cues in producing diminished attentional allocation towards the eyes in two-year-old children. Children with ASD did not look away any faster than controls when explicitly cued to look towards the eyes. In fact, explicit eye-looking cues produced stronger and longer lasting effects in children with ASD as compared to typically developing children. Similarly, when presented with implicit social cues, two-year-olds with autism neither shifted their attention away from the eyes or towards the location of the implicit cues. Thus, suggesting that reduced fixations towards the eyes in ASD is not an anxiety-driven response and is more likely to be a passive insensitivity to general social signals.

Such findings might explain discrepancies in the literature; for instance it might explain why some lab-based studies were unable to observe increased gaze aversion towards the eyes as pictures of faces do not produce the nuanced implicit social cues that might be associated with everyday interactions. They also explain some findings by von dem Hagen and Bright (2017), in that increased gaze aversion is only observed during a real interaction and not when participants are simply watching a video. It might be that passively asking someone to watch a video is not sufficient to elicit the implicit social cues that are associated with everyday social interactions. Thus, when we look at differences between high and low ASD trait participants we observe no overall significant findings. However, when we expose these same individuals to more realistic social situations then the low ASD trait participants become more likely to pick up on implicit social cues and this could in turn lead to the overall group differences. Moreover, even though some participants in the von dem Hagen and Bright (2017), experiment where told that the video call they were passively watching was 'live' they were not expected to actively interact with the stimuli and this might have been enough to mask the presence of any implicit social cue differences.

Limitations and future directions

Our study could be criticised for not taking enough precautions to convince participants that the video condition was not a real 'live' call. This is because all participants saw the Skype application being opened and heard the ringing sound. Moreover, the setting within which our interaction took place was a typical living room with lots of little items in the background; and whilst this might seem trivial it genuinely did feel like a real Skype call was occurring. A further limitation in our study is the scale we used to measure social anxiety traits. Whilst the GARS positively correlates with other measures associated with Social Anxiety (i.e. the Leibowitz Social Anxiety Scale) it is not a measure of social anxiety and is in fact a different construct of anxiety-driven gaze avoidance (Liebowitz, 1987; Domes, Marx, Spenthof, & Heinrichs, 2016). As such, whilst we found gaze aversion differences in participants who scored highly in GARS scores, this is not very surprising as it is exactly what that scale is supposed to measure. However, it is significant in that we observed differences between the talking and listening condition. Moreover, this aversion was directed towards the whole face as opposed to the eyes specifically. We initially, chose this more specialised GARS because most Social Anxiety measures only have two questions about gaze aversion, which means they might not pick up subtle differences in gaze behaviours within a non-clinical population. Future studies could use more stringent social anxiety measures to investigate differences in gaze behaviours within a more clinical population.

Participants were told that we were measuring the influence of anxiety, and pupil dilation during everyday interaction, and we chose this cover to avoid explicitly inform participants that we were measuring their eye position, as this may have modulated their gaze behaviour. Whilst we do not think that this cover story will have systematically biased our results, future research may try to explore ways in which the nature of the social interaction, and speaker, change people's attentional strategies. Our participants only ever interacted with a single individual, but our paradigm offers a perfect context to investigate how the nature of the speaker changes social interactions. For example, several studies have reported that a person's social status (e.g. Dalmaso, et al., 2012) modulates the degree of gaze following, and our paradigm provides the opportunity to test these social attentional mechanisms under more natural conditions. Similarly, our paradigm also potentially provides the opportunity to investigate how these processes evolve over time.

This papers most important contribution is the reaffirmation of how important social activity and top down influences are in everyday social interaction. Furthermore, we were able to pick up on previously difficult to obtain subtleties between high and low social interaction difficulties and gaze anxiety traits. It is rather surprising that we obtained all this information within a relatively short time frame, and with a non-clinical sample. Most importantly this study highlights the need for us to reconsider the units in which we measure social interaction and social cognition. It was Kurt Lewin (1935), who proposed that the most important decision an experimental psychologist makes is the units of analysis they choose to focus on. Most experimenters tend to employ a reductionist approach where they focus on the smallest possible unit of analysis. This makes sense as it removes a lot of the noise from the data and potentially ensures that the thing we are manipulating is what is driving the difference we are observing. However there comes a point in which this reductionist approach becomes counterproductive and ultimately changes the behaviours we are interested in. This is particularly true in the field of social cognition where researcher need to consider visual, auditory, and even cognitive processes.

In this paper, we propose a new approach to studying social attentional processes. The advantage of our paradigm is that it is a simple, yet effective way, to emulate a complex social interaction whilst simultaneously exerting extremely high levels of experimental control. Moreover, the results from our study illustrate that the nature of the social interaction significantly influences people's social attentional processes, which may account for many of the discrepancies found in the literature.

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