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Eye Gaze and Cortisol Levels in Socially Anxious Young Adults During an Interactive Real World Task

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EYE GAZE AND CORTISOL LEVELS IN SOCIALLY ANXIOUS YOUNG ADULTS DURING AN INTERACTIVE REAL WORLD TASK

An Honors Thesis

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by

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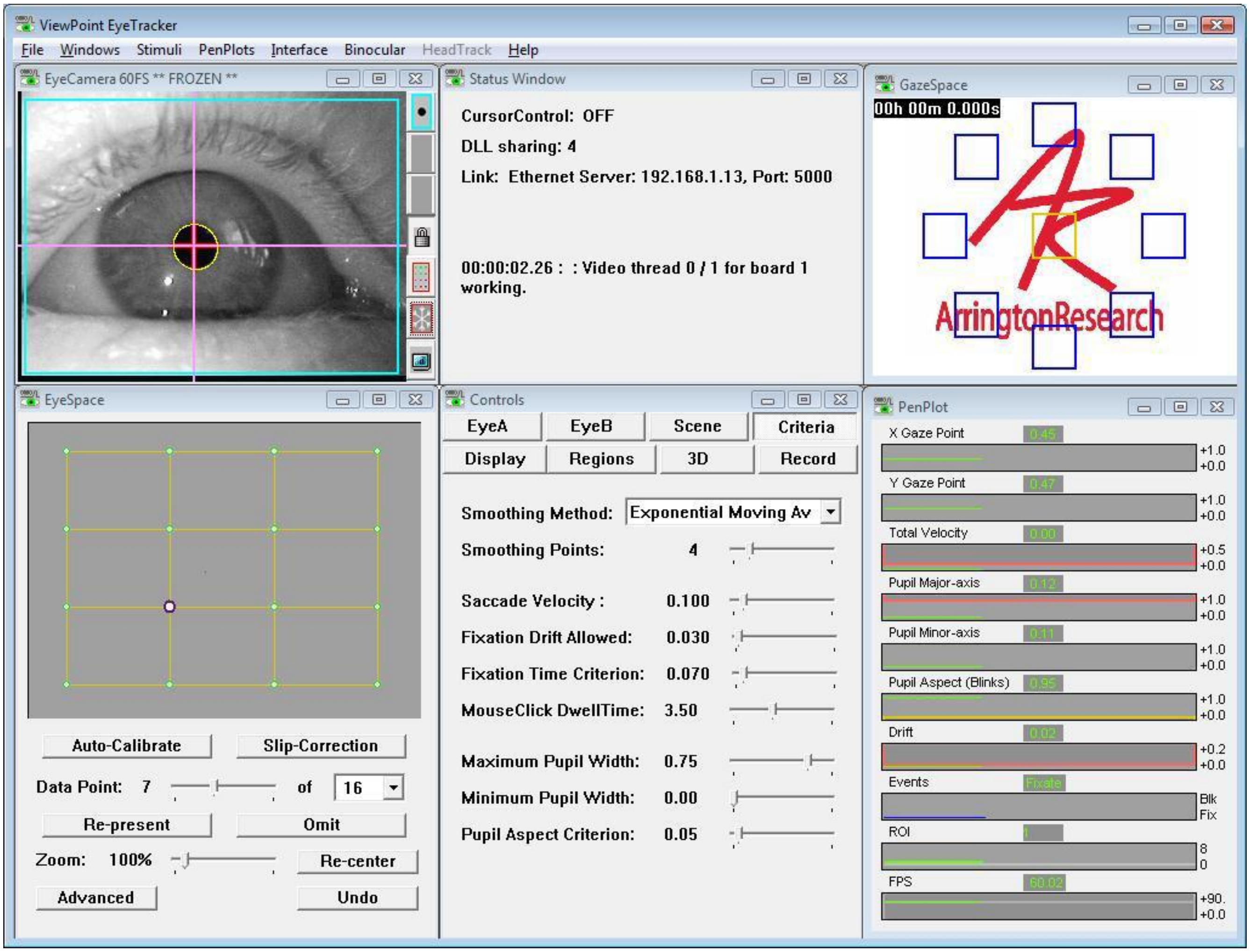
Figure 1.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00h 00m 0.000s
ArringtonResearch
EyeSpace
Auto-Calibrate
Slip-Correction
Data Point: 7 of 16
Re-present
Omit
Zoom: 100%
Re-center
Advanced
Undo
Controls
EyeA
EyeB
Scene
Criteria
Display
Regions
3D
Record
Smoothing Method: Exponential Moving Av
Smoothing Points: 4
Saccade Velocity : 0.100
Fixation Drift Allowed: 0.030
Fixation Time Criterion: 0.070
MouseClick DwellTime: 3.50
Maximum Pupil Width: 0.75
Minimum Pupil Width: 0.00
Pupil Aspect Criterion: 0.05
PenPlot
X Gaze Point
Y Gaze Point
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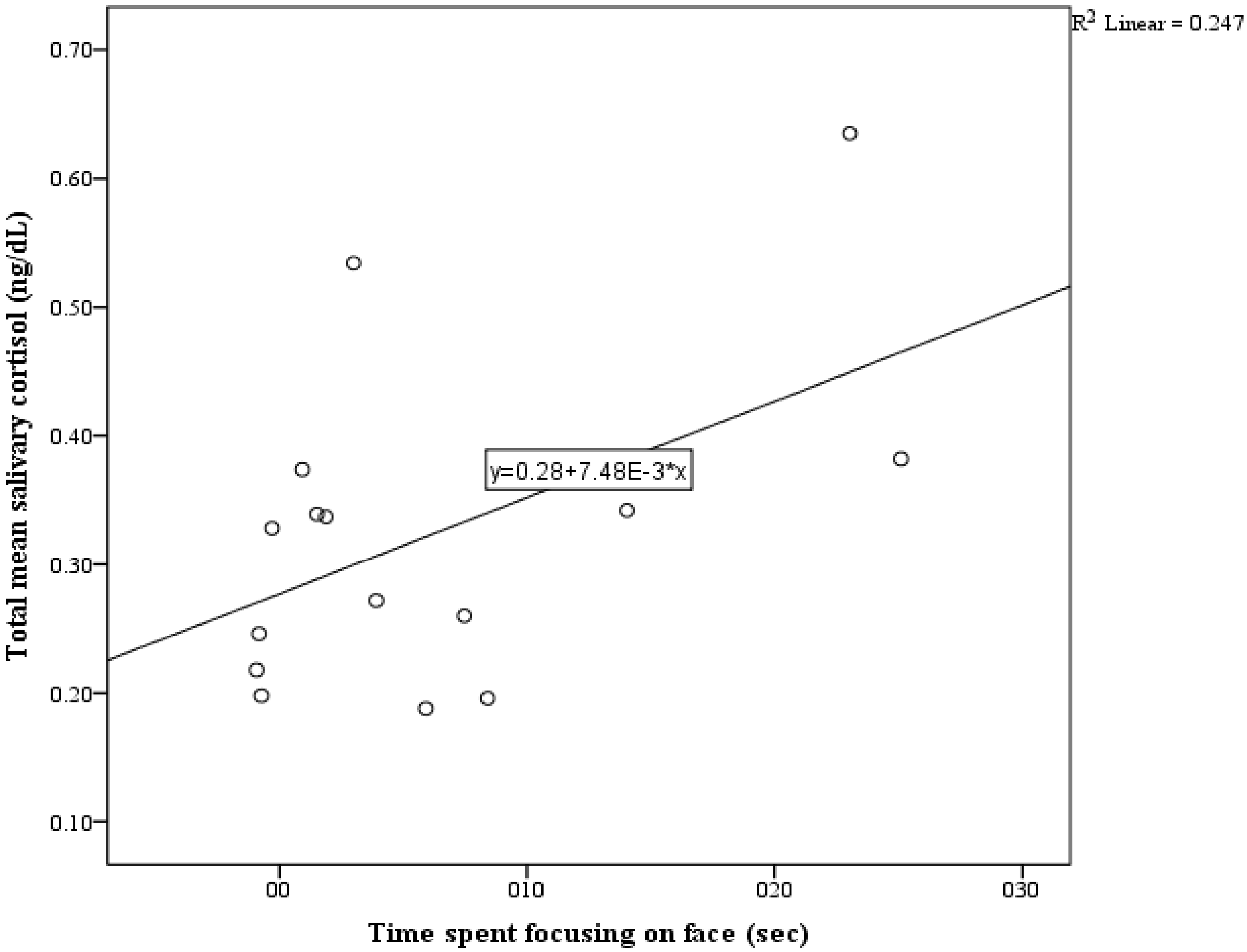
Pupil Major-axis
Pupil Minor-axis
Pupil Aspect (Blinks)
Drift
Events
ROI
FPS

Figure 2.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0.30
0.20
0.10
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00
010
020
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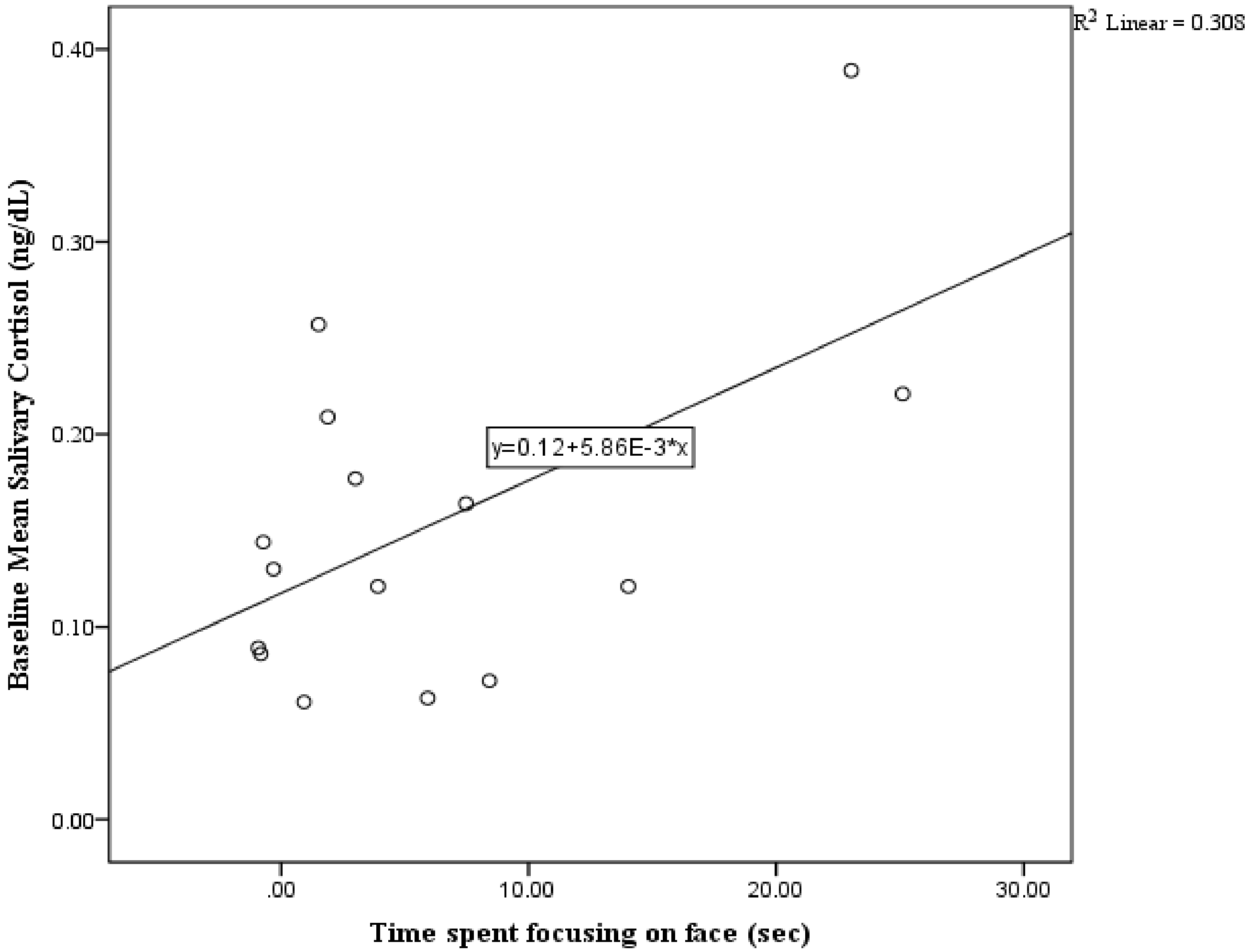
Time spent focusing on face (sec)

Figure 3.



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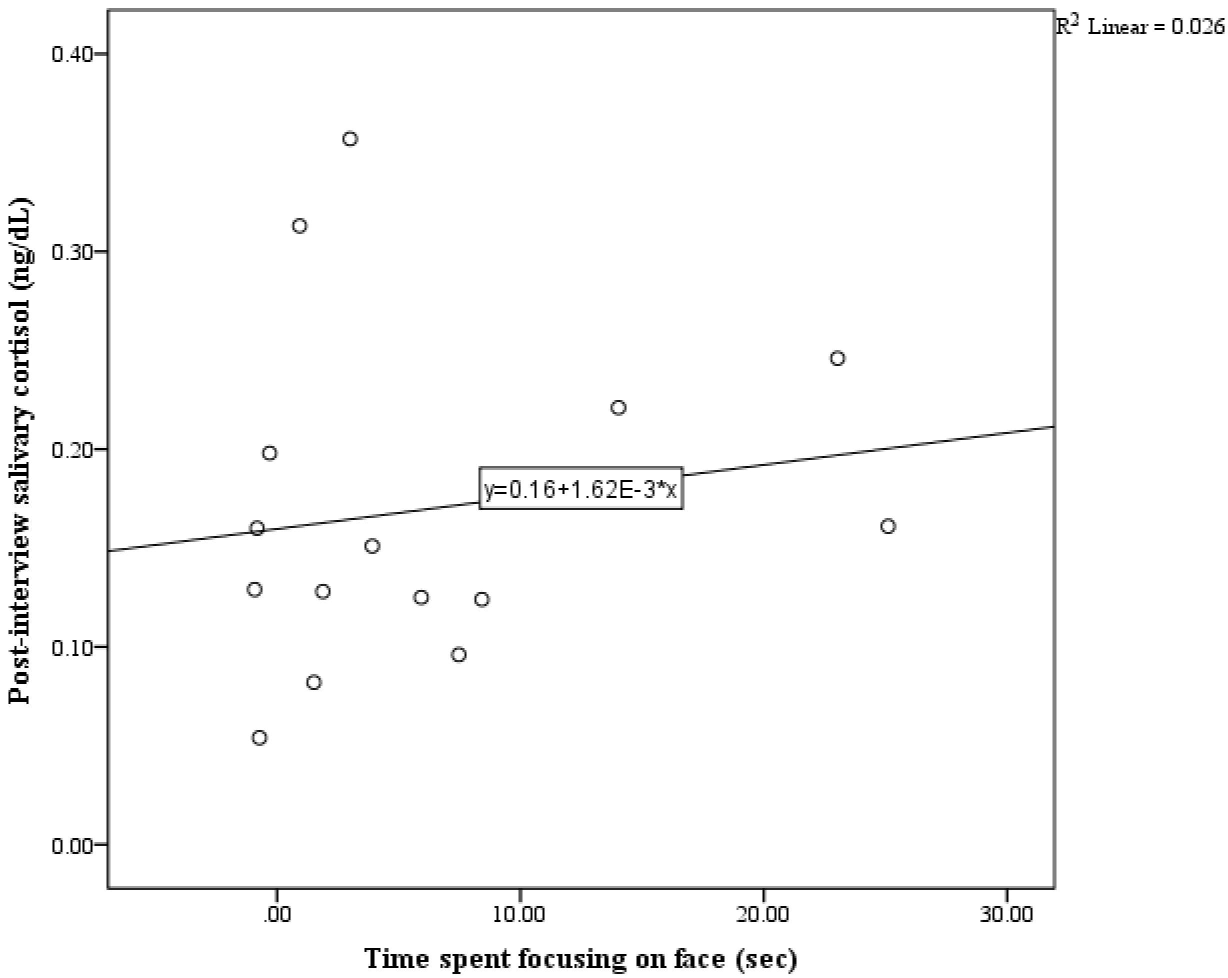
0.10
0.00
.00
10.00
20.00
30.00
Time spent focusing on face (sec)

Figure 4.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0.00
Post-interview salivary cortisol (ng/dL)
y=0.16+1.62E-3*x
.00
10.00
20.00
30.00
Time spent focusing on face (sec)

Figure 5.

	Mean	Std. Deviation	N
CBS	57.00	9.28	23
SPIN	23.39	16.38	23
STAIC	12.65	4.46	23

Figure 6.

	Mean	Std. Deviation	N
Region	5.97	8.13	16
Fixation	2.43	2.59	16
Pupil Area	0.12	0.10	16
Baseline Cortisol	0.14	0.08	22
Post Interview Cortisol	0.15	0.09	22
Total Cortisol Measured	0.30	0.12	22

Figure 7.

Abstract

Social anxiety is a disorder where people fear social interactions and is associated with physiological changes. Eye tracking studies have shown that people with social anxiety spent more time gazing at emotional faces presented on a computer screen and spent more time gazing at the eye region. There has been limited studies on tracking eye gaze in a real-life setting interacting with another person. We used a wearable eye tracker during a brief one-on-one interview about participants' challenges faced at work or school. Along with self-report psychological measures about social anxiety and shyness, we also measured participants' salivary cortisol as a metric for physiological stress. We hypothesized that socially anxious individuals would have higher cortisol levels and spent more time gazing at the face. However, there was no change in cortisol levels before and after the interview. In addition, socially anxious individuals had lower cortisol levels than less anxious people. Furthermore, the time spent fixating on the region of interest (ROI), which was the face, was not correlated with social anxiety, anxiety or shyness. Paradoxically, the more socially anxious participants seem to have had a lower physiological stress response than less socially anxious participants.

Keywords: Anxiety, Cortisol, Eye Tracking, Pupil Size, Region of Interest (ROI), Social Anxiety, Social Threat, Shyness, Wearable Eye Tracker

Eye Gaze and Cortisol Levels in Socially Anxious Young Adults During an Interactive Real-World Task

Social anxiety is a disorder that is prevalent in 7% of the population in the United States and affects 0.5 - 2.3% of the world population (American Psychiatric Association, 2013). It is characterized as fear of social interaction where the person with anxiety worries about judgement by others (American Psychiatric Association, 2013). Social anxiety is associated with physiological changes related to stress that include blushing, trembling, sweating (American Psychiatric Association, 2013) and changes in salivary cortisol (Beaton, Schmidt, Schulkin, & Hall, 2013; Shirotsuki et al., 2009; Yoon & Joormann, 2011). In social situations, individuals with social anxiety form a negative mental representation of their appearance and behavior as seen by others. They also focus their attention on this representation and any perceived threats in the environment. (Rapee & Heimberg, 1997).

Clark and Wells (1995) proposed a model for how socially anxious individuals maintain their anxiety. When in a social situation, individuals shift their attention to themselves, making them aware of their anxiety. This elevated self-awareness causes the individual to be less focused on the situation or person at hand thus increases the risk of a real or perceived social misstep. This reinforces the social anxiety and contributes to a negative self-impression. People with social anxiety also engage in safety behaviors to reduce rejection. Socially anxious people assume they have anxiety-induced performance deficits and assume that others negatively evaluate their performance during and after social interactions. Before and after a social situation, they ruminate on the interaction, past failures, and negative images of themselves (Clark & Wells, 1995).

Social anxiety also affects how people behave during social interactions. For example, socially anxious individuals take longer to disengage from gazing at faces showing negative emotions. Buckner, Maner, and Schmidt (2010) found that higher levels of social anxiety was related to slower gaze disengagement from faces showing the emotion of disgust. Similarly, Schofield and colleagues found that more social anxiety was related to increased time dwelling on emotional faces, such as angry (Schofield, Johnson, Inhoff, & Coles, 2012). In addition, Weiser and others (2009) found that the most socially anxious participants spent more time gazing at the eye region compared to individuals with medium to low levels of social anxiety. Socially anxious people may be responding more to facial expressions of threat and they may tend to attribute those emotional expressions (e.g. anger or disgust) in others to their own behavior.

However, other studies report people with social phobia spend less time looking at images of faces. Moukheiber and colleagues (2009) found that less time was spent dwelling and fixating on images of faces by socially anxious participants. Moreover, there was a negative correlation among social anxiety and time spent gazing at disgust and anger faces. Furthermore, Schneier and colleagues (2009) found that socially anxious individuals avoided direct eye gaze. They found that socially anxious people looked away from negative emotions and suggested that this could be a way of reducing arousal associated with facial expressions interpreted as a response to their self-perceived social awkwardness. Schneier and colleagues (2011) replicated findings on social anxiety and increased eye gaze avoidance in a later study.

Attentional biases in those with social anxiety that include difficulty disengaging from emotional faces could arise in a couple of ways. First, the *maintenance hypothesis* emphasizes a goal directed system of attention. According to Fox et al. (2001), this brain system selects and maintains focus on stimuli according to ongoing plans with voluntary shifts in internal attention and inhibition of attention to external stimuli. This hypothesis predicts that people with social anxiety have difficulty shifting attention to external stimuli. Moreover, people with social anxiety have difficulty shifting attention away from perceived threats resulting in difficulty disengaging from those perceived threats. In contrast, the *vigilance hypothesis* maintains that anxious individuals detect threat easily or have a low threshold for threatening stimuli and thus orient their attention towards perceived threats more often. It emphasizes externally driven shifts of attention (Armstrong & Olatunji, 2012).

A limitation of these studies is that participants were required to look at a computer screen not interact face-to-face with another person in the real world (Buckner et al., 2010; Schofield et al., 2012; Weiser et al., 2009). There is limited research using a wearable eye tracker to measure eye gaze during social interaction in the real world. In one example, children with autism spectrum disorder (ASD) and typically developing (TD) children wore a head-mounted eye tracker during a play session with an adult. Children with ASD spent the less time fixating on the adults' faces compared to TD children (Magrelli et al., 2013).

People with social phobia reported more anxiety before having to give a speech (Lorberbaum et al. 2004). In addition, those with higher levels of social anxiety had higher levels of bias towards focusing on internal threat information (Mills, Grant, Judah, & White, 2014). Furthermore, Boehme and colleagues (2014) found that socially anxious participants rated speech anticipation as more anxiety inducing, more arousing, and more negative than those without significant social anxiety did. In addition, they found that participants with social phobia spoke fewer words than those in the control group.

Pupil size increases during stress as part of the sympathetic nervous system response. In one study, participants with post-traumatic stress disorder (PTSD) had a larger pupil area to both trauma and neutral fixations when looking at stressful images (Felmingham, Rennie, Manor, & Bryant 2011). Another study found that pupil size was positively related to self-reported anxiety when looking at angry faces (Kret, Stekelenburg, Roelofs, & Gelder 2013). Moreover, people with elevated PTSD symptoms had larger pupils and stared longer at negative images (Kimble et al. 2010).

Social anxiety is associated with changes in salivary cortisol levels. The literature has been inconsistent on whether social anxiety is associated with high or low levels of salivary cortisol. For example, Beaton, Schmidt, Schulkin, and Hall (2013) found that social anxiety was associated with lower total salivary cortisol levels. Shirotsuki and colleagues (2009) found lower cortisol response to stressors as well. In contrast, Yoon & Joormann (2012) found increased levels in cortisol in response to stressors in relation to higher social anxiety.

The aim of this study was to measure eye gaze behavior and physiological stress in relation to social anxiety during a real-world social interaction. We used a unique eye-tracking system mounted to a set of specialized eyeglasses to measure that amount of time participants spent looking at the faces of the interviewer during a brief face-to-face interview. We hypothesized that those with higher social anxiety would have higher cortisol levels and spend more time focusing on the face than less socially anxious people. We also predicted that socially anxious individuals would stare longer at the face based on some of the literature (see Buckner et al., 2010; Schofield et al., 2012; Weiser et al., 2009) and the *vigilance hypothesis*, which states that anxious individuals detect threat more easily and focuses on external shifts in attention (Armstrong & Olatunji, 2012). We also predicted that socially anxious people would have a larger pupil area in response to the stress of participating in an interview.

Method

All methods were approved by the Institutional Review Board at the University of New Orleans.

Participants

Participants were recruited via emails sent out to their professors, fliers posted around campus, and word-of-mouth. Participants were aged between 16 to 31 years old (M=22, SD=4.03). There was 23 participants total (16 female). The majority of the participants were Caucasian (48%), while the rest were African American (35%), Asian (9%), and Hispanic (9%).

Psychological Questionnaires

Several questionnaires were used to measure social anxiety, shyness, and anxiety. The *Social Phobia Inventory* (SPIN) is a 17-item questionnaire which is used to measure social anxiety with a four-point scale (0 = a little bit to 4 = extremely; Connor, 2000). The *Cheek Buss Shyness Scale* (CBS) is a 20-item questionnaire that is used to measure shyness and has a five-point scale (1=very uncharacteristic to 5 = very characteristic; Cheek & Melchoir, 1985). The *How-I-Feel Questionnaire* or the *State-Trait Anxiety Inventory for Children* (STAIC) is used to measure anxiety in children was used to measure anxiety in young adults; the STAIC had a scale from 1 to 3 with 1 indicating the presence of little to no anxiety and 3 indicating higher levels of anxiety (Spielberger, 1973).

ViewPoint EyeTracker

The *ViewPoint EyeTracker* (Arrington, 2016) was used to measure the fixation time, time spent focusing on the region of interest (ROI), and pupil size. Time spent focusing on the region and fixation time were measured in seconds. The *ViewPoint EyeTracker* was used to track the participant’s eye gaze during the interview (see Figures 1 and 2). Pupil size also was measured as an indicator of sympathetic stress activation. The face of the interviewer was defined as the ROI and this was examined in relation to social anxiety and physiological stress responses (i.e. cortisol and pupil size).

Salivary Cortisol

Salivary cortisol levels were measured in saliva samples collected with Salivettes (Sarstedt, Nümbrect, Germany). Cortisol measures were taken before and after the interview. Participants placed the inert sponge from the salivette tube in their mouth for a minute in order to collect saliva. Samples were placed in a 4°C fridge until they were assayed. Saliva was assayed for cortisol using *Salimetrics*-enzyme-linked

immunosorbent assay (ELISA) kits (Salimetrics, College Station, PA) and were run in singlets. Salivary cortisol is reported in ug/dL.

Statistics

A paired *t*-test was used to see changes in salivary cortisol levels differed from baseline to post interview. Pearson correlations were used to relate total cortisol measured, shyness, social phobia, and current anxiety. Pearson correlations was used to examine potential relationships between total salivary cortisol and eye gaze measures. Pupil size was calculated by measuring the area of an ellipse.

Procedure

The experimenter briefed the participants on the experiment and read the consent form to participants. Once the consent form was signed, the experimenter collected the first saliva sample to measure baseline cortisol level. Then the survey was completed by the participant. After the surveys were completed, the experimenter placed the eye tracking glasses on the participant; the cameras that monitor the participant's eyes were adjusted, so that the eyes were well defined. Next, calibrations were done to ensure an accurate tracking of participant's gaze. Once calibrations were complete, the experimenter notified the participant that an interview related to challenges they faced in work or school would be forthcoming and gave them ten minutes to prepare for the interview. This time was given to increase anticipatory anxiety and allow enough time for salivary cortisol to change if it was going to change in a measurable way. The interview itself was five minutes long and the participant was prompted if she/he did not give detailed answers about stress and challenges in the workplace or school. Once the interview was completed, the eye-tracking apparatus was taken off and questions or concerns were answered. Afterwards, the participant placed a Salivette collection sponge (Sarstedt, Nümbrect, Germany) in their mouth for minute to collect saliva. Saliva samples were stored at +4°C until they were assayed to measure changes in their salivary cortisol levels from baseline.

Results

Salivary cortisol measures were available for all 23 participants but eye-tracking data was only available for 15 participants due to problems with data acquisition and storage or operator error. A paired *t*-test computed to test for differences in the cortisol levels before and after the interview. No statistically significant differences were found across the two data collection periods [$t(21) = -0.457$, $p > 0.05$]. Next, we examined the hypothesized relationship between the *Cheek Buss Shyness Scale*, the *Social Phobia Inventory*, and the *State-Trait Anxiety Inventory for Children* total scores and salivary cortisol levels. The three tests examining different aspects of social anxiety were positively correlated with each other [all *ps* < 0.01]. There was a trend approaching statistical significance between the *Cheek Buss Shyness Scale* and total cortisol [$r(21) = -0.331$, $p = 0.08$], the *Social Phobia Inventory* and total cortisol [$r(21) = -0.320$, $p = 0.074$] and the *State-Trait Anxiety Inventory for Children* [$r(21) = -0.313$, $p = 0.080$] and baseline cortisol levels. There was no significant correlation between the *Cheek Buss Shyness Scale*, the *Social Phobia Inventory*, the *State-Trait Anxiety Inventory for Children*, and time spent gazing at the face as measured by fixation time [all *p*s > 0.05]. Pupil size was not correlated with the *Cheek Buss Shyness Scale*, the *Social Phobia Inventory*, or the *State-Trait Anxiety Inventory for Children* scores [all *p*s > 0.05].

For the 15 participants with both cortisol and eye gaze data, total cortisol levels were positively correlated with time spent gazing in the ROI which corresponded to the face of the interviewer [$r(14) = 0.497$, $p = 0.03$] (see Figures 3, 4 & 5). The higher levels of cortisol levels that is our measure of physiological stress, the more time spent focusing on the ROI. Next, we examined cortisol and pupil size. There was no relationship between total, [$r(14) = -0.03$, $p = 0.46$], baseline [$r(14) = -0.14$, $p = 0.31$] or post-interview cortisol [$r(14) = 0.10$, $p = 0.36$] and pupil size. Results did not support expectations that elevated stress levels would be associated with higher cortisol levels and enlarge pupil size.

Discussion

To summarize, it was hypothesized that socially anxious individuals would have higher cortisol levels and spend more time dwelling on the face; it was also hypothesized that socially anxious individuals would have a larger pupil area. In short, there was no difference in cortisol levels before and after the interview. There was a correlation between the CBS, SPIN, and STAIC self-report measures and a trend to towards a negative correlation in the tests and the baseline cortisol levels. No correlation was found between the CBS, SPIN, STAIC, and gaze fixation nor there was a correlation between the CBS, SPIN, STAIC, and pupil size. There was a positive correlation between cortisol levels and time spent focusing on the facial region. A negative correlation was found between cortisol levels and pupil size. There was a smaller pupil size associated with higher anxiety. Therefore, there was a lower stress response in the shy and socially anxious with lower cortisol levels and smaller pupils.

Lower cortisol levels have been seen in shy and socially anxious individuals. For example, Beaton, Schmidt, Schulkin, & Hall (2013) found lower cortisol levels in shy individuals. Similarly, Shirotsuki et al. (2009) found low cortisol levels in response to a social stress situation in those with higher levels of social anxiety. It is possible that they may have been less stressed about the interview, or they may have been accustomed to social stress so much that the physiological response is lessened. However, no cortisol changes were found for either groups before and after the interview. It could be that they were not as stressed enough about the interview.

There was a positive correlation between cortisol levels and time spent focusing on the facial region. Therefore, it is possible that those who were not accustomed to a lot of stress such as the individuals who had the least amount of shyness, anxiety, and social anxiety may have been more stressed by the interview. Also, in contrast with the literature on pupil size (Felmingham, Rennie, Manor, & Bryant 2011; Kret, Stekelenburg, Roelofs, & Gelder 2013; Kimble et al. 2010), we found that social anxiety and shyness was associated with a smaller pupil area. Therefore, socially anxious individuals could have been accustomed to these social stressors in their day-to-day life.

There are several limitations in this study to keep in mind. First, there was a smaller sample size, which limited statistical power. If there was more participants, the results might be more generalizable. Second, some data of the data was missing. There was one participant who had no cortisol samples taken and five participants with no eye tracking data due to technical difficulties. Also, this study was done in during one semester. If this study had been conducted throughout the year, we would not only have more participants but potentially different results. In addition, the interview was only five minutes long. If the interview was longer and the variables changed (i.e. having the researchers wear professional attire to simulate a professional interview, increase number of interviewers) greater changes in cortisol levels could have been observed.

While there were some limitations to the study along with technical difficulties recording eye-tracking data, this experiment is an important addition to the literature. To the best of our knowledge, this is the first real-world interaction eye tracking study in people with social anxiety. Future work should try to further expand on this study by looking at different populations of people or in hiring practices.

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