Mild-to-moderate schizotypal traits relate to physiological arousal from social stress

Preethi Premkumar[1], Prasad Alahakoon[2], Madelaine Smith[1], Veena Kumari[3], Diviesh Babu[1], Joshua Baker[1]

[1]Department of Psychology, School of Social Sciences, Nottingham Trent University, Nottingham, UK

[2] Department of Agricultural Extension, Faculty of Agriculture, University of Peradeniya, Sri Lanka

[3]Centre for Cognitive Neuroscience, College of Life and Health Sciences, Brunel University London, Uxbridge, UK

Correspondence address

Dr Preethi Premkumar

Department of Psychology

Nottingham Trent University

Tel: +44 (0)115 848 4511

Email: preethi.premkumar@ntu.ac.uk

Abstract

Schizotypy denotes psychosis-like experiences, such as perceptual aberration, magical ideation and social anxiety. Altered physiological arousal from social stress is found in people with high schizotypal traits. Two experiments aimed to determine the relationship of schizotypy to physiological arousal from social stress. Experiment 1 tested the hypotheses that heart rate from social stress would be greater in high, than mild-to-moderate, schizotypal traits, and disorganised schizotypy would explain this effect. Experiment 1 tested social stress in 16 participants with high schizotypal traits and 10 participants with mild-to-moderate schizotypal traits. The social stress test consisted of a public speech and an informal discussion. The high schizotypal group had higher heart rate than the mild-to-moderate schizotypal group during the informal discussion, but not during the public speech. Disorganised schizotypy accounted for this group difference. Experiment 2 tested the hypothesis that mild-to-moderate schizotypal traits would have a linear relationship with physiological arousal from social stress. Experiment 2 tested 24 participants with mild-to-moderate schizotypal traits performing the abovementioned social stress test while their heart rate and skin conductance responses were measured. Mild-to-moderate schizotypal traits had a linear relationship with physiological arousal during the discussion with a stranger. Distress in disorganised schizotypy may explain the heightened arousal from close social interaction in high schizotypy than mild-to-moderate schizotypy. Mild-to-moderate schizotypal traits may have a linear relationship with HR during close social interaction because of difficulty with acclimatising to the social interaction.

Keywords: Heart rate; schizotypy; skin conductance; social stress; physiological arousal; public speech

Mild-to-moderate schizotypal traits relate to physiological arousal from social stress

Schizophrenia and other psychotic disorders are often characterised by hearing threatening voices and having beliefs that others are going to harm them (American Psychiatric Association, 2013). Schizophrenia has more severe psychopathology and a poorer rate of remission than other psychotic disorders (Harrow, Sands, Silverstein, & Goldberg, 1997). These psychosis-like experiences occur at a subclinical level. Schizotypy is a latent personality organisation that reflects psychosis-like experiences at a sub-clinical level and a putative liability for these schizophrenia-spectrum disorders and the psychoses (Grant, Green, & Mason, 2018; Fonseca-Pedrero, et al., 2018). Schizotypy is a multidimensional construct that consists of a cluster of personality traits that feature both normal and aberrant variations of psychosis-proneness (Cohen, Mohr, Ettinger, Chan, & Park, 2015; Oezgen & Grant, 2018). Schizotypy consists of three main dimensions, namely positive, negative and disorganised, and a fourth possible dimension, namely eccentricity (Oezgen & Grant, 2018). Positive schizotypy consists of perceptual aberrations, paranormal experiences and spiritual and magical beliefs. Negative schizotypy consists of social anhedonia and emotional withdrawal. Disorganised schizotypy refers to cognitive slippage and loosening of association (Mason, Claridge, & Jackson, 1995; Fonseca-Pedrero, Ortuño-Sierra, De Álbeniz, & Cohen, 2017; Meehl, 1962). The eccentric dimension is characterised by odd behaviour, odd speech and impulsive non-conformity (Oezgen & Grant, 2018). These schizotypal traits are common in the British population, where 75% of a representative sample (n=1,000) has encountered a paranormal experience (Pechey & Halligan, 2012). The incidence of such positive schizotypal traits in the general population is 100 times higher than that of schizophrenia (Hanssen, Bak, Bijl, & Vollebergh, 2005). Whether schizotypal traits decompensate to schizophrenia-liability

or psychosis-proneness depends on the prominence of the positive schizotypal traits (Schultze-Lutter, Nenadic, & Grant, 2019).

Disorganised schizotypy includes social anxiety (Mason, Claridge, & Jackson, 1995) and poor verbal fluency (Tan & Rossell, 2017). Disorganised schizotypy is also considered to be an analogue of thought disorder in psychosis (Rossell, Chong, O'Connor, & Gleeson, 2014). Thought disorder features illogical thinking, loose association and peculiar language (Grant & Beck, 2009), as well as communication deviance within the family (Tompson, Asarnow, Hamilton, Newell, & Goldstein, 1997). Disorganised schizotypy and thought disorder being related to elements of social anxiety, such as sensitivity to social rejection (Grant & Beck, 2009; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018), could make those with a high level of disorganised schizotypal traits inherently perceive casual social encounters as stressful.

Vulnerability to social stress along the psychosis continuum

Physiological arousal from stress is a multisensory response aimed at restoring the body's homeostasis (Day T. , 2005). Stress is characterised by nervousness, becoming upset, overreacting easily and/or having difficulty relaxing (Lovibond & Lovibond, 1995). To experience social stress, one must believe that their social surroundings are taxing, exceed their resources to manage them and/or endanger their well-being (Lazarus & Folkman, 1984). During stress, the hypothalamic-pituitary-adrenal axis stimulates the secretion of epinephrine and norepinephrine from the adrenal medulla (Naughton, Dinan, & Scott, 2014; Carlson & Birkett, Physiology of Behaviour, 2017, pp. 98-100) (Figure 1a). Secretion of epinephrine and norepinephrine increases blood flow to the cardiac muscles, and increases heart rate (HR) and cortisol release from the adrenal cortex. Separate from the hypothalamic-pituitary-adrenal axis, stress activates the sympathetic branch of

the vegetative nervous system, also known as the autonomous nervous system but no longer regarded autonomous because of the partial regulatory control of this nervous system (Rasia-Filho, 2006). Activating the sympathetic branch of the vegetative nervous system increases HR and the skin conductance response (SCR), and increases cortisol release from the adrenal cortex upon stimulating the secretion of epinephrine and norepinephrine from the adrenal medulla (Carlson & Birkett, Physiology of Behaviour, 2017, pp. 98-100) (Figure 1b). SCR occurs when sympathetic preganglionic neurons within the vegetative nervous system transmit impulses across synapses to the sympathetic postganglionic neurons in the sweat glands and results in secretion of acetylcholine within the sweat glands (Carlson, 2001).

The change in HR, SCR and cortisol level from stress can be tested *in vitro* by the Trier Social Stress Test (TSST) (Kirschbaum, Pirke, & Hellhammer, 1993). The TSST is a public-speaking task and an ecologically valid measure of daily social stress (Kirschbaum, Pirke, & Hellhammer, 1993). The standard TSST consists of a 30-minute baseline resting phase, followed by a three-minute anticipatory phase to prepare a speech on the participant's suitability for a job, delivering a short public speech in front of a small audience for five minutes, performing a mental arithmetic test for five minutes, and lastly a 60-minute recovery phase (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014). The long baseline and recovery phases allow for samples of plasma cortisol to be obtained whilst hypothalamic-pituitary-adrenal axis activity normalises (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014). Higher HR and cortisol release during the public speech than the mental arithmetic task (Kirschbaum, Pirke, & Hellhammer, 1993) suggests that the public speech is more stressful than the arithmetic task.

Social stress often precedes the onset of psychosis (Lange, et al., 2017). The stress diathesis model posits that psychosis arises from stressors, including prolonged unpleasant social interaction.

These stressors interact with a pre-existing vulnerability for psychosis and increase the likelihood of the onset of psychosis (Nuechterlein & Dawson, 1984). There is evidence for both elevated and diminished basal cortisol levels in psychosis (Bradley & Dinan, 2010), and elevated basal cortisol levels in high schizotypy (Walter, Fernandez, Snelling, & Barkus, 2018). Elevated cortisol at baseline may indicate that individuals with schizotypal traits have a hyper-aroused stress response system by default. Sustained daily stress could disrupt cortisol secretion in psychosis. Against this backdrop of altered basal cortisol level, patients with psychosis have a blunted cortisol response to the TSST at both the anticipatory stage and the post-speech stage (Ciufolini, Dazzan, Kempton, Pariante, & Mondelli, 2014). Likewise, individuals with high schizotypal traits and those at risk for psychosis have been shown to have diminished cortisol release in the post-speech phase of the TSST (Walter, Fernandez, Snelling, & Barkus, 2018; Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). Diminished cortisol release following the public speech could imply an attenuated endocrine response to an already over-exerted hypothalamic-pituitary-adrenal axis due to chronic arousal from daily stressors and/or slow recovery after the stressful event has passed (Collip, et al., 2013; Walter, Fernandez, Snelling, & Barkus, 2018). The stress-related change in cortisol level has different associations to daily stress depending on the type of vulnerable populations. A lower cortisol level during the TSST relates to higher daily stress in individuals at risk for psychosis (Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). Contrastingly, elevated cortisol level from daily stress relates to having more momentary psychosis-like experiences in siblings of patients with psychosis (Collip, et al., 2011a).

Evidence suggests that HR increases under social stress along the psychosis continuum. Increased HR during the TSST is greater-than-normal in patients with psychosis (Lange, et al., 2017). However, the increased HR during the TSST in individuals at risk for psychosis is

comparable to that of healthy individuals (Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). People at risk for psychosis also have greater HR than health controls after listening to criticism (Weintraub, et al., 2019), suggesting that elevated HR depends on the social context in at-risk individuals. Walter and colleagues (2018) did not measure HR or SCR during the TSST in individuals with high schizotypal traits. People with high schizotypal traits elicit greater-than-normal HR and SCR when imagining alien abduction (Mcnally, et al., 2004). Greater positive schizotypy relates to greater HR while viewing aversive pictures and films (Karcher & Glenn, 2012; Phillips & Seidman, 2008). People with high schizotypal traits and at-risk mental states may have elevated HR from perceiving social threat when imagining paranormal scenes, viewing aversive scenes and listening to criticism.

An inverted U-shaped model of stress (Sapolsky, 2015; Yerkes & Dodson, 1998) could explain the conflicting evidence of increased and decreased physiological arousal from social stress in schizotypy and at-risk mental states. Altered physiological arousal from social stress is also seen in social anxiety which has an inverted U-shaped relationship with HR when individuals with low to high levels of social anxiety perform a task under observation (Pujol, et al., 2013). The increased HR during social stress in people with low social anxiety, but decreased HR in patients with social anxiety disorder (Pujol, et al., 2013) suggests that persistent stress could diminish physiological arousal from social stress in high social anxiety. A similar association may be found in schizotypy because social anxiety and neuroticism contributes to the distress from high schizotypal traits (Premkumar, et al., 2015). Neuroticism is the preoccupation with negative emotions. Neuroticism in disorganised schizotypy relates to the blunted cortisol response during the TSST (Grant & Hennig, 2018). Thus, elevated anxiety in high schizotypy could diminish physiological arousal from social stress. Furthermore, anxiety in schizotypy rather than

'benign/happy schizotypy' *per se* could relate to physiological arousal from social stress (Grant, Green, & Mason, 2018). The following experiments sought to test these assumptions by studying individuals at different strata of schizotypal traits.

Furthermore, the different conditions under which social stress is measured could confound evidence of altered physiological arousal from social stress. The cortisol level was blunted in individuals with high schizotypy and at-risk mental states when the social stress was tested *in vitro* (Walter, Fernandez, Snelling, & Barkus, 2018; Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). Yet, cortisol levels were elevated in genetically at-risk individuals when daily social stress was assessed *in vivo* (Collip, et al., 2011a). Stress induction may be greater *in vitro* than *in vivo*. An informal discussion administered *in vitro* might mimic daily social stress that elevates cortisol levels in at-risk individuals (Collip, et al., 2011a). Hence, physiological arousal from interpersonal interaction might be different from a public speech which is a performance-based social situation. People with high schizotypal traits could experience more stress in close interpersonal interaction than public-speaking situations because of their paranoia in interpersonal situations (Horton, Barrantes-Vidal, Silvia, & Kwapil, 2014). Paranoia constitutes suspiciousness, perceived hostility and blaming others in ambiguous social situations, having less social engagement and more social problems (Combs, Finn, Wohlfahrt, Penn, & Basso, 2013). Individuals with a moderate level of paranoia are more alert to social threat from strangers and exhibit more momentary paranoia than those with a low level of paranoia (Collip, et al., 2011b). High paranoia in adolescents with social anxiety disorder would further suggest that paranoia is a part of social anxiety (Pisano, et al., 2016). People with high schizotypal traits are more anxious in interpersonal situations than people with depression-like tendencies (Miller & Lenzenweger, 2012). Hence, interpersonal sensitivity could be a hallmark of schizotypy. Distress from disorganised schizotypy could explain the link between

positive schizotypy and social stress because distress is more pronounced in disorganised schizotypy than positive schizotypy. Disorganised schizotypy includes social anxiety and has stronger correlations with sensitivity to rejection, criticism and praise than other schizotypal traits (Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018; Premkumar, Dunn, Onwumere, & Kuipers, 2019). Benign positive schizotypy, such as magical ideation, can be a positive experience, but not distressing (Grant & Hennig, 2019; Fumero, Marrero, & Fonseca-Pedrero, 2018). Disorganised schizotypy due to being overwhelmed, nervous or confused could explain the emergence of psychosis-like experiences from performing the TSST over and above positive and negative schizotypy (Grant & Hennig, 2019).

To summarise, the psychosis continuum is characterised by altered physiological arousal to social stress, namely blunted cortisol levels on the one hand but heightened HR on the other. Ambiguity about the direction of the relationship between schizotypal traits and physiological arousal from social stress could arises from social anxiety (Pujol, et al., 2013) having a non-linear relationship with physiological arousal during social stress, and (2) the type of social stressor being administered, namely performance-related or interpersonal. The aims of the following experiments aimed were (1) to determine the relation of schizotypy to physiological arousal from social stress, (2) to determine whether this relationship differs by the type of social stressor, namely public-speaking which is a performance-related social situation, and a discussion which is an interpersonal social situation, and (3) to distinguish between the positive and disorganised schizotypal traits in their relationship with physiological arousal from social stress.

*** Insert Figure 1 about here ***

Experiment 1

The first aim of the first experiment was to examine physiological arousal from social stress in schizotypy. It was hypothesised that,

1. People with high positive schizotypal traits would have greater HR than people with mild-to-moderate positive schizotypal traits during a close interpersonal interaction, namely an informal discussion,
2. Disorganised schizotypy would account for greater HR during an informal discussion in high positive schizotypy than mild-to-moderate positive schizotypy because of social anxiety in disorganised schizotypy (Mason, Claridge, & Jackson, 1995; Oezgen & Grant, 2018), and
3. Overall schizotypy would have a non-linear positive relationship with HR during an informal discussion, such that mild-to-moderate level of schizotypal traits would have a positive relationship with physiological arousal and high schizotypal traits would have a weak relationship with physiological arousal. Evidence suggests a non-linear relationship of social anxiety with HR during social stress (Pujol et al., 2013). We hypothesised a relationship between overall schizotypy, not positive schizotypy, and HR during an informal discussion because an overall schizotypal index captures social anxiety and distress from positive schizotypal traits better than either the positive or disorganised subscales.

Testing the validity of an informal discussion as a control task

The second aim was to determine if an informal discussion is a valid control task for the public speech task. A control task must match the experimental task in terms of social context, unpredictability and challenge (Dickerson & Kemeny, 2004). An informal discussion is like a free speech which is a non-evaluative speaking task that matches a public speech in the level of social

exposure and unpredictability (Het, Rohleder, Schoofs, Kirschbaum, & Wolf, 2009). A social role-play task, such as solving an interpersonal problem or an informal discussion, is a standard part of a social assessment battery and it matches public speaking in the level of social context, unpredictability and challenge (Horan & Blanchard, 2003; Bellack, Sayers, Mueser, & Bennett, 1994). An informal discussion is similar to a social problem-solving task. Change in mood and physiological arousal can gauge the success of an emotional manipulation. Mood can assess the ecological validity of the TSST because the change in mood following the TSST relates to the change in mood following an actual oral exam (Henze, et al., 2017). Furthermore, social interactions alter mood and physiological arousal (Horan & Blanchard, 2003; Henze, et al., 2017). A social problem-solving task alters mood more among patients with psychosis than healthy individuals (Horan & Blanchard, 2003). A control task is valid if it elicits less negative mood and greater positive mood and less physiological arousal than the experimental task (Giles, Mahoney, Brunyé, Taylor, & Kanarek, 2014). Hence, mood change and physiological arousal are valid means of testing the effectiveness of an emotional manipulation. It was hypothesised that:

4. Physiological arousal will be higher during a public speech than an informal discussion, and
5. Positive mood would be lower, but negative mood would be greater during a public speech than a discussion.

Method

Participants

Twenty-six participants (mean age = 25.8, S.D. = 6.2, 16 females) took part in the experiment. Participants were aged between 18 and 60 years and did not have a current diagnosis of psychosis. Participants were recruited by advertising the experiment on social networking websites for people with spiritual or paranormal beliefs, on the psychology department website in return for research credits and at a wellbeing event that offered psychic communication and spiritual remedies. It is thought that people with alternative spiritual beliefs score highly on schizotypal traits (Day & Peters, 1999). Eleven participants with high positive schizotypal traits were recruited from the well-being event and scored one S.D. above the mean score of a normative sample on O-LIFE-Unusual Experiences (Mason & Claridge, 2006). Sixteen participants were psychometrically defined as having high positive schizotypal traits by scoring ≥ 15 on the Unusual Experiences subscale of the O-LIFE, which represents the 75th percentile of the subscale (Mason & Claridge, 2006). Participants scoring <15 (n=10) were classified as having mild to moderate positive schizotypal traits. Scores on the O-LIFE-Unusual Experiences subscale ranged from 16-29 in the high schizotypal group and from 0-12 in the mild-to-moderate schizotypal group. Participants provided informed consent before the experiment began. The experiment was approved by the University's School of Social Sciences Research Ethics Committee.

Assessments

O-LIFE (Mason & Claridge, 2006; Mason, Claridge, & Jackson, New scales for the assessment of schizotypy, 1995): The O-LIFE has 104 questions to which participants answer 'Yes' or 'No'. The scale measures Unusual Experiences (positive schizotypy), Introvertive Anhedonia

(negative schizotypy due to solitude and lack of enjoyment from general activity), Cognitive Disorganisation (social anxiety and difficulty focusing attention) and Impulsive Nonconformity (reckless behaviour). The internal reliability of these subscales ranges from acceptable to good in the current sample according to Cronbach's alpha (α), with scores 0.88, 0.86, 0.74 and 0.69 on reliability, respectively.

Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988): The PANAS was administered to measure the change in mood during the social stress test and to test whether the informal discussion would be a valid control task for the public speech. Ten positive mood descriptors denote a state of high energy and pleasurable engagement. Ten negative mood descriptors denote aversive mood. Participants indicated how much they felt about each descriptor at that moment on a five-point Likert scale. The positive and negative subscales have good internal reliability in the current sample, namely 0.94 and 0.86, respectively.

Social stress test

Speech: Participants were asked to deliver a two-minute speech in front of a two-member audience. Participants spoke about their favourite subject in school and had five minutes to prepare and make notes beforehand. Participants were asked to stand while delivering the speech. The panel gave no emotional or verbal feedback during the speech and maintained a neutral expression to minimize external cues that may affect the participant's performance.

Informal discussion: Participants were asked to engage in a three-minute informal discussion with the panel. Participants spoke about their favourite hobby and had five minutes to

prepare beforehand. The panel members engaged in the discussion by asking questions and sharing their thoughts about the participant's hobbies. Participants remained seated during the discussion.

HR measurement

HR was recorded from a Biosemi Active Two electroencephalography amplifier and three Ag/AgCl electrodes. An Ag/AgCl electrode was placed close to the heart and two Ag/AgCl electrodes (reference electrodes) were placed one inch apart on the neck. HR was measured as the peak-to-peak intervals of the heartbeat and calculated as the average number of heart beats per minute (Weintraub, et al., 2019). Heartrate was averaged over 30-second epochs, resulting in four speech epochs and six discussion epochs (Owens & Beidel, 2015).

Procedure

The experiment was approved by the University's School of Social Sciences research ethics committee. Participants who met the screening criterion for schizotypy were invited to take part in the social stress test. Participants gave informed consent before the social stress test began and HR was monitored. The PANAS was administered before and after the public speech and the informal discussion.

Statistical analyses

Analyses of variance (ANOVAs) compared the groups with high and mild-to-moderate schizotypal traits on age and O-LIFE scores. ANOVAs on HR during the social stress test tested the first hypothesis. To test the second hypothesis, these ANOVAs were repeated on the standardised residual of the HR variable obtained from regressing Cognitive Disorganisation on

each HR variable. To test the third hypothesis, logarithmic and linear regressions were performed between positive schizotypy and HR during the six epochs of the discussion. Analyses were performed in SPSS, version 24. One-tailed tests were performed due to the directional nature of the hypotheses.

HR data and PANAS data were combined from experiment 1 (n = 26) and experiment 2 (n = 24) to test the fourth and fifth hypotheses. ANOVA was performed with task type (speech and discussion) and time (first 4 epochs, 0-30 s, 31-60 s, 61-90 s and 91-120 s) as the independent variables and HR the dependent variables. Skin conductance response (SCR) was measured in addition to HR in Experiment 2 (see Experiment 2, Methods). Hence, the ANOVA with task and time as independent variables was repeated with SCR as the dependent variable in Experiment 2. ANOVAs were performed with time (baseline, post-speech and post-discussion) as the independent variable and positive mood and negative mood as the dependent variables to test the fifth hypothesis. The Greenhouse-Geisser correction was applied when the sphericity assumption was violated. Analyses were performed in SPSS, version 24.

Results

Group comparisons of demographic characteristics, schizotypy and HR during the social stress test

The high positive schizotypal group had higher overall schizotypal traits, Unusual Experiences, Cognitive Disorganisation and Impulsive Non-conformity than the mild-to-moderate positive schizotypal group (Table 1). The high positive schizotypal group had significantly higher HR at each epoch from 31 s to 180 s of the discussion than the mild-to-moderate positive

schizotypal group. The group difference remained significant after covarying for Cognitive Disorganisation at 61-90 s, F (1, 24)=3.14, p=0.044 and at 121-150 s, F (1, 24)=3.93, p=0.029. The group differences were no longer significant after covarying for Cognitive Disorganisation at 31-90s, F(1, 24)=2.31, p=0.07; at 91-120 s, F (1, 24)=2.93, p=0.05; and at 151-180 s, F (1, 24)=2.70, p=0.057.

Relation between schizotypal traits and HR during the discussion

At 91-120 s of the discussion, the logarithmic regression between total schizotypal traits and HR was statistically significant, R=0.36, R^2=0.13, F (1,25)=3.51, p=0.036. At 151-180 s of the discussion, the logarithmic regression between total schizotypal traits and HR was statistically significant, R=0.35, R^2=0.12, F (1, 25)=3.35, p=0.040 (Figure 2).

*** Insert Table 1 and Figure 2 about here ***

Differences in physiological arousal and mood between the public speech and informal discussion

Heart rate: An ANOVA was performed with task (speech vs. discussion) and time as within-subject factors and HR as the dependent variable. The task-by-time interaction was not significant, F (3, 144)=1.31, p=0.276, η^2=03. The main effect of task was statistically significant, F (1, 48)=10.54, p=0.002, η^2=0.15, which indicated higher HR during the speech than the discussion (Figure 3a). There was a main effect of time, F (1.7, 129.9)=19.4, p<0.001, η^2=0.251. Separate ANOVAs for each task revealed that HR changed during the discussion (6 epochs), F (3.4, 45)=4.046, p=0.006, η^2=0.08, but not the speech, F (2.5, 120.1)=1.5, p=0.223, η^2=0.03. *Post hoc*

Bonferroni-corrected pairwise comparisons revealed higher HR at 0-30 s of the discussion than at 31-60 s, t=3.14, p=0.021, Cohen's d=0.44, and 121-150 s, t=3.81, p=0.003, Cohen's d=0.54. No differences between time were observed during the speech.

Skin conductance: An ANOVA with task (speech vs. discussion) and time as within-subject factors and SCR as the dependent variable revealed a task-by-time interaction, F (3, 69)=5.51, p=0.002, η^2=0.19 (Figure 3b). In addition, the main effect of task was statistically significant, F (1, 69)=11.22, p=0.003, η^2=0.3, indicating higher SCR during the speech than the discussion. The main effect of time was not significant, F (1.1, 46.9)=2.32, p=0.139, η^2=0.09. To test the task-by-time interaction further, separate ANOVAs were performed with time as the independent variable and SCR during the speech and discussion as the dependent variables. The ANOVA with speech as the dependent variable was significant, F (1.1, 26.3)=9.99, p=0.003, η^2=0.3. *Post hoc* Bonferroni-corrected pairwise comparisons revealed change in SCR over time during the speech, with greater SCR at 0-30 s than at 31-60 s, t (23)=3.18, p=0.025, Cohen's d=0.65; 61-90 s, t (23)=3.37, p=0.016, Cohen's d=0.69; and 91-120 s, t (23)=3.16, p=0.03, Cohen's d=0.64. SCR was greater at 31-60 s than at 61-90 s, t (23)=3.08, p=0.032, Cohen's d=0.63. In addition, the ANOVA with discussion as the dependent variable was significant, F (2.2, 51.6)=5.30, p=0.006, η^2=0.19. SCR was greater at 0-30 s than at 121-150 s, t=3.26, p=0.051, Cohen's d=0.67.

Positive mood changed over time (baseline, post-speech and post-discussion), F (2, 98)=8.63, p<0.001, η^2=0.15 (Figure 3c). *Post hoc* Bonferroni-corrected pairwise comparisons revealed lower positive mood during the speech than the discussion, t (49)=-3.15, p=0.008, Cohen's d=0.45; and at baseline than the discussion, t (49)=-3.68, p=0.002, Cohen's d=0.52. Negative mood also changed over time, F (2, 98)=15.7, p <0.001, η^2=0.24. *Post hoc* Bonferroni-corrected pairwise comparisons revealed greater negative mood during the speech than the

discussion, t (49)=5.37, p<0.001, Cohen's d=0.759, and at baseline than the discussion, t (49)=4.5, p<0.001, Cohen's d=0.64.

*** Insert Figure 3 about here ***

Discussion

The first experiment tested the hypotheses that (1) physiological arousal would be higher in people with between high, than and mild-to-moderate, positive schizotypal traits during a social stress test, (2) disorganised schizotypy would account for the group differences in HR during an informal discussion, and (3) the relation of schizotypy to physiological arousal from social stress would be non-linear. The first hypothesis was supported. As hypothesised, HR was higher in the group with high schizotypal traits than the group with mild-to-moderate schizotypal traits during from 31 s to 150 s of the discussion. This relationship was absent from the public speaking stage of the social stress test. Hence, schizotypy may affect social stress in close social interaction more than performance situations. Social interactions, such as delivering a public speech, have anticipation (the minute before the interaction), confrontation (first minute) and adaptation stages (last minute) (Sawyer & Behnke, 2002). Having higher HR during the discussion in the high schizotypal traits group would suggest that people with high schizotypal traits have difficulty acclimatising to a close interaction with strangers. People with high schizotypal traits may continue to feel nervous and have difficulty relaxing when interacting with strangers. Individuals at a high risk of psychosis have increased HR following criticism from a stranger which constitutes communication in an interpersonal situation (Weintraub, et al., 2019). Being sensitized to criticism

and rejection, people with high schizotypal traits may anticipate more social threat than normal in interpersonal interaction situations (Premkumar, Dunn, Onwumere, & Kuipers, 2019; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018). People with high positive schizotypal traits may have also found the informal nature of the discussion particularly stressful because of their propensity for anomalous experiences. The topic for the informal discussion was one's favourite hobbies which is of a more personal nature than the topic of one's favourite subject in school for the public speech. The personal nature of the discussion could have elicited further anxiety. The finding concerning the second hypothesis supports this view. As hypothesised, disorganised schizotypy fully accounted for differences in HR between the high and mild-to-moderate positive schizotypal groups at early and late stages of the informal discussion. This finding supports the view that disorganized schizotypy accounts for the distress in positive schizotypy (Grant & Hennig, 2019). Engaging in a discussion with a stranger may require more cognitive control than just "giving a prepared speech", as holding a discussion involves following a conversation and interacting with others. Thus, the informal discussion may have emphasised the cognitive difficulties found in disorganised schizotypy.

The third hypothesis was supported. There was a non-linear relationship between schizotypy and HR during the middle-to-late stages of the discussion. An inverted U-shaped pattern of physiological arousal from stress is also seen in social anxiety, extraversion and neuroticism (Burkhard & Wolfgang, 1992; Sapolsky, 2015; Werre, 1987; Pujol, et al., 2013). Physiological arousal during an informal discussion with strangers may co-vary linearly with mild-to-moderate schizotypal traits but reach a plateau at a high level of schizotypal traits owing to emotional dysregulation during close social interaction at a high level of schizotypal traits (Collip, et al., 2013). A larger sample of n=25 of people with mild-to-moderate schizotypal traits would

have 80% power to test a linear relation between mild-to-moderate schizotypal traits and HR during a discussion.

Differences in HR, SCR and mood changes between the speech and informal discussion

As hypothesised, HR and SCR were higher during the public speech than the informal discussion. Furthermore, HR and SCR were higher at the confrontation stage (0-30 s) than at the adaptation stage (121-150 s) of the discussion task. HR is highest at the confrontation stage of social situations because people habituate to the social stressor following sensitization (Sawyer & Behnke, 2002). The lower physiological arousal during the discussion than the public speech and the time signature of the change in physiological arousal suggest that the discussion is a suitable control task. SCR was also higher at the start of the speech than at later stages. The findings also supported the hypothesis that positive mood would be lower, whereas negative mood would be higher following the public speech compared to the discussion. These results suggest that an informal discussion is suitable as a valid control task for the speech task because of the control task having lower physiological arousal than the experimental task (Giles, Mahoney, Brunyé, Taylor, & Kanarek, 2014). Future testing should counterbalance the task order to account for differences in task difficulty. It is possible that any difference in response between the two paradigms may be due to participant receiving verbal and non-verbal feedback (which is potentially rewarding) during the informal discussion. Although the panel maintained a neutral stance, the reciprocal nature of the discussion could have contributed towards improvement in mood during the informal discussion.

Experiment 2

Having multiple measures of physiological arousal improves the validity of a possible relationship between schizotypy and social stress. SCR is another sensitive measure of physiological arousal besides HR (Coren & Bill Mah, 1993; Rozenman, Vreeland, & Piacentini, 2017). Emotional arousal tasks elicit heightened SCR across the psychosis continuum (Kring & Moran, 2008). Having a high level of positive schizotypal traits coincides with having greater SCR when watching aversive pictures (Ragsdale, Mitchell, Cassisi, & Bedwell, 2013) and hearing innocuous acoustic tones (Allen, Freeman, & McGuire, 2007). Hence, the second experiment measured SCR and HR in response to social stress.

Experiment 1 found that disorganised schizotypy explained the difference in physiological arousal between high and mild-to-moderate positive schizotypal groups. Disorganised schizotypy includes social anxiety which could specifically explain the relationship between positive schizotypy and increased SCR from social stress. Social anxiety is an intense fear of being rejected, embarrassed or humiliated in social and performance situations (American Psychiatric Association, 2000). People with social anxiety avoid seeing positive and negative facial expressions before delivering a speech (Mansell, Clark, Ehlers, & Chen, 1999; Singh, Capozzoli, Dodd, & Hope, 2015). People with social anxiety are vigilant for rejection and expect to be accepted more than people with low social anxiety (Harrewijn, van der Molen, van Vliet, Tissier, & Westenberg, 2018). Anxiety in disorganised schizotypy could affect close interaction with strangers more than a public speech. Anxiety and neuroticism explain the relationship between mild-to-moderate schizotypal traits and vigilance for rejection (Kwapil, Brown, Silvia, Myin-Germeys, & Barrantes-Vidal, 2012; Premkumar, et al., 2015). Disorganised schizotypy also comprises distress because O-LIFE

Cognitive Disorganisation, its psychometric measure, includes items about neuroticism. Items about neuroticism within the Cognitive Disorganisation subscale of the O-LIFE explain the relationship between disorganised schizotypy and a blunted cortisol response to the TSST (Grant & Hennig, 2018). Engaging in a discussion with strangers may expose features of disorganised schizotypy, including maintaining cognitive control over the direction of the conversation, difficulties with speech expression and comprehension, and discomfort when speaking on topics of a personal nature.

The first aim of this experiment was to test (1) the linear relation of mild-to-moderate schizotypal traits to multiple indices of physiological arousal during a social stress test, and (2) the role of social anxiety in disorganised schizotypy in this relationship. It was hypothesised that:

1. Mild-to-moderate schizotypal traits will relate to greater physiological arousal (HR and SCR) during social stress, and
2. Disorganised schizotypy as social anxiety will explain the relation between mild-to-moderate positive schizotypal traits and physiological arousal in a close interaction.

Methods

Participants

Twenty-four participants (mean age = 24.4 years, S.D. = 9.5, range = 20 to 57) were recruited from the University student population by social networking and advertising the experiment in the psychology department in return for research credits. A third of the sample (n = 16) was female. Participants who scored ⩽13 out of 74 on the SPQ total were classed as having mild-to-moderate schizotypal traits. A score below 13 on the SPQ denotes the 90th percentile of schizotypal traits in the healthy population with the local region (Castro & Pearson, 2011),

Assessments

Schizotypal Personality Questionnaire (SPQ) (Raine, 1991): The SPQ has 74 items to which participants respond 'Yes' or 'No'. The SPQ was used instead of the O-LIFE, because the SPQ contains nine subscales that are based on the diagnostic criteria of Schizotypal Personality Disorder (Asai, Sugimori, Bando, & Tanno, 2011; Oezgen & Grant, 2018). Hence, it is possible to examine these finer constructs in relation to physiological arousal (Table 2). These subscales combine into the three dimensions of schizotypal traits, namely Cognitive-Perceptual (positive schizotypy), Interpersonal (social anxiety, no close friend) and Disorganised (odd speech and behaviour). However, the SPQ is less adept at measuring psychometrically-defined schizotypy than the O-LIFE (Oezgen & Grant, 2018). The internal reliability of the three main subscales in the current sample ranges from poor to acceptable, having Cronbach's α values of 0.55, 0.83 and 0.72 respectively.

Leibowitz Social Phobia Scale (LSPS) – self-report version (Liebowitz, 1987; Safran, et al., 1999): The scale measures anxiety and avoidance in 11 social interaction situations and 13 performance-related situations, resulting in four subscales, namely Social Interaction-related Anxiety and Social Interaction-related Avoidance, Performance-related Anxiety and Performance-related Avoidance. Participants rate each item on anxiety and avoidance (0 = none to 3 = severe). The subscales have good internal reliability in the current sample, with Cronbach's α values of 0.81, 0.81, 0.87 and 0.88 respectively.

HR and SCR measurement

HR and SCR were recorded from a Biopac MP160 system with a Bionomadix wireless photoplethysmograph. HR was recorded from a pulse transducer placed on the fifth-digit finger of the left hand that recorded the pulse pressure waveform. SCR was recorded from Ag/AgCl electrodes placed on the second-digit and third-digit fingers of the left hand that were connected to an SCR amplifier. HR and SCR data were recorded at 75 kiloHz and transmitted to the AcqKnowledge computer software (Nassar, Elsamahy, Awadallah & Elmahalawy, 2018). HR was measured as the peak-to-peak intervals of the heartbeat. HR was calculated as the number of heart beats per minute (Weintraub, et al., 2019) and averaged over 30 s epochs (Owens & Beidel, 2015). SCR was calculated as the absolute conductance averaged over 30 s epochs (Öhman, 1981, p. 91).

Procedure

The experiment was approved by the University's School of Social Sciences research ethics committee. Participants gave informed consent and proceeded to complete the self-report assessments. The social stress test was administered identically to that of experiment 1. Participants rated the PANAS before and after the public speech and the informal discussion.

Statistical analyses

One-tailed Pearson correlations between schizotypy and physiological arousal tested the first hypothesis. A mediation analysis (Baron & Kenny, 1986) tested the second hypothesis. Zero-order correlations first tested for statistically significant relations among SPQ-Cognitive-Perceptual (the predictors), SPQ-social anxiety, SPQ-odd speech and LSPS-Social Interaction Anxiety (the mediators) and the physiological responses (the outcome variable). Mediation

analyses were performed with SPQ-Cognitive-Perceptual as the predictor (X), SPQ-social anxiety, SPQ-Odd Speech and LSPS-Social Interaction Anxiety as the mediators (M), and HR at 0-30 as the outcome variable (Y). HR at 0-30 s alone was used as the outcome variable because it correlated with schizotypal traits and LSPS-Social Interaction Anxiety (see results). SPQ Disorganised does not denote 'true' disorganised schizotypy; disorganised schizotypy is best captured by O-LIFE Cognitive Disorganisation (Oezgen & Grant, 2018). Instead, many items from the Social Anxiety and Odd speech subscales of the SPQ feature in the 'adjusted factor' for disorganised schizotypy (Oezgen & Grant, 2018). Hence, the SPQ-Odd Speech subscale of Disorganised dimension alone was used in the mediation analyses. The mediation analyses were performed using PROCESS, version 3.3 (Hayes, 2018).

Results

Total SPQ and all three SPQ dimensions were correlated with HR at 0-30 s of the discussion (Table 2). SPQ Cognitive-Perceptual was also correlated with HR at 31-60 s of the discussion. Magical thinking, a subscale of the SPQ Cognitive-Perceptual dimension, was correlated with HR at 31-60 s, 91-120 s and 121-150 s of the discussion. Unusual experiences, another subscale of the SPQ Cognitive-Perceptual dimension, was correlated with HR at 0-30 s, 31-60 s, 61-90 s and 151-180 s of the discussion. LSPS – Social Interaction Anxiety was correlated with total SPQ and the Interpersonal and Disorganised SPQ dimensions, the Magical Thinking, Suspiciousness, Social Anxiety, Odd or Eccentric Behaviour and Odd Speech subscales of the SPQ, and HR at 0-30 s and 31-60 s of the discussion. A mediation analysis with SPQ Cognitive-Perceptual as the predictor variables, SPQ-Social Anxiety, SPQ-Odd Speech and LSPS-Social Interaction Anxiety as

mediators and HR at 0-30 s of the discussion as the outcome variable was performed (Table 3). The mediators fully mediated the relation between SPQ Cognitive-Perceptual and HR at 0-30 s of the discussion.

Total SPQ, the Cognitive-Perceptual dimension and its subscale of Referential Thinking, and the Interpersonal dimension and its subscale of No Close Friends correlated with greater SCR at each epochs of the discussion from 31 to 180 s of the discussion. LSPS-Social Interaction Anxiety correlated with greater SCR at 31-120 s of the speech.

*** Insert Tables 2 and 3 about here ***

Discussion

This is the first experiment to our knowledge to study the relationship between mild-to-moderate schizotypal traits and physiological arousal during a social stress test and the role of social anxiety in this relationship. As hypothesised, a linear relationship between mild-to-moderate schizotypal traits and physiological reactivity to social interaction was found. The relationship between schizotypy and social stress is linear when examining mild-to-moderate schizotypy. Social anxiety and odd speech fully mediated the relation between positive schizotypy and HR at 0-30 seconds. Greater overall schizotypy and its three dimensions, namely Cognitive-Perceptual, Interpersonal and Disorganised, related to greater HR at the start of the discussion. The Magical Thinking and Unusual Experiences subscales of SPQ-Cognitive-Perceptual related to greater HR from 31 s to 180 s of the discussion. The subscales of Referential Thinking and No Close Friends related to greater SCR throughout the discussion.

The first minute of taking part in a social interaction is known as the confrontation stage. HR is highest at the confrontation stage (Sawyer & Behnke, 2002). The Cognitive-Perceptual, Interpersonal and Disorganisation dimensions of the SPQ related to greater HR at the confrontation stage of the discussion. The rise from mild to moderate levels of schizotypal traits may be associated with more stress of engaging in close social interaction with strangers. A greater level of certain positive schizotypal traits, namely Referential Thinking, Magical Thinking and Unusual Experiences, and the interpersonal trait of having No Close Friends could accompany higher HR and SCR throughout a close social interaction with strangers. Stress is characterised by difficulty relaxing, getting nervous and overreacting (Lovibond & Lovibond, 1995). Experiencing these positive and interpersonal schizotypal traits at moderate levels could make it difficult to relax with a stranger. Referential thinking is when casual external events, such as social encounters, are incorrectly interpreted as having an unusual meaning. Referential thinking could increase judgemental biases during social interaction and social anxiety (Meyer & Lenzenweger, 2009; Morrison & Cohen, 2014). Interpersonal schizotypal traits, such as having no close friends, relate to poor recognition of non-verbal cues during social interaction (Shean, Bell, & Cameron, 2007), and so related to greater perceived social threat.

Social anxiety and odd speech in disorganised schizotypy mediated the association between the positive schizotypy as measured by Cognitive-Perceptual dimension of the SPQ and HR at the beginning (0-30 s) of the discussion. This finding supports the view that disorganisation accounts for the distress in positive schizotypy (Grant & Hennig, 2019) and ‘effects of disorganised schizotypy are likely to be mis-attributed to positive/negative schizotypy’ (Grant & Hennig, 2019). The finding mirrors the mediation of the effect of positive schizotypy on physiological arousal during social interaction by disorganised schizotypy seen in Experiment 1. Among the schizotypal

dimensions, disorganised schizotypy relates most strongly to social anxiety due to sensitivity rejection, criticism and praise (Premkumar, Dunn, Onwumere, & Kuipers, 2019; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018). Hence, disorganised schizotypy may contribute towards distress and social anxiety in positive schizotypy (Oezgen & Grant, 2018). Social anxiety in disorganised schizotypy may be characterised by more confusion and nervousness in social gatherings making it hard for people with disorganised schizotypal traits to follow the conversation (Oezgen & Grant, 2018). Social anxiety due to perceiving more criticism and rejection and less praise in schizotypy may play out in casual social interactions. Latent anxiety from past social interactions, either with family or peers, may relate to increased momentary stress in casual social interactions.

Limitations and directions for future research

Physiological arousal at baseline before the social stress test was not measured. Thus, the effect of antecedent extraneous stressors on HR and SCR or increased basal physiological arousal cannot be ruled out. Participants delivered the speech while standing but engaged in the discussion while sitting which could have confounded the differences observed in physiological arousal between the speech and the discussion. Future research could include a non-social condition as an additional control task. Administering different schizotypy scales in Experiments 1 and 2 would make it difficult to directly compare the findings from both experiments. Still, both experiments showed that schizotypy relates to social stress and this relationship is consistent across measures of schizotypal traits. The absence of a relation between schizotypy and physiological arousal during the public speech contrasts with previous findings (Grant & Hennig, 2018; Walter, Fernandez, Snelling, & Barkus, 2018). The public speech task lasted for two minutes in the current

study, while the public speech task lasts for five minutes in the TSST. Participants were given five minutes to prepare the speech in the current study compared to 10 minutes in the original TSST. Furthermore, the public-speaking task may not have been as stressful in the current study as in the original TSST. The topic of the speech was more personal in the current study, i.e. about participants' favourite subject in school, compared to the original TSST which was about applying for their dream job. Future research could examine altered functioning of the hypothalamic-pituitary-adrenal cortex axis (Walter, Fernandez, Snelling, & Barkus, 2018) and the vegetative nervous systems in terms of the pituitary volume, because the pituitary volume varies with the severity of psychosis (Shah, et al., 2015) and is amenable to psychological intervention (Premkumar, et al., 2018).

Conclusion

An informal discussion with strangers is a valid control task for a public speech task in the social stress test as well as a sensitive test of social stress in schizotypy. A high level of positive schizotypal traits is characterised by heightened physiological arousal from close social interaction, namely an informal discussion. A non-linear relationship between overall schizotypal traits and HR when interacting with strangers in Experiment 1 could imply dysregulation of the vegetative nervous system in high schizotypal traits, but upregulation of the physiological arousal system in mild-to-moderate schizotypy. The findings lend support to the U-shaped relationship between arousal and stress (Sapolsky, 2015; Yerkes & Dodson, 1998). Having high positive schizotypal traits could inhibit the ability to acclimatise to informal social interaction. Such acclimatisation may be optimal in mild-to-moderate positive schizotypy, since mild-to-moderate positive schizotypal traits have a positive linear relationship with physiological arousal during social

interaction. Distress in disorganised schizotypy could account for the relationship between mild-to-moderate positive schizotypy and physiological arousal during social interaction. Benign positive schizotypy may relate to social stress because of its relationship with distress in disorganised schizotypy (Grant & Hennig, 2019). Social anxiety in disorganised schizotypy may allow stress to persist in casual social interactions with strangers. Sensitivity to criticism and rejection are forms of social anxiety that relate strongly to disorganised schizotypy (Premkumar, Dunn, Onwumere, & Kuipers, 2019; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018). Such social anxiety could heighten arousal during social interaction with strangers and disrupt optimal social interaction with strangers.

Conflict of interest

The authors declare no conflict of interest.

Statement of funding

The authors received no funding from an external source.

Authorship

Prasad Alahakoon and Madelaine Smith collected the data. All authors contributed towards the data analysis and interpretation of the results. All authors were involved in drafting, writing or revising the research report and read and approved the final version of the manuscript.

Acknowledgements

We are thankful to the reviewers for their detailed and constructive review of the manuscript and their thoughtful suggestions in improving the analyses and interpretation of the findings.

References

Öhman, A. (1981). Electrodermal activity and vulnerability to schizophrenia: a review. *Biological Psychology, 12*(2), 87-145.

Allen, A. P., Kennedy, P. J., Cryan, J. F., Dinan, T. G., & Clarke, G. (2014). Biological and psychological markers of stress in humans: Focus on the Trier Social Stress Test. *Neuroscience and Biobehavioral Reviews, 38*, 94–124.

Allen, P., Freeman, D., & McGuire, P. (2007). Slow habituation of arousal associated with psychosis proneness. *Psychological Medicine, 37*, 577–582.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders.* Washington, DC: American Psychiatric Association.

Asai, T., Sugimori, E., Bando, N., & Tanno, Y. (2011). The hierarchic structure in schizotypy and the five-factor model of personality. *Psychiatry Research, 185*, 78–83.

Balog, Z., Somlai, Z., & Kéri, S. (2013). Aversive conditioning, schizotypy, and affective temperament in the framework of the salience hypothesis. *Personality and Individual Differences*, 109–112.

Baron, R., & Kenny, D. (1986). The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Barrantes-Vidal, N., Chun, C. A., Myin-Germeys, I., & Kwapil, T. R. (2013). Psychometric schizotypy predicts psychotic-like, paranoid, and negative symptoms in daily life. *Journal of Abnormal Psychology, 122*(4), 1077-1087.

Bebbington, P., & Kuipers, L. (1994). The predictive utility of expressed emotion in schizophrenia: An aggregate analysis. *Psychological Medicine, 24*(3), 707-718.

Bellack, A. S., Mueser, K. T., Wade, J., Sayers, S., & Morrison, R. L. (1992). The ability of schizophrenics to perceive and cope with negative affect. *British Journal of Psychiatry, 160*, 473–480.

Bellack, A. S., Sayers, M. D., Mueser, K. T., & Bennett, M. E. (1994). Evaluation of social problem solving in schizophrenia. *Journal of Abnormal Psychology, 106*, 371-378.

Blöte, A. W., Kint, M. J., Miers, A. C., & Westenberg, P. M. (2009). The relation between public speaking anxiety and social anxiety: A review. *Journal of Anxiety Disorders, 23*(3), 305-313.

Boesch, M., Sefidan, S., Ehlert, U., Annen, H., Wyss, T., Steptoe, A., & La Marca, R. (2014). Mood and autonomic responses to repeated exposure to the Trier Social Stress Test for Groups (TSST-G). *Psychoneuroendocrinology, 43*, 41-51.

Bradley, A. J., & Dinan, T. G. (2010). A systematic review of hypothalamic–pituitary–adrenal axis function in schizophrenia: implications for mortality. *Journal of Psychopharmacology, 24*(11), 91–118.

Brosey, E., & Woodward, N. (2015). Schizotypy and clinical symptoms, cognitive function, and quality of life in individuals with a psychotic disorder. *Schizophrenia Research, 166*(1-3), 92-97.

Burkhard, B., & Wolfgang, B. (1992). The arousal-activation theory of extraversion and neuroticism: A systematic analysis and principal conclusions. *Advances in Behaviour Research and Therapy, 14*(4), 211-246.

Carlson, N. R. (2001). *Physiology of Behavior* (Vol. 7th). London: Allyn and Bacon.

Carlson, N. R., & Birkett, M. A. (2017). *Physiology of Behaviour* (Twelfth ed.). Harlow: Pearson.

Castro, A., & Pearson, R. (2011). Lateralisation of language and emotion in schizotypal personality: Evidence from dichotic listening. *Personality and Individual Differences, 51*(6), 726-731.

Ciufolini, S., Dazzan, P., Kempton, M., Pariante, C., & Mondelli, V. (2014). HPA axis response to social stress is attenuated in schizophrenia but normal in depression: Evidence from a meta-analysis of existing studies. *Neuroscience and Biobehavioral Reviews, 47*, 359-368.

Cochrane, M., Petch, I., & Pickering, A. (2010). Do measures of schizotypal personality provide non-clinical analogues of schizophrenic symptomatology? *Psychiatry Research, 176*(2-3), 150-154.

Cohen, A., Mohr, C., Ettinger, U., Chan, R., & Park, S. (2015). Schizotypy as An Organizing Framework for Social and Affective Sciences. *Schizophrenia Bulletin, 41*(Suppl 2), S427–S435.

Coleman, M. J., Levy, D. L., Lenzenweger, M. F., & Holzman, P. S. (1996). Thought disorder, perceptual aberrations, and schizotypy. *Journal of Abnormal Psychology, 105*(3), 469-473.

Collip, D., Nicolson, N. A., Lardinois, M., Lataster, T., van Os, J., & Myin-Germeys, I. (2011a). Daily cortisol, stress reactivity and psychotic experiences in individuals at above average genetic risk for psychosis. *Psychological Medicine, 41*(11), 2305-2315.

Collip, D., Oorschot, M., Thewissen, V., Van Os, J., Bentall, R., & Myin-Germeys, I. (2011b). Social world interactions: how company connects to paranoia. *Psychological Medicine, 41*, 911–921.

Collip, D., Wigman, J., Myin-Germeys, I., Jacobs, N., Derom, C., Thiery, E., . . . van Os, J. (2013). From Epidemiology to Daily Life: Linking Daily Life Stress Reactivity to Persistence of Psychotic Experiences in a Longitudinal General Population Study. *PLoS ONE, 8*(4), e62688.

Combs, D. R., Finn, J. A., Wohlfahrt, W., Penn, D. L., & Basso, M. R. (2013). Social cognition and social functioning in nonclinical paranoia. *Cognitive Neuropsychiatry, 18*(6), 531-548.

Coren, S., & Bill Mah, K. (1993). Prediction of physiological arousability: a validation of the Arousal Predisposition Scale. *Behaviour research and therapy, 31*(2), 215 -219.

Day, S., & Peters, E. (1999). The incidence of schizotypy in new religious movements. *Personality and individual differences, 27*, 55-67.

Day, T. (2005). Defining stress as a prelude to mapping its neurocircuitry: No help from allostasis. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 29*, 1195 – 1200.

Dickerson, S. S., & Kemeny, M. E. (2004). cute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychological Bulletin, 130*, 355-391.

Fonseca-Pedrero, E., Debbané, F., Ortuño-Sierra, J., Chan, R. C., Cicero, D. C., Zhang, L. C., . . . Jablensky, A. (2018). The structure of schizotypal personality traits: A cross-national study. . *Psychological Medicine, 48*, 451-462.

Fonseca-Pedrero, E., Ortuño-Sierra, J., De Álbeniz, M., & Cohen, A. (2017). A latent profile analysis of schizotypal dimensions: Associations with psychopathology and personality. *Psychiatry Research, 253*, 110-115.

Fumero, A., Marrero, R. J., & Fonseca-Pedrero, E. (2018). Well-being in schizotypy: The effect of subclinical psychotic experiences. *Psichothema, 30*(2), 177-182.

Giles, G. E., Mahoney, C. R., Brunyé, T. T., Taylor, H. A., & Kanarek, R. B. (2014). Stress effects on mood, HPA axis, and autonomic response: comparison of three psychosocial stress paradigms. *PloS One, 9*(12), e113618.

Goberman, A. M., Hughes, S., & Haydock, T. (2011). Acoustic characteristics of public speaking: Anxiety and practice effects. *Speech Communication, 53*(6), 867-876.

Grant, P., & Beck, A. (2009). Evaluation sensitivity as a moderator of communication disorder in schizophrenia. *Psychological Medicine, 39*(7), 1211-1219.

Grant, P., & Hennig, J. (2018). Stress induced cortisol release and schizotypy - The importance of cognitive slippage and neuroticism. *Psychoneuroendocrinology, 96*, 142.

Grant, P., & Hennig, J. (2019). Schizotypy, social stress and the emergence of psychotic-like states - a case for benign schizotypy? *Schizophrenia Research*.

Grant, P., Green, M. J., & Mason, O. J. (2018). Models of Schizotypy: The Importance of Conceptual Clarity. *Schizophrenia Bulletin, 44*(2), S556–S563.

Green, M. J., & Phillips, M. L. (2004). Social threat perception and the evolution of paranoia. *Neuroscience and Biobehavioral Reviews, 28*(3), 333-342.

Hanssen, M., Bak, M., Bijl, R., & Vollebergh, W. (2005). The incidence and outcome of subclinical psychotic experiences in the general population. *British Journal of Clinical Psychology, 44*, 181-191.

Harrewijn, A., van der Molen, M. J., van Vliet, I. M., Tissier, R. L., & Westenberg, P. M. (2018). Behavioral and EEG responses to social evaluation: A two-generation family study on social anxiety. *NeuroImage: Clinical, 17*, 549–562.

Harrow, M., Sands, J. R., Silverstein, M. L., & Goldberg, J. F. (1997). with more debilitating effects than other psychotic disorders. *Schizophrenia Bulletin, 23*(2), 287–303.

Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis* (2nd Edition ed.). London: Guildford Press.

Heimberg, R. G., Holt, G. S., Schneir, F. R., Spitzer, R. L., & Liebowitz, M. R. (1993). The issue of subtypes in the diagnosis of social phobia. *Journal of Anxiety Disorders, 7*, 249–269.

Heimberg, R., Hope, D., Dodge, C., & Becker, R. (1990). DSM-III-R subtypes of social phobia: Comparison of generalized social phobics and public speaking phobics. *Journal of Nervous and Mental Disease, 173*, 172-179.

Henze, G. I., Zänkert, S., Urschler, D. F., Hiltl, T. J., Kudielka, B. M., Pruessner, J. C., & Wüst, S. (2017). Testing the ecological validity of the Trier Social Stress Test: Association with real-life exam stress. *Psychoneuroendocrinology, 75*, 52–55.

Het, S., Rohleder, N., Schoofs, D., Kirschbaum, C., & Wolf, O. (2009). Neuroendocrine and psychometric evaluation of a placebo version of the 'Trier Social Stress Test'. *Psychoneuroendocrinology, 34*(7), 1075-1086.

Horan, W., & Blanchard, J. (2003). Emotional responses to psychosocial stress in schizophrenia: the role of individual differences in affective traits and coping. *Schizophrenia Research*, 271-283.

Horton, L. E., Barrantes-Vidal, N., Silvia, P. J., & Kwapil, T. R. (2014). Worries about being judged versus being harmed: disentangling the association of social anxiety and paranoia with schizotypy. *PLoS ONE, 9*(6), e96269.

Hughes, A. A., Heimberg, R. G., Coles, M. E., Gibb, B. E., Liebowitz, M. R., & Schneier, F. R. (2006). Relations of the factors of the tripartite model of anxiety and depression to types of social anxiety. *Behaviour Research and Therapy, 44*(11), 1629-1641.

Karcher, N., & Glenn, S. (2012). Magical ideation, schizotypy and the impact of emotions. *Psychiatry Research, 197*(1-2), 36-40.

Kirschbaum, C., Pirke, K., & Hellhammer, D. (1993). The Trier Social Stress Test—a tool for investigating psychobiological stress responses in a laboratory setting. *28*, 76-81.

Kirschbaum, C., Strasburger, C., & Langkrär, J. (1993). Attenuated cortisol response to psychological stress but not to CRH or ergometry in young habitual smokers. *Pharmacology, Biochemistry and Behavior, 44*, 527-531.

Kring, A., & Moran, E. (2008). Emotional Response Deficits in Schizophrenia: Insights From Affective Science. *Schizophrenian Bulletin, 34*(5), 819–834.

Kuipers, E., Bebbington, P., Dunn, G., Fowler, D., Freeman, D., Watson, P., & Garety, P. (2006). Influence of carer expressed emotion and affect on relapse in non-affective psychosis. *British Journal of Psychiatry, 188*, 173-179.

Kwapil, T., Brown, L., Silvia, P., Myin-Germeys, I., & Barrantes-Vidal, N. (2012). The expression of positive and negative schizotypy in daily life: an experience sampling study. *Psychological Medicine, 42*, 2555–2566.

Lange, C., Deutschenbaur, L., Borgwardt, S., Lang, U., Walter, M., & Huber, C. (2017). Experimentally induced psychosocial stress in schizophrenia spectrum disorders: A systematic review. *Schizophrenia Research, 182*, 4-12.

Lazarus, R., & Folkman, S. (1984). *Stress, Appraisal, and Coping.* New York: Springer Publishing Company.

Leff, J., & Vaughn, C. E. (1985). The Expressed Emotion Scales. In J. Leff, C. E. Vaughn, J. Leff, & C. E. Vaughn (Eds.), *Expressed emotion in families: Its significance for mental illness* (pp. 37-63). London: Guidlford Press.

Liebowitz, M. (1987). Social Phobia. *Modern problems in pharmacopsychiatry, 22*, 141-173.

Loas, G., Dimassi, H., Monestes, J., & Yon, V. (2013). Criterion Validity of the Cognitive Slippage and Schizotypal Ambivalence Scales. *Psychological Reports, 113*(3), 930-934.

Lovibond, S., & Lovibond, P. (1995). *Manual for the depression, anxiety and stress scales, 2nd ed.* Sydney: Psychology Foundation.

Lysaker, P., Salvatore, G., Grant, M., Procacci, M., Olesek, K., Buck, K., . . . Dimaggio, G. (2010). Deficits in theory of mind and social anxiety as independent paths to paranoid features in schizophrenia. *Schizophrenia Research, 124*(1), 81-85.

Mannuzza, S., Schenier, F. R., Chapman, T. F., Liebowitz, M. R., Klein, D. F., & Fyer, A. J. (1995). Generalized social phobia: Reliability and validity. *Archives of General Psychiatry, 52*, 230–237.

Mansell, W., Clark, D. W., Ehlers, A., & Chen, Y. P. (1999). Social anxiety and attention away from emotional faces. *Cognition and Emotion, 13*, 673-690.

Mason, O., & Claridge, G. (2006). The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE): Further description and extended norms. *Schizophrenia Research, 82*, 203-211.

Mason, O., Claridge, G., & Jackson, M. (1995). New scales for the assessment of schizotypy. *Personality and Individual Differences, 18*(1), 7-13.

Mason, O., Claridge, G., & Jackson, M. (1995). New scales for the assessment of schizotypy. *Personality and Individual Differences, 18*, 7–13.

Mcnally, R., Lasko, N., Clancy, S., Macklin, M., Pitman, R., & Orr, S. (2004). Psychophysiological Responding During Script-Driven Imagery in People Reporting Abduction by Space Aliens. *Psychological Science, 15*(7), 493-497.

Meehl, P. (1962). Schizotaxia, schizotypy, schizophrenia. *American Psychologist, 17*, 827-838.

Meyer, E. C., & Lenzenweger, M. F. (2009). The specificity of referential thinking: A comparison of schizotypy and social anxiety. *Psychiatry Research, 165*, 78–87.

Miller, A., & Lenzenweger, M. (2012). Schizotypy, Social Cognition, and Interpersonal Sensitivity. *Personality Disorders: Theory, Research, and Treatment, 3*(4), 379–392.

Morrison, S. C., & Cohen, A. S. (2014). The moderating effects of perceived intentionality: exploring the relationships between ideas of reference, paranoia and social anxiety in schizotypy. *Cognitive Neuropsychiatry, 19*(6), 527-539.

National Insitute of Health and Care Excellence. (2016). *Psychosis and Schizophrenia in Children and Young People: Recognition and Management CG155.* National Institute of Health and Care Excellence.

Naughton, M., Dinan, T. G., & Scott, L. V. (2014). Corticotropin-releasing hormone and the hypothalamic-pituitary-adrenal axis in psychiatric disease. *Handbook of Clinical Neurology, 124*, 69-91.

Nuechterlein, K. H., & Dawson, M. E. (1984). A Heuristic Vulnerability/Stress Model of Schizophrenic Episodes. *Schizophrenia Bulletin, 10*(2), 300-312.

Oezgen, M., & Grant, P. (2018). Odd and disorganized–Comparing the factor structure of the three major schizotypy inventories. *Psychiatry Research, 267*, 289-295.

Owens, M. E., & Beidel, D. C. (2015). Can virtual reality effectively elicit distress associated with social anxiety disorder? *Journal of Psychopathology and Behavioral Assessment, 37*, 296-305.

Pallanti, S., Quercioli, L., & Hollander, E. (2004). Social anxiety in outpatients with schizophrenia: A relevant cause of disability. *American Journal of Psychiatry, 161*, 53–58.

Pechey, R., & Halligan, P. (2012). *Prevalence and correlates of anomalous experiences in a large non-clinical sample, 85*(2), 150-162.

Phillips, L., & Seidman, L. (2008). Emotion Processing in Persons at Risk for Schizophrenia. *Schizophrenia Bulletin, 34*(5), 888-903.

Pisano, S., Catone, G., Pascotto, A., Iuliano, R., Tiano, C., Milone, A., . . . Gritti, A. (2016). Paranoid Thoughts in Adolescents with Social Anxiety Disorder. *Child Psychiatry & Human Development, 47*(5), 792-798.

Preacher, K. J., & Leonardelli, G. J. (2003). *Calculation for the Sobel test*. Retrieved October 2019, from http://www.psych.ku.edu/preacher/ sobel/sobel.htm

Premkumar, P., Bream, D., Sapara, A., Fannon, D., Anilkumar, A. P., Kuipers, E., & Kumari, V. (2018). Pituitary volume reduction in schizophrenia following cognitive behavioural therapy. *Schizophrenia Research, 192*, 416-422.

Premkumar, P., Dunn, A., Onwumere, J., & Kuipers, E. (2019). Perceived criticism and perceived praise predict schizotypy in the non-clinical population: The role of affect and perceived expressed emotion. *European Psychiatry*.

Premkumar, P., Onwumere, J., Albert, J., Kessel, D., Kumari, V., Kuipers, E., & Carretié, L. (2015). The relation between schizotypy and early attention to rejecting interactions: The influence of neuroticism. *World Journal of Biological Psychiatry, 16*(8), 587-601.

Premkumar, P., Onwumere, J., Betts, L., Kibowski, F., & Kuipers, E. (2018). Schizotypal traits and their relation to rejection sensitivity in the general population: Their mediation by quality of life, agreeableness and neuroticism. *267*, 201-209.

Premkumar, P., Williams, S., Lythgoe, D., Andrew, C., Kuipers, E., & Kumari, V. (2013). Neural processing of criticism and positive comments from relatives in individuals with schizotypal personality traits. *World Journal of Biological Psychiatry, 14*, 57-70.

Pruessner, M., Béchard-Evans, L., Boekestyn, L., & Iyer, S. N. (2013). Attenuated cortisol response to acute psychosocial stress in individuals at ultra-highrisk for psychosis. *Schizophrenia Research, 146*, 79-86.

Pujol, J., Giménez, M., Oritz, H., Soriano-Mas, C., López-Solà, M., Farré, M., . . . Martín-Santos, R. (2013). Neural response to the observable self in social anxiety disorder. *Psychological Medicine, 43*(4), 721-731.

Ragsdale, K., Mitchell, J., Cassisi, J., & Bedwell, J. (2013). Comorbidity of schizotypy and psychopathy: Skin conductance to affective pictures. *Psychiatry Research, 210*(3), 1000-1007.

Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*, 556-564.

Raine, A., Reynolds, C., Lencz, T., Screbo, A., Triphon, N., & Kim, D. (1994). Cognitive-Perceptual, Interpersonal, and Disorganized Features of Schizotypal Personality. *Schizophrenia Bulletin, 20*(1), 191-201.

Rasia-Filho, A. A. (2006). Is there anything “autonomous” in the nervous system? *Advances in Physiology Education, 30*, 9-12.

Rawlings, D., & Freeman, J. (1996). A questionnaire for the measurement of paranoia/suspiciousness. *British Journal of Clinical Psychology, 35*(3), 451-461.

Rossell, S. L., Chong, D., O'Connor, D. A., & Gleeson, J. F. (2014). An investigation of gender differences in semantic processing in individuals with high schizotypy. *Psychiatry Research, 215*(2), 491-493.

Rozenman, M., Vreeland, A., & Piacentini, J. (2017). Thinking anxious, feeling anxious, or both? Cognitive bias moderates the relationship between anxiety disorder status and sympathetic arousal in youth. *Journal of Anxiety Disorders, 45*, 34-42.

Safran, S., Heimberg, R., Homer, K., Juster, H., Schneier, F., & Liebowitz, M. (1999). Factor Structure of Social Fears: The Liebowitz Social Anxiety Scale. *Journal of Anxiety Disorders, 13*(3), 253-270.

Sapolsky, R. (2015). Stress and the brain: Individual variability and the inverted-U. *Nature neuroscience, 18*(10), 1344-1346.

Sawyer, C., & Behnke, R. (2002). Reduction in public speaking state anxiety during performance as a function of sensitization processes. *Communication Quarterly, 50*(1), 110-121.

Schizophrenia Commission. (2013). *The Abandoned Illness: A Report by the Schizophrenia Commission. 2012.* Rethink Mental Illness.

Schlosser, D., Zinberg, J., Loewy, R., Casey-Cannon, S., O'Brien, M., & Bearden, C. (2010). Predicting the longitudinal effects of the family environment on prodromal symptoms and functioning in patients at-risk for psychosis. *Schizophrenia Research, 118*, 69-75.

Schultze-Lutter, F., Nenadic, I., & Grant, P. (2019). Psychosis and schizophrenia-spectrum personality disorders require early detection on different symptom dimensions. *Frontiers in Psychiatry, 10*(476).

Shah, J., Tandon, N., Howard, E., Mermon, D., Miewald, J., Montrose, D., & Keshavan, M. (2015). Pituitary volume and clinical trajectory in young relatives at risk for schizophrenia. *Psychological Medicine, 45*(13), 2813–2824.

Shean, G., Bell, E., & Cameron, C. D. (2007). Recognition of nonverbal affect and schizotypy. *Journal of Psychology, 141*(3), 281–291.

Singh, J., Capozzoli, M., Dodd, M., & Hope, D. (2015). The Effects of Social Anxiety and State Anxiety on Visual Attention: Testing the Vigilance–Avoidance Hypothesis. *Cognitive Behaviour Therapy*, 1-12.

Tan, E. J., & Rossell, S. L. (2017). Disorganised schizotypy is selectively associated with poorer semantic processing in non-clinical individuals. *Psychiatry Research, 256*, 249-252.

Tompson, M. C., Asarnow, J. R., Hamilton, E. B., Newell, L. E., & Goldstein, M. J. (1997). Children with schizophrenia-spectrum disorders: Thought disorder and communication problems in a family interactional context. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 38*(4), 421-429.

Waldeck, T. L., & Miller, L. S. (2000). Social skills deficits in schizotypal personality disorder. *Psychiatry Research, 93*, 237-246.

Walter, E., Fernandez, F., Snelling, M., & Barkus, E. (2018). Stress induced cortisol release and schizotypy. *Psychoneuroendocrinology, 89*, 209–215.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

Weintraub, M., de Mamani, A., Villano, W., Evans, T., Millman, Z., Hooley, J., & Timpano, K. (2019). Affective and physiological reactivity to emotional comments in individuals at elevated risk for psychosis. *Schizophrenia Research, 206*, 428-435.

Werre, P. F. (1987). Extraversion--Introversion, Contingent Negative Variation and Arousal. In J. Strelau, & H. J. Eysenck, *Personality Dimensions and Arousal* (pp. 59-75). New York: Plenum Press.

Yerkes, R., & Dodson, J. (1998). The relation of strength of stimuli to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18*, 459-482.

Tables

Table 1. Differences in demographic characteristics and heart rate between high and mild-to-moderate positive schizotypal traits groups in Experiment 1

	High positive schizotypal traits (n=16) Mean (S.D.)	Range	Mild-to-moderate positive schizotypal traits (n=10) Mean (S.D.)	Range	F or Chi-square value (df=24)	*One-tailed p value*	Effect size, η^2
Age	26.8 (7.5)		24.2 (3.2)		1.01	0.307*	0.04
Gender: male/female	6/10		4/6		0.02	0.899*	
O-LIFE							
Unusual experiences	22.1 (3.9)	16-29	5.6 (4.1)	0-12	107.79	**<0.001**	0.82
Introvertive anhedonia	10.7 (5.9)	3-20	8.4 (5.9)	5-20	0.98	0.116	0.04
Cognitive disorganisation	17.5 (5.9)	5-23	12.9 (5.1)	1-21	4.09	**0.027**	0.14
Impulsive non-conformity	12.7 (4.1)	5-19	9.2 (2.7)	6-14	5.70	**0.012**	0.19
Total	63.1 (14.5)	42-87	36.1 (11.9)	15-53	24.19	**<0.001**	0.50
		Heart rate					
Speech							
(0-30 s)	101.95 (15.35)		92.95 (20.74)		1.61	0.108	0.06
(31-60 s)	99.65 (14.72)		89.34 (22.67)		1.99	0.085	0.08
(61-90 s)	98.75 (13.77)		90.76 (23.87)		1.17	0.144	0.05
(91-120 s)	99.78 (15.37)		91.61 (21.80)		1.26	0.136	0.05
Discussion							
(0-30 s)	94.09 (12.64)		86.03 (17.71)		1.84	0.093	0.07
(31-60 s)	91.25 (13.12)		79.62 (19.13)		3.40	**0.039**	0.12
(61-90 s)	91.64 (12.87)		79.82 (15.51)		4.43	**0.023**	0.15

Table 1 continued

	High positive schizotypal traits (n=16) Mean (S.D.)	Range	Mild-to-moderate positive schizotypal traits (n=10) Mean (S.D.)	Range	F or Chi-square value (df=24)	*One-tailed p value*	Effect size, η^2
(91-120 s)	89.57 (12.10)		77.55 (15.88)		4.78	**0.019**	0.17
(121-150 s)	90.47 (12.16)		79.00 (13.95)		4.90	**0.018**	0.17
(151-180 s)	89.95 (11.89)		77.76 (18.76)		4.16	**0.026**	0.15

Values in bold indicate statistically significant group differences; * two-tailed p-values are reported.

Table 2. One-tailed Pearson correlations, *r* (*p*), between schizotypal traits (total and subscale scores of the SPQ), social anxiety and heart rate averaged over 30 s epochs during a public speech test and an informal discussion in Experiment 2

			LSPS – social interaction fear	Speech				Discussion					
	Mean (S.D.)	Range		0-30	31-60	61-90	91-120	0-30	31-60	61-90	91-120	121-150	151-180
						Heart rate							
SPQ													
Total	19.2 (9.4)	2-40	0.53**	-0.25	-0.22	0.001	-0.15	0.48**	0.36*	0.20	-0.15	0.31	0.25
Cogper	6.4 (3.1)	0-13	0.21	-0.15	-0.10	0.10	-0.08	0.42*	0.42*	0.26	-0.08	0.34	0.36*
Reference.	2.0 (1.4)	0-6	-0.19	0.09	0.15	0.26	0.15	0.07	-0.03	-0.14	0.15	0.01	-0.03
Magic.	1.6 (1.0)	0-3	0.52**	-0.51**	-0.37*	-0.15	-0.45*	0.32	0.41*	0.32	-0.45*	0.43*	0.39*
Unu. Exp.	1.5 (1.1)	0-3	-0.17	-0.005	0.03	0.18	0.26	0.37*	0.44*	0.42*	0.26	0.35*	0.48**
Suspic.	1.4 (1.3)	0-5	0.39*	-0.03	-0.13	-0.07	-0.20	0.38*	0.33	0.17	-0.20	0.18	0.20
Interper	8.3 (5.2)	0-21	0.63***	-0.25	-0.25	-0.05	-0.17	0.44*	0.33	0.16	-0.17	0.24	0.18
Soc. Anx.	3.5 (1.9)	0-8	0.82***	-0.17	-0.21	0.01	0.04	0.57**	0.48**	0.34	0.04	0.32	0.29
No Cl. Friends	1.9 (1.9)	0-7	0.38	-0.37*	-0.16	-0.02	-0.28	0.22	0.10	0.06	-0.28	0.24	0.15
Const. Affect	1.5 (1.5)	0-5	0.34	-0.14	-0.28	-0.10	-0.09	0.18	0.09	-0.15	-0.09	-0.04	-0.13
Disorg	5.8 (3.1)	1-12	0.53**	-0.20	-0.21	-0.04	-0.17	0.44**	0.26	0.16	-0.17	0.27	0.17
Ecc. Behave.	2.1 (1.7)	0-6	0.23*	-0.02	-0.09	0.01	-0.14	0.38*	0.29	0.13	-0.14	0.27	0.15
Odd Speech	3.7 (1.9)	1-7	0.52**	-0.32	-0.27	-0.08	-0.16	0.39*	0.17	0.16	-0.16	0.20	0.15
LSPS – Social Interaction Anxiety	12.2 (6.5)	1-28	1.00	-0.16	-0.16	0.16	-0.07	0.46*	0.40*	0.30	-0.07	0.27	0.33

Table 2 continued

	LSPS – social interaction fear		Speech				Discussion					
	Mean (S.D.)	Range	0-30	31-60	61-90	91-120	0-30	31-60	61-90	91-120	121-150	151-180
			Skin conductance									
SPQ												
Total			0.06	0.07	0.06	0.04	0.26	0.47*	0.48*	0.46*	0.45*	0.52**
Cogper			-0.05	-0.10	-0.09	-0.11	0.39	0.50*	0.53**	0.42*	0.48*	0.59**
Reference.			-0.16	-0.24	-0.23	-0.24	0.35	0.50*	0.52**	0.48*	0.50**	0.55**
Magiec.			0.04	0.13	0.16	0.16	0.08	0.14	0.18	0.14	0.19	0.22
Unu. xp.			-0.07	-0.24	-0.27	-0.29	0.41*	0.23	0.23	0.12	0.21	0.31
Suspic.			0.07	0.11	0.11	0.09	0.16	0.36	0.38	0.28	0.28	0.38
Interper			0.13	0.17	0.16	0.15	0.21	0.42*	0.42*	0.44*	0.41*	0.48*
Soc. Anx.			0.23	0.33	0.35	0.34	0.16	0.24	0.26	0.24	0.26	0.38
No Cl. Friends			0.03	-0.01	-0.03	-0.04	0.22	0.45*	0.48*	0.52**	0.48**	0.46*
Const. Afect			0.06	0.07	0.04	0.03	0.09	0.22	0.15	0.28	0.20	0.24
Disorg			0.04	0.07	0.05	0.04	0.13	0.38	0.37	0.36	0.32	0.36
Ecc. Behave.			-0.14	-0.12	-0.13	-0.15	-0.01	0.32	0.29	0.32	0.25	0.29
Odd Speech			0.19	0.22	0.20	0.20	0.23	0.34	0.36	0.30	0.31	0.32
LSPS – Social Interaction Anxiety			0.38	0.55**	0.58**	0.57**	0.01	0.16	0.17	0.21	0.22	0.32

Note: * $p \leq 0.05$, ** $p \leq 0.01$, $p \leq 0.001$; Cogper – Cognitive-Perceptual dimension; Const. Affect - Constricted Affect; Disorg – Disorganised dimension; Ecc. Behave. - Odd or Eccentric Behaviour; Interper – Interpersonal dimension; LSPS: Leibowitz Social Phobia Scale; Magic. - Odd Beliefs or Magical Thinking; No Cl. Friends. - No Close Friends; Suspic. – Suspiciousness; Reference. - Ideas of Reference; Soc. Anx. - Excessive Social Anxiety; SPQ: Schizotypal Personality Questionnaire; Unu. Exp. - Unusual Perceptual Experiences.

Table 3. Mediation analyses with Schizotypal Personality Questionnaire Cognitive-Perceptual as the predictor variable (X), heartrate at 0-30 s of the discussion (Y) and SPQ-Social Anxiety, SPQ-Odd Speech and Leibowitz social phobia scale (LSPS) – Social Interaction Anxiety as the mediators (M)

Mediators	a_n, X→M (p-value)	b_n, M→Y (p-value)	Indirect effect, a_n x b_n (95% C.I.)	Total effect, c (p-value)	Direct effect, c' (p-value)	Total R^2
				0.43 (0.039)	0.26 (0.065)	0.36
SPQ-Social Anxiety	0.48 (0.017)	0.40 (0.340)	0.63 (-0.94 to 2.97)			
SPQ-Odd Speech	0.58 (0.003)	-0.11 (0.700)	-0.20 (-1.56 to 0.94)			
LSPS-social anxiety	0.21 (0.333)	0.13 (0.706)	0.09 (-0.72 to 1.02)			

Footnote: Standardised coefficients are reported.

Figures title:

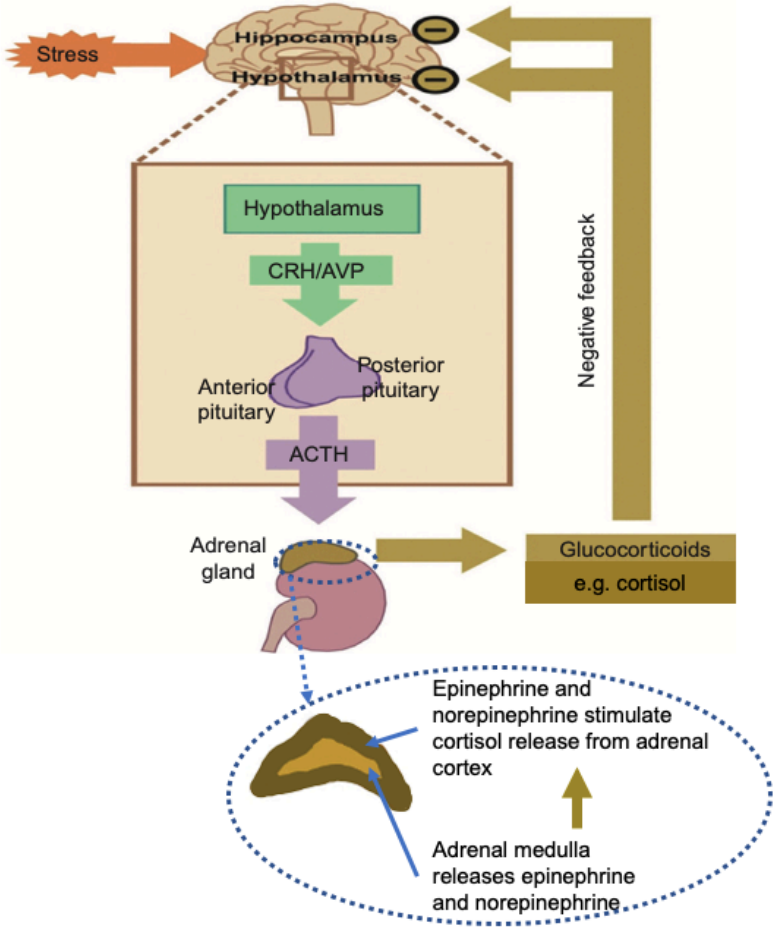
Figure 1. (a) Flow diagram of the response of the hypothalamic-pituitary-adrenal cortex (HPA) axis to stress. Taken with copyright permission from Naughton, M., Dinan, T., & Scott, L. (2014). Corticotropin-releasing hormone and the hypothalamic-pituitary-adrenal axis in psychiatric disease. *Handbook of Clinical Neurology*, 124, 69-91, and (b) the vegetative nervous system showing how the sympathetic branch increases heart rate. Taken with copyright permission from Carlson, N. R., & Birkett, M. A. (2017). Physiology of behavior (Global edition [of] twelfth ed.). Harlow: Pearson Education Limited.

Figure 2. Scatterplot showing the non-linear relation between schizotypy and HR at (a) 91-120 s and (b) 151-180 s of the discussion based on level of schizotypal traits.

Figure 3. Change in (a) HR and (b) skin conductance between 30 second epochs during the 2 min speech (solid line) and 3 min discussion (dotted line), (c) positive affect (solid line) and negative affect (dotted line) before and after the speech and discussion. Values on the trend lines are means. Values in boxes are the standard error of the mean.

Figure 1

(a)


Stress
Hippocampus
Hypothalamus
Hypothalamus
CRH/AVP
Anterior pituitary
Posterior pituitary
ACTH
Negative feedback
Adrenal gland
Glucocorticoids
e.g. cortisol
Epinephrine and norepinephrine stimulate cortisol release from adrenal cortex
Adrenal medulla releases epinephrine and norepinephrine

(b)

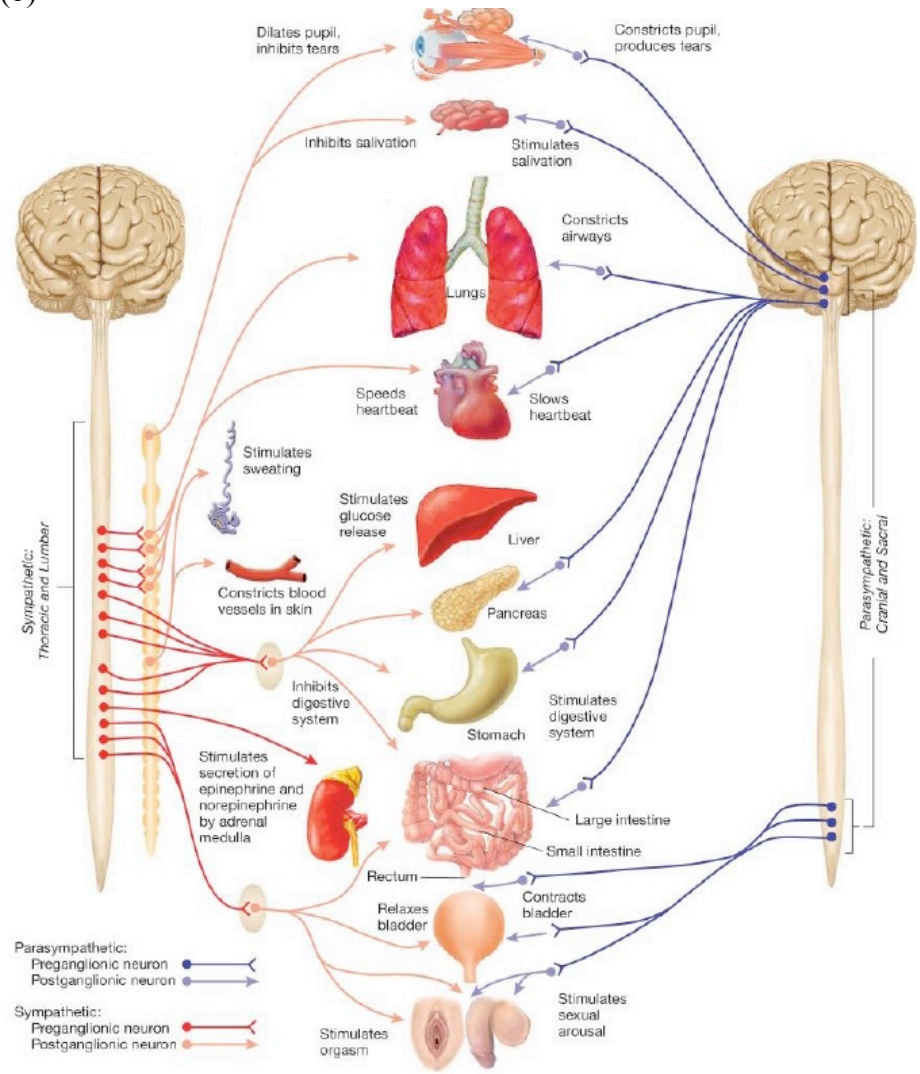

Dilates pupil, inhibits tears
Constricts pupil, produces tears
Inhibits salivation
Stimulates salivation
Constricts airways
Lungs
Speeds heartbeat
Slows heartbeat
Stimulates sweating
Stimulates glucose release
Liver
Constricts blood vessels in skin
Pancreas
Inhibits digestive system
Stomach
Stimulates digestive system
Stimulates secretion of epinephrine and norepinephrine by adrenal medulla
Large intestine
Small intestine
Rectum
Relaxes bladder
Contracts bladder
Stimulates sexual arousal
Stimulates orgasm
Sympathetic: Thoracic and Lumbar
Parasympathetic: Cranial and Sacral
Parasympathetic:
Preganglionic neuron
Postganglionic neuron
Sympathetic:
Preganglionic neuron
Postganglionic neuron

Figure 2

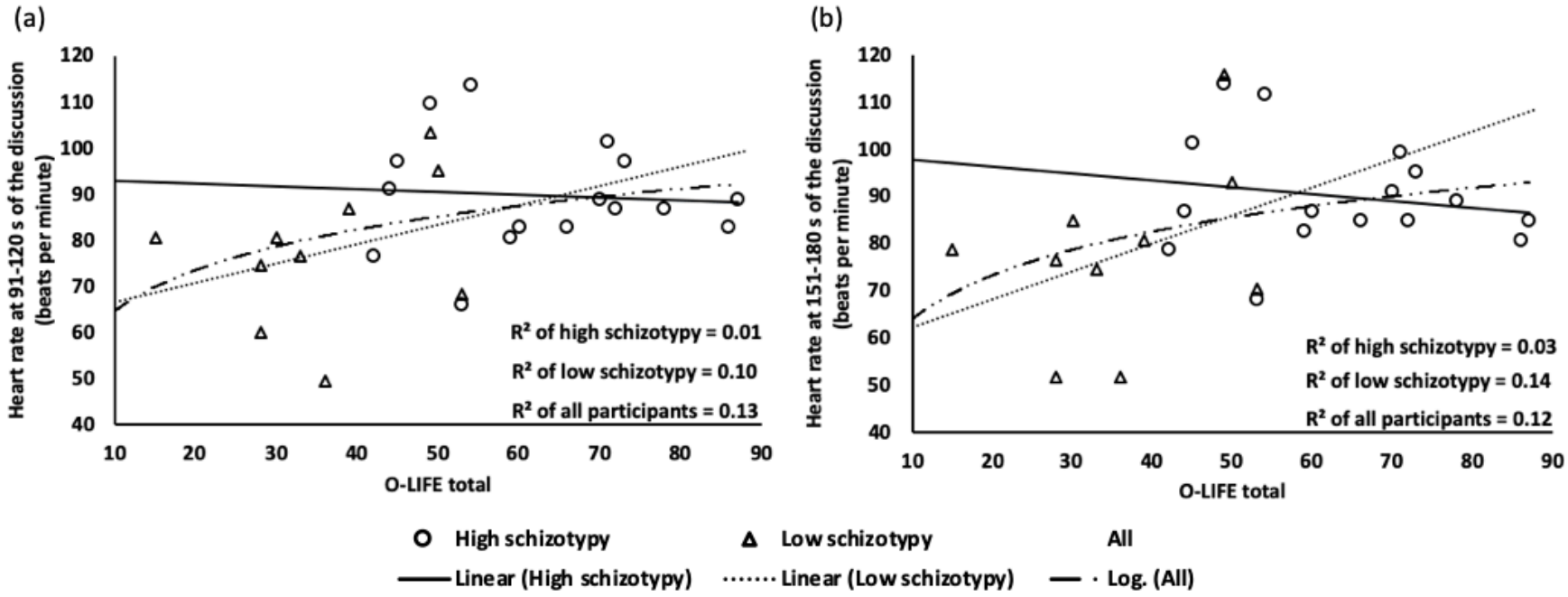
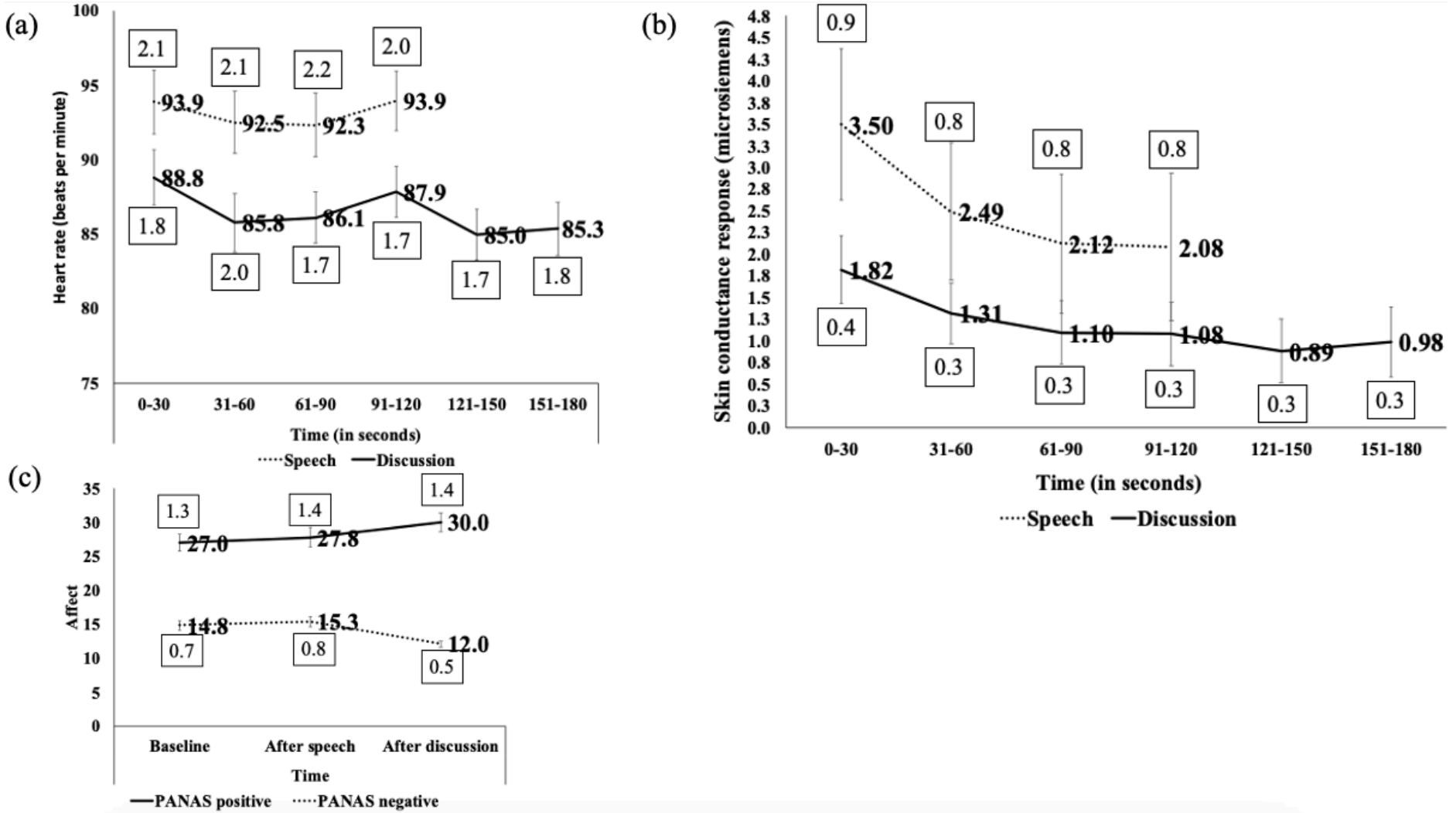

(a)
Heart rate at 91-120 s of the discussion (beats per minute)
120
110
100
90
80
70
60
50
40
10
20
30
40
50
60
70
80
90
O-LIFE total
R² of high schizotypy = 0.01
R² of low schizotypy = 0.10
R² of all participants = 0.13
(b)
Heart rate at 151-180 s of the discussion (beats per minute)
120
110
100
90
80
70
60
50
40
10
20
30
40
50
60
70
80
90
O-LIFE total
R² of high schizotypy = 0.03
R² of low schizotypy = 0.14
R² of all participants = 0.12
High schizotypy
Low schizotypy
All
Linear (High schizotypy)
Linear (Low schizotypy)
Log. (All)

Figure 3


(a)
Heart rate (beats per minute)
100
95
90
85
80
75
2.1
2.1
2.2
2.0
93.9
92.5
92.3
93.9
88.8
85.8
86.1
87.9
85.0
85.3
1.8
2.0
1.7
1.7
1.7
1.8
0-30
31-60
61-90
91-120
121-150
151-180
Time (in seconds)
Speech
Discussion
(b)
Skin conductance response (microsiemens)
4.8
4.5
4.3
4.0
3.8
3.5
3.3
3.0
2.8
2.5
2.3
2.0
1.8
1.5
1.3
1.0
0.8
0.5
0.3
0.0
0.9
0.8
0.8
0.8
3.50
2.49
2.12
2.08
1.82
1.31
1.10
1.08
0.89
0.98
0.4
0.3
0.3
0.3
0.3
0.3
0-30
31-60
61-90
91-120
121-150
151-180
Time (in seconds)
Speech
Discussion
(c)
Affect
35
30
25
20
15
10
5
0
1.3
1.4
1.4
27.0
27.8
30.0
14.8
15.3
12.0
0.7
0.8
0.5
Baseline
After speech
After discussion
Time
PANAS positive
PANAS negative