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INTRA-EXPOSURE LEVELS OF ANXIOUS AROUSAL IN A LAB-BASED EXPOSURE INTERVENTION FOR FEAR OF PUBLIC SPEAKING

by

Matteo Bugatti

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Abstract

Background. Exposure therapy is effective for addressing social anxiety and public speaking fears, yet there are differences in suggested exposure strategies among empirically supported, manualized treatments. Manualized exposure strategies differ in the relative theoretical emphasis that underpins the specific procedural approach. Some approaches rely more heavily on the principle of habituation and formal cognitive restructuring; alternative approaches emphasize inhibitory learning and the individual's response to his/her own negative emotions, while promoting present-focused awareness. Innovative process methods can shed light on the similarities and differences between these approaches. Objectives. The goal of this study was to examine differences in anxious arousal between these exposure approaches, while testing the feasibility, reliability, and validity of recently developed social sensing technology (“Sociometric Badges”) for data collection during a public speaking exposure task. Method: Data were collected from a sample of N = 66 socially anxious undergraduate students who were randomly assigned to one of two public speaking exposure conditions: (a) procedures that emphasized habituation, or (b) procedures that emphasized inhibitory learning. Sociometric badges were used to measure each participant's vocal fundamental frequency (F0), which is an indicator of anxious arousal. Participants also completed self-report measures of anxiety and emotion regulation prior to the exposure task. Results. Although F0 observations demonstrated internal consistency based on time series autocorrelations, self-report symptoms of social anxiety did not display a significant correlation with average F0. No between condition differences in average within exposure F0 were observed based on logistic regression and t-test analyses. Conclusion. Badge technology may be a useful tool for investigating exposure mechanisms. Despite theoretical differences, habituation and inhibitory learning-focused strategies appear to promote similar levels of within exposure arousal.
Intra-exposure levels of anxious arousal in a lab-based exposure intervention for fear of public speaking

Research findings spanning several decades have supported the efficacy of exposure therapy for the treatment of numerous behavioral health problems (Abramowitz, 2013; Abramowitz, Deacon, & Whiteside, 2012). Most of the extant literature has focused on the utilization of exposure strategies for the treatment of anxiety- and fear-related disorders. Specifically, exposure strategies have received strong empirical support for their efficacy in treating specific phobia, social anxiety, panic disorder, and agoraphobia (Abramowitz, Deacon, & Whiteside, 2012). In addition, a substantial body of research supports the employment of exposure strategies for the treatment of post-traumatic stress disorder, as well as obsessive-compulsive disorder (e.g., Abramowitz, 1996; Foa et al., 1995; Wald & Taylor, 2007). Finally, more recent efforts have integrated the use of exposure strategies in protocols designed for the treatment of depressive disorders (Hayes et al., 2007).

Learning

Grounded in traditional learning theory, exposure strategies evolved from Pavlovian classical conditioning theory as well as Skinnerian operant conditioning theory (Abramowitz et al., 2012; Wolpe, 1961). Pavlovian classical conditioning theory was formulated by laureate scientist Ivan Pavlov who inadvertently discovered these phenomena while conducting gastroenterological research. Pavlov found that by pairing an Neutral Stimulus (NS) with an Unconditioned Stimulus (US) that naturally elicited an Unconditioned Response (UR), the organism, following several repetitions, would begin to exhibit a Condition Response (CR), in which the UR would occur by presenting the NS alone, thus converting the NS into a Conditioned Stimulus (CS; Pavlov, 1927). Skinnerian operant conditioning, on the other hand,
shifts the emphasis from behavioral antecedents to behavioral consequences. As such, operant conditioning theory posits that the frequency of a behavior can be increased by subsequently rewarding the behavior through positive or negative reinforcement, or decreased by subsequently punishing the behavior through positive or negative punishment (Skinner, 1953). Mowrer’s (1947) two-factor theory states that learning is often a product of both types of conditioning. The lack of complete integration of these accounts underscores differences in their underlying theoretical underpinnings.

**Exposure Approaches**

Arguably, there is more agreement in the field regarding the process of extinction as a pivotal mechanism underlying new learning (Hoffmann, 2008). Based on the terminology provided by Pavlovian classical conditioning theory, extinction is the process of weakening the CS – US association. Nevertheless, diverse models have attempted to account for behavioral extinction over the decades. From this extensive body of literature, two theories appear to be more prominent based on recent writing and research, namely emotional processing theory (Foa & Kozak, 1986), and the inhibitory learning model (Craske et al., 2014). Although compatible, if not complementary, these two theories differ in the emphasis that is placed on the contribution of specific mechanisms underlying extinction learning. A theory that has gained widespread modern popularity in the field, *emotional processing* theory (Foa & Kozak, 1986; Foa, Huppert, & Cahill, 2006), posits that the principal mechanism underlying the process of exposure therapy is habituation. This mechanism is characterized by the progressive decrease in fear or anxiety that occurs in response to a stimulus resulting from repeated presentation. This process is driven by emotional processing, which involves habituation as well as the disconfirmation of threat-related beliefs, and is further composed of three separate but related phenomena: 1) the
activation of fear networks (or schemata), as indicated by increased physiological arousal as well as the psychological experience of fear (e.g., threat-related beliefs and assumptions), 2) within-session habituation, which is indicated by the gradual decrease in physiological arousal as well as psychological experience of fear, and 3) between-session habituation, as indicated by the systematic decline in fear responses across sessions.

While acknowledging the probable co-occurrence of mechanisms such as habituation, Craske et al. (2014) posits that the process of inhibitory learning is the primary mechanism responsible for the process of extinction. This theory, referred to as the inhibitory learning model, maintains that the association of conditioned and unconditioned stimuli vis-à-vis Pavlovian conditioning is not erased (i.e., unlearned), but rather bypassed through the acquisition of new associations between conditioned and unconditioned stimuli where the conditioned stimulus no longer reliably predicts the unconditioned stimulus (e.g., Bouton & King, 1983; Bouton, 1993; Craske et al., 2014). Furthermore, Craske et al. (2014) argue that the inhibitory learning model is supported by research findings that identify the integral role of the medial prefrontal cortex in inhibiting the activity of the amygdala, which is responsible for fear conditioning, following extinction learning (Milad et al, 2007; Milad et al., 2009; Shin & Liberzon, 2010).

Craske et al. (2014) provide a set of guidelines for enhancing inhibitory learning when conducting exposure, which include: 1) expectancy violation, in regard to the frequency and intensity of aversive outcomes associated with the feared stimuli, 2) deepened extinction, which is characterized by the extinction of individual conditioned stimuli before being combined in exposure strategies, 3) occasional association of conditioned and unconditioned stimuli, which redirects the focus on the conditioned stimulus by augmenting expectancy violation, 4) removal
of safety signals and behaviors, which have been found to hinder inhibitory learning (e.g., Sloan & Telch, 2002), 5) variability, which promotes the retrieval of the newly acquired information regardless of the specific context, 6) retrieval cues, which differ from safety signals as they remind the individual of the inhibitory learning experience, 7) multiple contexts, and 8) reconsolidation, which is the process of retrieving memories that are consolidated in the long term memory, in order to allow for their modification during the reconsolidation time frame (Nader, Schafe, & Le Doux, 2000).

Many behavioral treatment protocols rely heavily on exposure-based strategies (Abramowitz et al., 2012). Nevertheless, different manualized treatment protocols, each employing some form of exposure strategy, appear to rely on distinct theoretical underpinnings, varying in their relative implicit and explicit emphasis on habituation, emotional processing, and inhibitory learning. Narrowing the scope to empirically supported treatments (ESTs), or even more specifically examining cognitive-behavioral (CBT) approaches, established protocols appear to emphasize different hypothesized exposure mechanisms. For instance, the treatment protocol delineated by Hope et al. (2010) in the Managing Social Anxiety treatment manual, which is considered by many to be CBT’s gold-standard exposure procedure for the treatment of social anxiety, appears to emphasize the principle of habituation. On the other hand, a more recently developed transdiagnostic approach, the Unified Protocol for Transdiagnostic Treatment of Emotional Disorders (UP; Barlow et al., 2010), appears to emphasize inhibitory learning. Although both treatment protocols are supported by empirical evidence, there is a dearth of applied intervention research that directly compares alternative bona fide exposure procedures that differently emphasize different learning mechanisms.

**Process Research**
In line with the need to clarify mechanisms underlying exposure procedures, there has been growing attention devoted to answering the question of how psychotherapy works (Boswell, 2015). Process research often requires the employment of time-consuming and cost-prohibitive methods (e.g. psychotherapy coding, audio signal analysis, physiological response analysis), and the high resource costs have often led researchers to either scale down their work (e.g., sample a small number of sessions or segments of sessions) or to develop methodological advances that harness technology (Xiao et al., 2015). An example of such innovation is the creation of a novel electronic device, the Sociometric Badge 03-02 (Sociometric Solutions, 2013), which is a palm-sized device that gathers data on social signals (e.g., speech pattern, body movement). This portable device, which is worn around the neck with a lanyard, has been extensively utilized in business and health care settings, in order to track social and interpersonal communication patterns that are related to productivity and other outcomes.

For instance, Kim et al. (2008) utilized Sociometric badges as a feedback tool. These researchers gathered interpersonal data from group interactions that were analyzed in real-time through “Meeting Mediator” software, and then presented this information, in real-time, to group members through an electronic device. This process was found to enhance group interaction, improve group performance, and improve group satisfaction. Similarly, Wu et al. (2008) utilized Sociometric badges to gather longitudinal interpersonal data. Sociometric badges were worn by IT configuration specialists for a month during regular work hours, and the subsequent data analyses focused on delineating workers’ social network structure in face-to-face communication. The effect of cohesion (i.e., the degree to which an actor’s contacts are connected to each other) in face-to-face interactions was found to be much stronger than in electronic communication, and was positively correlated with higher worker productivity (Wu et
al., 2008). These findings were corroborated by Watanabe et al. (2012), who conducted a similar study focusing on the comparison of the effect of team activity levels and face-to-face communication on team performance. Likewise, Gloor et al. (2012) found a positive association between face-to-face interaction and creative output in teams. Finally, a pilot study conducted by Waber and Williams (2012) focusing on communication between nurses in a large hospital demonstrated a link between non-linguistic features of speech and trust. Concretely, specific patterns of speech while communicating about patients and treatment procedures were associated with increased trust.

Interpersonal process and communication variables (both conscious and unconscious) have clear relevance to psychotherapy and the face-to-face delivery of exposure interventions (e.g., communication and impacts between participants). However, Sociometric badges have never been utilized in the field of clinical psychology. To date, the small group of researchers who have studied speech and acoustic processes have relied on technologically complex and time intensive acoustic and speech analysis. Although the social sensors of interest are capable of collecting a wide range of communication indicators, a common point of convergence between traditional acoustic and speech analysis and the data collected by the Sociometric badge is the measurement of fundamental vocal frequency (F0).

F0 is defined as the lowest frequency that is produced by a periodic waveform, which in this case is produced by natural human speech (Black, 1961). Human vocal phonation (i.e., the creation of speech sounds) is characterized by the sequential opening and closing of the vocal cords in the glottis. Relative to human speech, F0 represents an objective index of the frequency of this process (Weeks et al., 2012). Several studies have also shown that F0 is a reliable indicator of anxious arousal (e.g., Andy et al., 2014) – that is, higher F0 is associated with higher
anxious arousal. For instance, Laukka et al (2008) compared intra-exposure (i.e., measured during the actual exposure task) F0 levels in patients before and after receiving pharmacological anxiolytic treatment. The results from this study indicated that decreases in reported intra-exposure anxiety were accompanied by decreases in several vocal cues, including F0. Similarly, Weeks et al. (2012) found that F0 levels were positively related to social anxiety disorder diagnostic severity. Moreover, a study conducted by Scharffstein et al. (2011) compared vocal patterns and characteristics of children with social phobia to those of children with Asperger’s syndrome. Speech in children with social phobia was characterized by distinctive vocal patterns, such as higher F0 levels.

Evoking emotional arousal is a key component of all exposure procedures. Sociometric badges could, therefore, appeal to the need for an accessible device capable of collecting data relevant to intra-exposure process. Importantly, Sociometric badges have not been used to measure F0 in clinically-relevant contexts. Consequently, there is a pressing need to examine whether or not this device is capable of reliably and validly collecting relevant exposure data. For instance, one would expect that F0 data gathered by Sociometric badges, as those collected by more traditional acoustic methodological approaches, to positively relate to measures of social anxiety severity as well as self-reported state anxiety. If found to yield reliable and valid arousal data, the near future could see the utilization of Sociometric badges as non-intrusive data-collection tools in naturalistic clinical studies.

**Specific Aims**

This preliminary study had several interrelated aims motivated by an interest in learning more about the differences and similarities between distinct exposure procedures, as well as the role of novel tools for measuring intra-exposure processes. The first study aim was to examine
the feasibility, reliability, and validity of the Sociometric badge. Feasibility was primarily determined by ease of use, informal participant feedback, and the acquisition of usable data. Reliability was assessed by examining the degree of autocorrelation at multiple lags in the arousal time series. Criterion-related convergent validity was examined by assessing the correlations between badge-derived F0 during a public speaking exposure exercise and established self-report measures of anxiety and emotion regulation.

The second study aim was to compare average intra-exposure F0, as measured by Sociometric badges during a public speaking exercise, between the employment of the exposure strategy delineated in the Managing Social Anxiety manual (Hope et al., 2010) and the strategy delineated in the UP (Barlow et al., 2010) manual. As noted, the Hope et al. (2010) protocol stresses the importance of habituation as the principal process underlying the effective delivery of exposure, while the UP protocol relies more heavily on the inhibitory learning model. Social anxiety (SA), and more specifically fear of public speaking, was selected as the focus of this study based on convenience sampling. Epidemiological studies have consistently found SA to have some of the highest prevalence rates among the general population (e.g., lifetime prevalence DSM IV SAD = 5.0 %, CI = 4.6 to 5.4; Grant et al., 2005). Furthermore, anxiety related to performing tasks in public, such as delivering a speech, have been steadily reported as a hallmark symptom of SA (American Psychiatric Association, 2013), which therefore ensured the relevance of the study’s exposure tasks.

Expected Outcomes

Based on successful use in other applied settings, we expected that the Sociometric badges would be feasible to use with participants and that they would yield usable and reliable data. In line with previously reported findings, we also expected that participants who scored
higher on anxiety-related symptoms based on established self-report measures would evidence higher average intra-exposure F0 levels.

Emotional arousal (e.g., activation of anxiety and fear) is a key component of both habituation and inhibitory-learning focused exposure approaches. Given the preliminary nature of this research, a basic question is whether or not these manualized strategies reliably differ in their evocation of intra-exposure trial arousal. Given the absence of existing data in this area and the exploratory nature of the research, we did not specify a priori directional hypotheses regarding the difference in average F0 between the two approaches. Although speculative, we did consider rival hypotheses that could offer plausible explanations for the potential outcomes. For example, we considered that higher than average F0 might be observed in the inhibitory learning-focused condition because this approach focuses more on the reduction of in-the-moment emotion avoidance and suppression strategies. Conversely, we considered that higher than average F0 might be observed in the habituation-focused condition because it places greater emphasis on the level of experienced distress, as well as prompts the individual to focus on oneself, which in the context of a public speaking exercise could on its own result in spikes in arousal (thereby resulting in a higher average F0).

**Method**

**Participants**

Potential participants were administered an online version of the LSAS. Previous research (e.g., Heimberg et al., 1999) has demonstrated that a score of 30 or higher indicates the probable presence of social anxiety disorder. Therefore, individuals who achieved a score of 30 or higher on the scale were invited to the lab for additional participation.
Sixty-six undergraduate college students (females=38%, $M_{age} = 18.7$ years, age range: 18-23 years) were recruited through the Research Pool system of the University at Albany, State University of New York, and were awarded 1.0 credit for participating in the study. This study was reviewed and approved by the University Institutional Review Board.

**Measures**

The Multidimensional Experiential Avoidance Questionnaire (MEAQ; Gámez et al., 2011) is a 62-item measure assessing experiential avoidance (EA), which can be broadly defined as the tendency to avoid negative internal experiences. Items are rated on a 7-point Likert scale ranging from 0 (strongly disagree), to 6 (strongly agree). Previous studies have indicated that the MEAQ possess good validity and reliability (e.g. Gámez et al., 2011). This measure displayed high internal consistency within the present study’s sample ($\alpha = .87$).

The Overall Anxiety Severity and Impairment Scale (OASIS; Norman et al., 2006) is a 5-item measure assessing anxiety frequency, severity, and related impairment. Items are rated on a 0 (lowest severity/impairment) to 4 (highest severity/impairment) scale. The OASIS has been found to display good validity and reliability (e.g. Campbell-Sills et al., 2009; Norman et al., 2006). The measure displayed high internal consistency within the present study’s sample ($\alpha = .88$).

The Anxiety Sensitivity Index (ASI-3; Taylor et al., 2007) is an 18-item measure assessing anxiety sensitivity, which can be broadly defined as the fear of sensations associated with the experience of anxiety. Items are rated on a 5-point Likert scale ranging from 0 (Very little) to 5 (Very much). The ASI-3 possesses good validity and reliability (Taylor et al., 2007). The measure displayed high internal consistency within the present study’s sample ($\alpha = .90$).
The Leibowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) is a 24-item measure assessing social anxiety symptoms. Each item is rated on a 4-point Likert scale measuring the experience of fear associated with the item ranging from 0 (None) to 4 (Severe), as well as the frequency of avoidance behavior related to the item ranging from 0 (Never) to 4 (Usually). The LSAS can be either administered by a clinician or completed as a self-report questionnaire. Both versions have been found to possess sufficient validity and reliability (e.g., Fresco et al., 2001; Heimberg et al., 1999). The measure displayed high internal consistency within the present study’s sample (α = .95).

Subjective Units of Discomfort (SUDs; Wolpe, 1969) are a verbal self-report indicator of state anxiety. Individuals are asked to provide a self-report rating of their current experience of discomfort ranging from 0 (None) to 10 (Severe). SUDs have been found to possess sufficient validity and reliability (Kaplan & Smith, 1995).

**Procedure**

Participants were asked to complete a battery of anxiety and related self-report measures (composed by LSAS, OASIS, MEAQ, and ASI-3), and were then randomly assigned to either the CBT (habituation-based) or UP (inhibitory-based) exposure condition for fear of public speaking exposure exercises.

**CBT.** Participants (n = 34) in the CBT condition were familiarized with the CBT model of SA as well as the tasks and goals of the CBT exposure technique for fear of public speaking. Specifically, participants were asked to identify the automatic thought (AT) that most frequently occurred to them when experiencing anxiety-provoking situations involving public speaking. Participants were then assisted in formulating a rational response to the AT that they were instructed to recite whenever the AT entered their stream of thought. Participants were also
provided with a rationale for habituation and introduced to its process. Finally, a behavioral goal for the task (e.g., attempting to deliver a speech for the duration of the exercise) was set collaboratively.

**UP.** Participants \( n = 32 \) in the UP condition were familiarized with the UP three-component model of emotion (i.e. thoughts, feelings, and behaviors) as well as the tasks and goals of the UP exposure technique. Participants were asked to identify factors for each component that characterized their experience of anxiety during a typical public speaking task, and were then instructed to re-evaluate the validity of their most frequently occurring public speaking-related anxious thought. Finally, participants were assisted in identifying emotion-driven/avoidance “safety” behaviors that they typically employ during public speaking as a means of avoiding the discomfort of fully experiencing the intense emotions (e.g., anxiety) associated with public speaking. Participants were assisted in identifying the long-term consequences of relying on avoidance strategies and were instructed to refrain from engaging in any of the identified emotion-driven/avoidance behaviors and instead to mindfully, although non-judgmentally, acknowledge their emotional response.

**Exposure exercise**

Once familiarized with the concepts and goals of the exposure exercise, including the use of SUDs, participants were accompanied to a conference room, where they were asked to deliver a 5-minute impromptu speech on the topic of gun control in the presence of the research assistant, while wearing a Sociometric badge. Participants were also video recorded and were told that a team of raters would later assign a score to their performance.

Participants in both conditions were asked to give a speech on gun control. In addition, all participants were asked to provide SUDs ratings; however, the frequency of these self-report
ratings varied depending on the condition: the CBT manualized approach required ratings at 1-minute intervals, while the UP approach only collected ratings at the beginning and end of the task. This procedural difference follows from the potentially distinguishable mechanisms of emphasis of the two approaches. Concretely, habituation emphasizes a gradual decrease in arousal, so more ratings are obtained during the process of the exposure as a way to track such a decrease. Because it places less emphasis on decreases in arousal, frequent assessments are deemed less necessary in the UP approach. Following the exercise, all participants were debriefed, and then dismissed.

**Data Analytic Approach**

Data analysis was conducted in IBM SPSS 24 (IBM, Inc.) and comprised two sets of analyses. First, we examined arousal time series from a randomly selected 20% of participants. We then applied univariate time series analysis (Box, Jenkins, & Reinsel, 1994) to examine the degree of autocorrelation between arousal recordings at multiple lags. A significant degree of autocorrelation was expected, which would demonstrate consistency in measurement across occasions.

Based on previous research demonstrating consistent sex differences in F0 (e.g., Laukka et al., 2008), we then conducted an independent samples t-test to examine sex differences in average intra-exposure F0 levels. We subsequently tested a hierarchical multiple regression model to examine the associations between established self-report measures and F0. Specifically, LSAS was entered in step 1, followed by OASIS, ASI-3, and MEAQ, each entered individually at subsequent steps. The goal of this analysis was to assess the relationship between each measure included within the set of anxiety-related self-report measures and F0 to investigate convergent validity.
We then conducted two tests of between condition differences. One test utilized a sequential logistic regression to predict exposure condition membership (i.e. CBT or UP), from F0, entered in step 1, and pre-post exposure SUDS change scores entered in step 2. Logistic regression was chosen because it can flexibly handle independent variables that are not normally distributed. We then conducted a complementary t-test to assess the presence of a significant difference in average intra-exposure F0 levels between the experimental exposure conditions.

Finally, an exploratory hierarchical multiple regression model was tested to assess the relationship between post-exposure SUDs ratings as a dependent variable, where pre-exposure SUDs ratings, exposure condition, and F0 levels, were each added as a predictor to the model in a separate step.

**Results**

**Data Screening**

IBM SPSS MVA was utilized to investigate the pattern of missing data and evaluate its randomness. Fundamental vocal frequency values were found to be missing for 8 cases. Little’s MCAR test indicated that there was no significant deviation from a pattern of values that are “missing completely at random,” $\chi^2 = 3.137, p = 1.0$. Thus, there was support for imputation of missing values using the expectation maximization (EM) algorithm (Musil et al., 2002). The Separate Variance $t$ tests indicated that there was no relationship between missingness and other quantitative variables.

Minimum and maximum values, means, range, and standard deviations of each of the variables appeared to be within normal limits. Furthermore, no univariate outliers were observed. Moderate departures from normality were observed. Anxiety sensitivity was positively skewed (skeweness = .922) and leptokurtic (kurtosis = .943). Social anxiety was positively skewed.
(skewness = 1.087) and leptokurtic (kurtosis = 1.389). In order to reduce the impact of univariate outliers, as well as to address the departures from normality, these two variables were transformed. Given the moderate degree of the positive skew that characterized the anxiety sensitivity, and LSAS variables, a square root transformation was applied. The transformations successfully rendered the distribution of the variables normal. Expected and de-trended normal probability plots confirmed that sufficient normality had been achieved. Following transformation, cases were screened for multivariate outliers through Mahalanobis distance. This examination failed to identify any multivariate outliers with $\chi^2(5) = 20.515$ with $p < .001$. Bivariate scatterplots for all possible combination of variables confirmed the assumptions of linearity and homoscedasticity. The ratio of cases to IVs was calculated and confirmed the feasibility of multiple regression. The absence of multicollinearity was also verified. Finally, a set of preliminary analyses ascertained the absence of baseline differences in self-report anxiety measures (LSAS, OASIS, ASI-3, and MEAQ) between groups (i.e., CBT and UP) and by sex.

**Consistency of Measurement**

A univariate time series analysis (Box, Jenkins, & Reinsel, 1994) of F0 time series from a randomly selected 20% of participants was conducted in order to inferentially assess the degree of autocorrelation between anxious arousal recordings (i.e., F0), as measured by the Sociometric badges at multiple lags. A significant degree of autocorrelation was found for all sampled participants at lags 1 – 6. The only exceptions were found for lags 7, 9 and 10, where one autocorrelation score failed to reach significance, and lag 8, where two autocorrelation scores failed to reach statistical significance. The range of autocorrelation scores, standard errors, and statistical significance for each lag in this subsample in the analysis are reported in Table 1.
These results supported consistency in measurement across occasions, which provides preliminary evidence of the reliability of the F0 measurement with the Sociometric badges.

**Sex Difference**

An independent samples t-test was conducted in order to examine sex differences in mean intra-exposure F0. A statistically significant difference was found, \( t(63) = 7.525, p < .001 \), two tailed, indicating that female participants \((M = 428.5, SD = 66.2)\) produced higher mean intra-exposure F0 than male participants \((M = 295.0, SD = 71.6)\). In order to control for these inherent sex differences in F0, we standardized F0 scores separately for each sex before inclusion in the analyses, following the procedure delineated by Laukka et al. (2008). All subsequent analyses utilized the standardized F0 scores that were produced following this procedure.

**Convergent Validity**

A hierarchical multiple regression model was tested to predict average intra-exposure F0. Self-report ratings were added to the prediction model in accordance to the following order: social anxiety (LSAS, \( M = 51.27, SD = 21.62 \)), anxiety severity and impairment (OASIS, \( M = 6.02, SD = 3.71 \)), anxiety sensitivity (ASI-3, \( M = 22.48, SD = 12.04 \)), and experiential avoidance (MEAQ, \( M = 204.5, SD = 31.71 \)). Each measure was added to the equation as a predictor on a separate model step. This hierarchy was constructed based on the assumption that measures focusing on state anxiety (i.e., LSAS and OASIS) should be more closely related to transient physiological changes, such as F0 levels, than measures focusing on trait anxiety (i.e., ASI-3 and MEAQ). Table 2 displays Pearson correlations between the variables. Anxiety sensitivity (ASI) and anxiety severity and impairment (OASIS) displayed the highest bivariate correlation (Pearson’s \( r = .54, p < .001 \)), followed by anxiety sensitivity (ASI) and experiential avoidance.
(MEAQ) (Pearson’s r = .52, p < .001), anxiety sensitivity (ASI) and social anxiety (LSAS) (Pearson’s r = .51, p < .001), social anxiety (LSAS) and experiential avoidance (MEAQ) (Pearson’s r = .50, p < .001), anxiety severity and impairment (OASIS) and social anxiety (LSAS) (Pearson’s r = .49, p < .001), and anxiety severity and impairment (OASIS) and experiential avoidance (MEAQ) (Pearson’s r = .39, p < .01). In addition, tolerance and VIF values did not demonstrate significant multicollinearity. The scatterplot of the residuals did not reveal concerns regarding linearity and homoscedasticity. In addition, the associated Durbin-Watson statistic, which failed to reach significance, indicated independence of errors.

At step 1, social anxiety symptoms did not account for significant variance in F0, $F(1, 64) = .993, p = .323, R^2 = .015$ (adjusted $R^2$ value = .0). At step 2, overall anxiety severity and impairment was added to the equation and failed to explain incremental variance, $F_{inc} (1, 63) = .087, p = .768, R^2$ change=.001. At step 3, anxiety sensitivity was added to the equation and also failed to account for incremental variance, $F_{inc} (1, 62) = 1.302, p = .258, R^2$ change = .020. At step 4, experiential avoidance was added to the equation and also failed to explain incremental variance in F0, $F_{inc} (1, 61) = .468, p = .496, R^2$ change=.007. Unstandardized regression coefficients ($B$) and intercept, the standardized regression coefficients ($\beta$), the semipartial correlation ($sr_i^2$), $R^2$, and adjusted $R^2$ are reported in Table 2. After step 4, with all of the IVs entered in the equation, the overall model failed to reach statistical significance, $R^2 = .044, F(4,61) = .705, p = .591$. These results failed to support convergent validity.

**Prediction of Exposure Condition**

A sequential logistic regression analysis was performed to assess if average F0 could predict exposure condition participation (CBT or UP). Within-person standardized average SUDS was included on the second step. There was not a good model fit (discrimination among
groups) on the basis of F0 alone \( \chi^2 (1) = 1.898, \, p = .168, \) -2 Loglikelihood = 89.537 (Nagelkerke R\(^2\) = .038). The constant only model correctly classified 51.5\% of cases, while the model after inclusion of F0 as predictor correctly classified 56.1\% of cases. The addition of average SUDS did not significantly improve model fit. \( \chi^2 (2) = .063, \, p = .801, \) -2 Loglikelihood = 89.473 (Nagelkerke R\(^2\) = .039). The effects of predictors in this model are reported in Table 3.

**Between Condition Difference in F0**

An independent samples t-test was also conducted in order to compare the mean intra-exposure F0 of participants who received the habituation-focused CBT exposure intervention and those who received the inhibitory-learning focused exposure intervention. The results failed to identify a statistically significant difference between conditions, \( t(64) = 1.364, \, p = .177, \) two tailed.

**Exploratory Multiple Regression**

Because SUDs are themselves often used as an indicator of exposure process and outcome, we elected to conduct an exploratory hierarchical multiple regression model predicting post-exposure SUDs levels. We entered pre-exposure SUDs ratings at the first step in order to control for their effect on post-exposure SUDs. In the second step, exposure condition was added to the model. Finally, in the third and last step, F0 was added to the model. Tolerance and VIF values did not demonstrate significant multicollinearity. The scatterplot of the residuals did not reveal concerns regarding linearity and homoscedasticity. In addition, the associated Durbin-Watson statistic, which failed to reach significance, indicated independence of errors.

At step 1, pre-exposure discomfort ratings alone failed to account for significant variance in post-exposure SUDs, \( F_{inc} (1, 64) = 2.262, \, p = .138, \) \( R^2 = .034. \) At step 2, exposure condition was added to the model and failed to explain incremental variance, \( F_{inc} (1, 63) = 1.113, \, p = .335, \)
At step 3, F0 was added to the model and failed to account for significant incremental variance, $F_{inc} (1, 62) = 1.344, p = .268, R^2 = .061$. Unstandardized regression coefficients ($B$) and intercept, the standardized regression coefficients ($\beta$), the semipartial correlation ($sr^2_i$), $R^2$, and adjusted $R^2$ are reported in Table 4.

**Feasibility**

Given this pilot use of the Sociometric badges in clinically-oriented research, we also informally monitored participants’ reaction to these novel data collection tools. All participants were able to understand how to utilize the Sociometric badges. In addition, there were no complaints regarding any aspect of the utilization of these tools, which did not appear to disrupt the experimental task.

**Discussion**

In this study, we investigated several interconnected research questions evaluating the differences and similarities between two distinct exposure procedures, as well as the use of Sociometric badges for measuring intra-exposure processes. The first study aim was to examine the feasibility, reliability, and validity of the Sociometric badge for investigating intra-exposure process with anxious individuals. Participants were able to wear the badges with little difficulty. There were no negative reactions or expressed concerns, and the badge did not appear to interfere with participation. In addition, results from the time series analysis of longitudinal F0 observations demonstrated a significant degree of autocorrelation across multiple lags. Concretely, this means that adjacent measurements, within person, were highly correlated with one another. A high degree of autocorrelation would be expected in such intensively measured physiological indicators, and these results provide initial support for reliability of measurement.
Criterion-related convergent validity was examined by assessing the correlations between badge-derived F0 during a public speaking exposure exercise and established self-report measures of anxiety and emotion regulation. The relatively low correlations between F0 and other established self-report measures was somewhat surprising, yet not inconsistent with existing research. The results failed to demonstrate a significant association between average intra-exposure badge-derived F0 and self-reported social anxiety symptoms (based on LSAS scores). Even validated self-report measures of anxiety may not correlate strongly with non-self-report (e.g., psychophysiological) indicators, which has been demonstrated in previous investigations (McLeod, Hoehn-Saric, & Stefan, 1986). Nevertheless, given the absence of clinical research using Sociometric badges to-date, this was considered to be a logical starting point.

The ASI-3 and the MEAQ have demonstrated sensitivity to change in applied clinical studies (e.g., Thompson-Brenner et al., under review), yet both can be conceptualized as trait-like measures of cognitive vulnerability and emotion regulation, respectively. As such, we might expect these measures to be less strongly correlated with state physiological arousal such as F0. Hence the decision to assign lower priority to these variables in the hierarchical regression models. Moreover, the OASIS, while measuring state anxiety, focuses on non-specific factors of distress related to the experience of anxiety in recent days, which again, may not necessarily relate to arousal induced by a subsequent experimental task. Concretely, although we expected significant correlations among these factors, the absence of associations can be accounted for by theory and some existing research (e.g., Endler & Kocovski, 2001). Although we cannot conclusively state that this method for assessing F0 is invalid, the observed results fail to provide convincing support. As such, the reported inferential results should be interpreted cautiously.
The second broad study aim was to compare average intra-exposure F0, as measured during a public speaking exercise by Sociometric badges, between the employment of the exposure strategy delineated in the *Managing Social Anxiety* manual (Hope et al., 2010) and the strategy outlined by the UP (Barlow et al., 2010) manual. This comparison failed to identify significant differences in average intra-exposure F0 between the experimental conditions, suggesting that the employment of the two exposure strategies may not produce significantly different levels of anxious arousal in participants. Despite differences in theoretical emphasis, both habituation and inhibitory learning have been hypothesized to function complementarily within the broader process of extinction (Craske et al., 2014), which could partly explain our inability to identify significant differences. Consistent with this null finding, self-report ratings of distress (SUDs) also failed to differentiate between exposure conditions.

Lastly, our exploratory analysis failed to identify a significant relationship between post-exposure self-reported discomfort, pre-exposure self-reported discomfort, condition, and F0. This result is notable on multiple levels. First, surprisingly few studies have directly compared two bona fide exposure approaches derived from the same broadly defined theoretical orientation (i.e., CBT), so the observed similarities in post-exposure SUDs is noteworthy. Second, physiological arousal and subjective distress are, at least theoretically, distinguishable constructs. F0 is a physiologically-based indicator that is, for the most part, not under the direct control of participants. Conversely, distress ratings are based on one’s subjective sense of discomfort in a given moment. Negative arousal may be a component of this rating, but subjective discomfort is not reducible to basic arousal. Indeed this study failed to find a significant correlation between average F0 and post-exposure SUDs. It is possible, however, that a closer examination of the contemporaneous and cross-lagged associations between F0 and SUDs would reveal a higher
degree of association. At the very least, it is important to recognize that self-reports of discomfort might not be an appropriate for substitute F0 as valid and reliable indicators of physiological anxious arousal. Nonetheless, it is plausible that the additional cognitive processes that are required for the production of self-reports ratings of discomfort might provide useful insight into other anxiety-related psychological constructs (e.g., anxiety sensitivity).

Although the lack of significant differences between the conditions should be taken with caution, the results also have implications for psychotherapy integration. Previous research (e.g., Oswald et al., 2015), has demonstrated that clinicians from non-CBT orientations often view exposure therapy as too highly structured and artificial in such a way that it interferes with productive processing of emotions. A global difference between the approaches investigated in this study was the expected frequency of distress ratings and the level of structure during the exposure trial. The results appear to demonstrate that more structure does not necessarily lead to decrements in experienced arousal or in subjective distress. Such a finding might lead non-CBT therapists to increase their willingness to integrate structured exposure therapy practices with their patients.

**Limitations**

This study possessed several limitations. First, the sample was exclusively composed of undergraduate students, which ultimately limits the generalizability of our findings. Although SA and performance-related anxiety are amongst the most prevalent conditions in the general population, college students, who are often required to deliver speeches as part of their academic curricula, might not compose a representative sample. In addition, the eligibility criteria were set for the inclusion of individuals who reported symptom levels indicating the probable presence of SA, which was exclusively based on the score achieved on one self-report measure.
Furthermore, the study procedures were chosen in an attempt to balance internal and external validity. On the one hand, psychoeducation and the exposure instructions and procedures closely followed established, manualized clinical procedures in order to maximize clinical relevance. Yet, on the other hand, exposure therapy is often used in the context of longer-term treatment. Even intensive, single session exposure interventions typically last approximately 3 hours (Öst, Salkovskis, & Hellström, 1991). Future naturalistic studies of psychotherapy process aiming to achieve higher external validity should be conducted in clinical settings in order to ensure the collection of clinically relevant data.

Although the study was powered to test a multiple regression model with a limited number of main effects and a one-way test of mean differences, the limited size of the sample precluded the testing of more complicated multivariate models. Given the subtle nature of the processes investigated by this line of research, future studies should also comprise larger samples in order to ensure sufficient statistical power to detect small effects. Furthermore, the modest sample necessitated the use of the EM algorithm for dealing with missingness and several variables required statistical transformations. Although these steps are not problematic per se (e.g., missingness was unrelated to key variables or group differences), these steps potentially impact the generalizability of the results.

Finally, the study did not include a formal control group upon which to compare the two bona fide exposure approaches. This was largely a consequence of the required sample size for a three-condition experiment. In addition, the selection of an appropriate control condition is not necessarily straightforward. Simply asking socially anxious individuals to give an impromptu speech would likely elicit arousal, and the assessment procedure would have required both the use of badges and the solicitation of SUDs. The strength of this manipulation would have been
questionable. Furthermore, it is possible that the use of the badge itself would have elicited arousal in generally non-socially anxious participants. In this instance, the appropriate attribution of the cause of the arousal would be difficult to ascertain. Nevertheless, this omission might have limited our ability to compare intra-exposure anxious arousal between the experimental conditions and either a group of potential participants who had not endorsed significant symptoms of SA, or a group of potential participants who were not delivered a manualized exposure technique.

**Future Directions**

Future lab-based investigations could incorporate a formal control condition using larger samples, as well as increase the number of exposure trials in order to assess between-trial habituation. Furthermore, in addition to average arousal levels, future research should examine variability in arousal across time. This study provided initial support for the feasibility and reliability of a specific Sociometric badge metric. However, similar support for its convergent validity was not demonstrated. As noted, the absence of significant correlations between self-report and non-self-report assessment methods in other published research implies that we cannot conclude with certainty that the non-self-report method lacks validity. It is also important to place the observed results within the context of this non-clinical sample. Clearly, additional research is required to examine the reliability and validity of these devices for use in clinical samples. The utilization of Sociometric badges in clinical samples could provide the ultimate validation for this methodological approach by allowing more sophisticated comparisons of F0 data with symptom measures and behavior observations obtained through the administration of clinician-administered assessment tools. Setting this aside, there does appear to be promise for using such technology in behavior therapy process research.
References


Table 1

*Univariate Time Series Analysis of Individual Intra-Exposure F0*

<table>
<thead>
<tr>
<th>Lag</th>
<th>Autocorrelation</th>
<th>SE</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.128 - .335</td>
<td>.042 - .064</td>
<td>.0 - .023</td>
</tr>
<tr>
<td>2</td>
<td>.047 - .321</td>
<td>.042 - .064</td>
<td>.0 - .02</td>
</tr>
<tr>
<td>3</td>
<td>.051 - .208</td>
<td>.042 - .064</td>
<td>.0 - .02</td>
</tr>
<tr>
<td>4</td>
<td>.026 - .252</td>
<td>.042 - .064</td>
<td>.0 - .012</td>
</tr>
<tr>
<td>5</td>
<td>(.003) - .218</td>
<td>.042 - .064</td>
<td>.0 - .024</td>
</tr>
<tr>
<td>6</td>
<td>(.082) - .246</td>
<td>.042 - .063</td>
<td>.0 - .032</td>
</tr>
<tr>
<td>7</td>
<td>(.114) - .241</td>
<td>.042 - .063</td>
<td>.0 - .05</td>
</tr>
<tr>
<td>8</td>
<td>(.065) - .242</td>
<td>.042 - .063</td>
<td>.0 - .079</td>
</tr>
<tr>
<td>9</td>
<td>(.104) - .215</td>
<td>.042 - .063</td>
<td>.0 - .085</td>
</tr>
<tr>
<td>10</td>
<td>(.119) - .234</td>
<td>.042 - .063</td>
<td>.0 - .124</td>
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</tbody>
</table>

*Note.* Lag, Autocorrelation, SE, and p-value indicate the range of values that were found in the sub-sample of cases that was examined by this analysis.
Table 2

Hierarchical Multiple Regression of ASI-3, OASIS, MEAQ, and LSAS Variables on F0

<table>
<thead>
<tr>
<th>Variables</th>
<th>z-F0</th>
<th>ASI-3</th>
<th>MEAQ</th>
<th>OASIS</th>
<th>LSAS</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>sr^2</th>
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</thead>
<tbody>
<tr>
<td>ASI-3</td>
<td>-.07</td>
<td></td>
<td></td>
<td>-.02</td>
<td>.01</td>
<td>-.22</td>
<td>-.17</td>
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</tr>
<tr>
<td>MEAQ</td>
<td>.08</td>
<td>.52***</td>
<td></td>
<td>.00</td>
<td>.01</td>
<td>.10</td>
<td>.08</td>
<td></td>
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</tr>
<tr>
<td>OASIS</td>
<td>.03</td>
<td>.54***</td>
<td>.39**</td>
<td></td>
<td>.01</td>
<td>.04</td>
<td>.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSAS</td>
<td>.12</td>
<td>.51***</td>
<td>.50***</td>
<td>.49***</td>
<td>.12</td>
<td>.11</td>
<td>.18</td>
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<tr>
<td>Means</td>
<td>0</td>
<td>22.5</td>
<td>204.49</td>
<td>6.02</td>
<td>7.01</td>
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<td></td>
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<tr>
<td>SD</td>
<td>1.0</td>
<td>12.04</td>
<td>31.71</td>
<td>3.71</td>
<td>1.45</td>
<td>R^2 = .05 Adj R^2 = -.02 R = .21</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note. ASI-3 = Anxiety Sensitivity Index-3; MEAQ = Multidimensional Experiential Avoidance Questionnaire; OASIS = Overall Anxiety Severity and Impairment Scale; LSAS = Liebowitz Social Anxiety Scale. *p < .05. **p < .01. ***p < .001.
Table 3

*Logistic Regression Analysis of Exposure Strategy as a Function of F0, and SUDS change*

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>Wald $\chi^2$-test</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval for Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>F0</td>
<td>-.37</td>
<td>1.87</td>
<td>.70</td>
<td>.41</td>
</tr>
<tr>
<td>SUDs-change</td>
<td>.07</td>
<td>.06</td>
<td>1.07</td>
<td>.64</td>
</tr>
<tr>
<td>(Constant)</td>
<td>-.06</td>
<td>.06</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* F0 = Fundamental frequency; SUDs-change = Pre- to post-exposure discomfort rating change score.
Table 4

Hierarchical Multiple Regression of Pre-Exposure SUDs, Exposure Strategy, and F0 Variables on Post-Exposure SUDs

<table>
<thead>
<tr>
<th>Variable</th>
<th>SUDs-E (DV)</th>
<th>SUDs-S Start</th>
<th>EXP</th>
<th>F0</th>
<th>B</th>
<th>SE B</th>
<th>B</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>.00</td>
<td>.00</td>
<td>.03</td>
<td>.25</td>
<td>.06</td>
<td>.03</td>
<td></td>
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</tr>
<tr>
<td>F0</td>
<td>.16</td>
<td>-.01</td>
<td>.17</td>
<td>.13</td>
<td>.17</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>.00</td>
<td>.00</td>
<td>.50</td>
<td>.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>1.00</td>
<td>1.00</td>
<td>.50</td>
<td>1.0</td>
<td>R² = .06</td>
<td>Adj R² = .02</td>
<td>R = .25</td>
<td></td>
</tr>
</tbody>
</table>

Note. SUDs-E = Standardized post exposure discomfort ratings; SUDs-S = Standardized pre exposure discomfort ratings; EXP = Exposure strategy; F0 = Standardized fundamental frequency. *p < .05. **p < .01. ***p < .001.