Performance deficits in naturalistic reading aloud are associated with social anxiety symptoms

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Abstract

Individuals with social anxiety exhibit biased self-evaluations in social settings, yet research remains conflicted on whether these individuals exhibit actual social performance deficits. Conflicting findings may be due to methodological differences across studies, such as the task being studied or the level of analysis at which performance deficits are measured. In the current study, we investigated whether social anxiety symptoms were associated with performance deficits in naturalistic reading aloud, examining performance at multiple levels of analysis. We recruited 58 young adults to read multi-sentence passages aloud while their audio was recorded. Audio recordings were then coded in terms of surface-level performance deficits–misproductions and hesitations in speech–at both the passage and word level. Passage-level analyses revealed social anxiety symptoms were associated with increased rates of hesitations, but not of misproductions. At the word level, social anxiety symptoms were associated with both increased hesitations and increased misproductions, dependent in the latter case upon word-level features. We also found that misproductions were positively associated with hesitations at the passage level, and were more likely to precede hesitations (as opposed to follow them) at the word level. Collectively, the results suggest that social anxiety symptoms are associated with performance deficits. Moreover, increased hesitation rates in naturalistic reading aloud may be indicative of a post-error slowing effect due to heightened self-monitoring of speech errors when reading aloud. Broadly, results demonstrate the utility of fine-grained measurement in studying social performance deficits and align with mechanistic accounts of hyperactive self-monitoring in social anxiety.

Introduction

Socially anxious individuals display a negative bias in assessing their social performance (Inderbitzen-Nolan et al., 2007; Rapee & Heimberg, 1997; Spence et al., 1999).

However, prior work has been mixed as to whether social anxiety is associated with actual social performance deficits (Miers et al., 2009), as opposed to self-reported deficits reflecting biases in self-perception (Lau et al., 2023; Spence et al., 1999). Conflicting findings may in part arise from methodological differences across studies (Thompson et al., 2019) and the fact that most prior work relies on relatively broad assessments of performance. In the current study, we sought to investigate whether social anxiety symptoms were associated with performance deficits in naturalistic reading aloud, examining performance at multiple levels of analysis.

Prior research has tended to rely primarily on relatively broad measures of social performance in a given environment, employing subjective assessments of performance determined by how observers rate an individual based on several minutes of behavior at a time or on the entire task (e.g., Inderbitzen-Nolan et al., 2007; Losiak et al., 2015; Miers et al., 2009; Rapee & Lim, 1992; Spence et al., 1999). The inherent imprecision of a coarse-grained approach may explain the irregularity in prior work of detecting (e.g., Losiak et al., 2015) or not detecting (e.g., Rapee & Lim, 1992) performance deficits among socially anxious individuals. Moreover, the presence of performance deficits in social anxiety may depend on the task being studied. For example, Voncken and Bögels (2008) reported that performance deficits associated with social anxiety were only observed for unstructured social interactions (i.e., during a conversation), not for structured social interactions (during an impromptu speech). In contrast, other investigations find evidence for performance deficits in both structured and unstructured social interactions (Inderbitzen-Nolan et al., 2007; Thompson et al., 2019), and others still have found no differences for either type of social interaction (Beidel et al., 1985). In the related setting of evaluating verbal performance during a mock interview, findings are likewise mixed (Silber-Varod et al., 2016; Strahan & Conger, 1998).

Although reading aloud is a common concern for individuals with social anxiety (Beidel et al., 1999; Blöte et al., 2015), little work to date has examined whether social anxiety symptoms are associated with performance deficits while reading aloud. Nonetheless, the evaluation of verbal performance more generally is common in prior studies investigating potential performance deficits in social anxiety. At the coarse-grained level, prior studies suggest that phonetic cues may be especially sensitive to various group differences in social anxiety. For example, in a study of 20 Hebrew speakers high or low in social anxiety symptoms, Silber-Varod et al. (2016) found that during a conversational interview, verbal

responses of those high in social anxiety were significantly longer in duration than others', and such participants additionally displayed increased variability in their vocal pitch—i.e., irregularity both in fundamental frequency and in intensity. Phonetic analysis further provides a rich trove of measurable details (Ladefoged, 1996; Tavakoli et al., 2025) that can afford a more fine-grained approach to identifying social performance deficits.

Speech data are highly amenable to both eliciting and observing mistakes (Jalongo & Hirsh, 2010); on account of their salience both to the speaker and the listener, errors in speech may amplify otherwise subtle social performance effects (facilitating data annotation and improving statistical power). Moreover, reading aloud is distressing both for socially anxious individuals (Beidel et al., 1999; Blöte et al., 2015) and for the general population (Chavira & Stein, 2005; Millward, 1977). In summary, naturalistic reading provides not only an ecologically-valid, real-world scenario for studying potential social performance deficits in social anxiety, but further enables assessment of performance at a fine-grained level of analysis. Reading aloud additionally affords a "ground truth" (the provided text) against which performance can be compared, which may facilitate more objective and reliable quantification of performance levels.

The current study investigated possible relations between social anxiety symptoms and performance deficits in naturalistic reading aloud, with performance quantified at multiple levels of analysis. At the level of individual reading passages, we examined whether "surface-level" performance deficits (i.e. misproductions or hesitations in speech) were associated with social anxiety symptoms. At a finer-level of analysis, we additionally examined whether word-level misproductions or hesitations related to social anxiety symptoms, as well as further interrelations between these measures. We initially hypothesized that individuals high in social anxiety symptoms would superficially perform as well as those low in social anxiety, presumably due to increased attention and effort dedicated to maintaining surface-level performance in a social setting (Eysenck et al., 2007). Notably, the possibility also remained that fine-grained analysis at the word level could reveal an unexpected pattern, whereby individuals higher in social anxiety symptoms exhibit distinct – perhaps more subtle – surface-level performance deficits as well.

Methods

Participants

58 young adults (mean age = 22.66 ± 4.63 years; 54 female, 4 male) were recruited from psychology courses at Florida International University and consented to participate in exchange for course credit. Prior analyses using this dataset were reported in Alexander and Buzzell (2023). Four participants were excluded from analyses due to low overall comprehension accuracy (≤ 50%, chance = 25%) and another three were excluded because of persistent audible distractions in the audio files (e.g., other individuals present in the room during recording); this left 51 participants included in analyses for the current study (mean age = 22.51 ± 4.49 years; 48 female, 3 male). Power analyses performed in G*Power 3.1.9.6 (Faul et al., 2009) were used to determine the initial sample size (Alexander & Buzzell, 2023). Additional demographic information is included in Table 1. The nature of the participant pool (i.e., university students enrolled in psychology courses) led to a high proportion of female participants (94%). Given that the study was conducted in Miami-Dade County, in which 75% of residents speak a language other than English at home (U.S. Census Bureau, 2022), English monolinguals and bilinguals who self-reported having learned English by age six were included among study participants. Colorblindness, lack of normal or corrected-to-normal vision, and history of head trauma or communication disorders were additional exclusion criteria. Participants were required to have access to an internet connection, webcam, microphone, and desktop or laptop computer, and were willing to record themselves for this online study. All procedures were approved by the Florida International University Institutional Review Board.

Table 1: Participant demographics

Race/Ethnicity						
Participants	Asian	Black or African-American	Hispanic, Latino, or Spanish	White	Multiple Selected	Undisclosed
Total	2 (3.4%)	3 (5.2%)	34 (58.6%)	7 (12.1%)	11 (19.0%)	1 (1.7%)
Analyses	2 (3.9%)	1 (2.0%)	30 (58.8%)	7 (13.7%)	10 (19.6%)	1 (2.0%)
Pronouns						
	she/her	he/him	they/them	other	undisclosed	
Total	50 (86.2%)	4 (6.9%)	1 (1.7%)	1 (1.7%)	2 (3.4%)	
Analyses	44 (86.3%)	3 (5.9%)	1 (2.0%)	1 (2.0%)	2 (3.9%)	
Socioeconomic class affiliation						
	affluent	middle	working		poor	
Total	2 (3.4%)	31 (53.4%)	23 (39.7%)		2 (3.4%)	
Analyses	2 (3.9%)	28 (54.9%)	19 (37.3%)		2 (3.9%)	

Procedure

Due to the COVID-19 pandemic, data were collected remotely in January-June 2022. Following consent, participants completed demographic, trait, and state questionnaires online via REDCap (Harris et al., 2019). Participants were then directed to a “Reading Aloud Task” in which they read aloud passages presented on-screen in a web browser while recording themselves via Zoom (Zoom Video Communications, Inc., San José, California). A comprehension question followed each passage. Participants additionally completed a standard lexical decision task, which is beyond the scope of the current report and not described further. Participants sent the audio recording of the Reading Aloud Task directly to the researchers for review/analysis. Crucially, this created an inherent social context, with participants reading naturalistic texts aloud under the premise of being evaluated and with the knowledge that researchers would review their recording.

Stimuli

Twenty reading passages were created to be realistic—reminiscent of the material a student might be asked to read aloud in a classroom setting. Passages had an average length of 170 words (range: 140–223 words) and a Flesch Reading Ease score (Flesch, 1948) of 51.47 (range: 36.5–73.8). Word frequency was not directly manipulated, and thus

allowed to vary naturally across passages, with an average word frequency of 4.01 (range: 3.86–4.38), where an individual word's frequency is defined as the base-10 logarithm of one plus the absolute count of its tokens in the SUBTLEXus corpus (Brysbaert & New, 2009). Values for words not present in the corpus were imputed using the corpus median. Note that such variation in word frequency facilitates further analyses to determine whether any effects of interest interact with word frequency, either at the level of an individual word or as each passage's average word frequency.

To address separate analyses (pertaining to experimental questions not relevant to the current report, see Alexander & Buzzell, 2023), emotional valence was manipulated such that half the passages started with semantically positive content and ended with semantically negative content; the order was reversed in the remaining ten passages. The order of passages shown was pseudo-random; for further details, see Alexander and Buzzell (2023). Due to experimenter error, one passage ("broccoli") was presented to participants with a word missing; another ("sun") was presented accurately but the error coding file contained a mistake causing extraneous, false positive errors in the coded data. These two passages are accordingly excluded from all analyses.

Reading Task

The Reading Aloud task was implemented as a PsychoPy task converted to JavaScript for running on the Pavlovia.org web server (Bridges et al., 2020). Participants were provided with instructions that they should read the passages aloud, each presented on-screen in its entirety and roughly taking between one and two minutes to complete. Each passage was shown centered on a light gray background with black text in Arial font, proportional in vertical size to the dimensions of a participant's computer screen. Participants advanced the task by pressing the spacebar on their keyboard. While there was no fixed time limit for each passage, participants were instructed to start immediately, and not to 'pre-read' the text. Following each passage, participants were asked to answer a multiple-choice comprehension question about the text, selecting one of four possible answers using the "a", "b", "c", and "d" keys on their keyboard. See Supplemental Materials for a complete list of passages and questions. Such questions provided a measure of task attention/engagement (facilitating later removal of outliers with exceptionally low comprehension performance). Participants were

given an optional 60-second break between each comprehension question and the following passage.

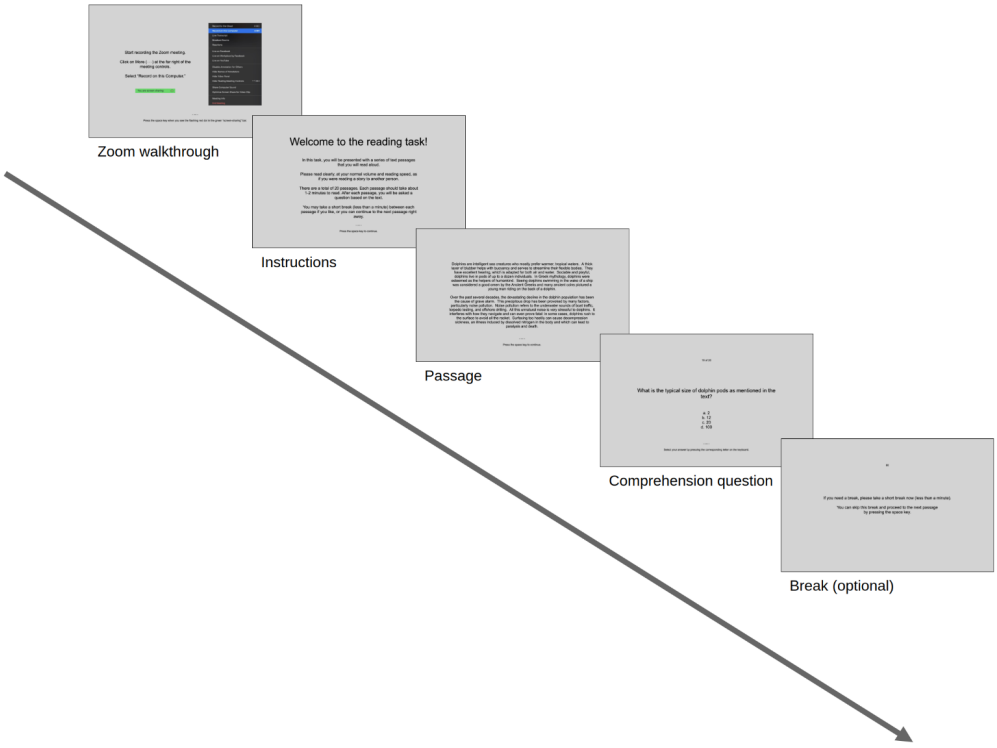

Figure 1: Task Procedure

Social Anxiety Assessment

Each participant completed a battery of self-report surveys, including a standard demographic questionnaire. Analyses for the current study focus on the Screen for Adult Anxiety-Related Disorders (SCAARED, Angulo et al., 2017), which assesses various anxiety disorders in adult populations. Analyses focused on the social phobia subscale of the SCAARED (SCAARED-Social) as the indicator of social anxiety symptom severity.

Error Coding

Two trained coders separately annotated errors for each participant's audio file, classifying each syllable as being either correct (not marked) or as involving one or more categories described below. Errors, broadly construed, were conceptualized as deviations from the text written and/or from fluent reading thereof. For each such deviation, the actual speech produced was transcribed, along with any subsequent verbal self-corrections made.

The pair of coders reconciled these annotations, syllable by syllable. Regions where one coder marked an error and the other did not were left as-is (i.e. to include the error). For areas in conflict – wherein the same audio was interpreted by the two coders as being either different kinds of errors or the same error category but marked on different syllables – the two coders re-listened to the audio together and decided by consensus how to finalize error coding for that section. In cases where two annotations were independent and therefore not in conflict (e.g., a misproduction and a hesitation on the same syllable), both were included in the final reconciled form.

Based on pilot data, the protocol was designed to achieve accurate coding of two categories of interest: misproductions and hesitations. Misproductions, the first chief category of interest, were defined as any instance of a single syllable being replaced with another (e.g., producing “including” or “bercluding” when the text was “concluding”) or an addition or deletion of one or more phonemes that did not alter syllabification (e.g., “tide” for “stride” or vice versa). To reduce ambiguity in coding, a word substituted for a completely different word (e.g., “happy” for “delighted” or vice versa) was considered a misproduction. Hesitations, the second chief category of interest, were defined as pauses of unnatural duration (i.e., not merely syntactically-governed prosodic breaks). Because pause naturalness depends on speaking style, register, and speed, rather than being an absolute duration, this category’s cutoff was based on whether a given pause was perceived to be natural in context. Bearing in mind the particular speaker, sentence structure, and punctuation, a hesitation was when such a pause seemed disfluent. The coding protocol included four additional error categories – insertion/duplications, omissions, word-stress errors, and elongations – which served to capture edge cases that might otherwise be inappropriately coded as a misproduction or hesitation. The presence of these additional categories was designed to improve the accuracy and homogeneity of these two chief categories of interest.

Analytic Strategy

Data cleaning and preliminary analyses

Audible anomalies in the recordings (e.g., others entering the room) were noted by annotators during error coding. Any individual passage having such a note was removed from further analyses (31 passages, 3.4%). Participants with five or more anomalous passages, or with persistently faint audio, were considered outliers and completely removed from further

analyses (3 participants). Participants performing near or below chance on comprehension questions across all twenty passages were removed due to presumed task inattention (cutoff: ≤ 50% correct responses, chance = 25%; 4 participants).

For statistical modeling, the primary measures of interest were hesitation rate and misproduction rate as indices of surface-level performance. These measures were both assessed at the passage level (although additional corresponding analyses at the word level, described below, were also performed). For each participant, hesitation rate was separately quantified for each passage by dividing the number of words associated with hesitations within a given passage by the total number of words within that passage. The same approach was used to compute misproduction rate, again at the passage level. We additionally computed descriptive statistics (means and standard deviations) for all passage-level variables of interest; see Table 2.

Statistical analyses

We focused our analyses on a broad measure of social anxiety symptoms: the social phobias subscale of the SCAARED (SCAARED-Social). To assess whether social anxiety symptoms were associated with performance deficits at the passage level, we tested the predictive power of SCAARED-Social with respect to hesitation rate and misproduction rate, independently. We fit two mixed effects models with hesitation rate or misproduction rate as the outcome measure; social anxiety symptoms, operationalized as the SCAARED-Social score, served as a fixed effect, with a random intercept for participant and passage. All fixed effect predictors were z-scored prior to modeling. Models were constructed in R (R Core Team, 2025) using lme4 (Bates et al., 2015) and the lmerTest wrapper (Kuznetsova et al., 2017) following data processing with purrr (Wickham & Henry, 2023) and dplyr (Wickham, François, et al., 2023), then plotted using the effects (Fox, 2003; Fox & Weisberg, 2019) and interactions (Long, 2024) packages. Significant models were rerun controlling for age and for gender (see Supplemental Materials), and all results were qualitatively similar. Effect sizes are reported as standardized β coefficients, alongside 95% bootstrapped confidence intervals computed via the confint() function.

To foreshadow the results, we found that higher SCAARED-Social scores were associated with increased passage-level hesitation rates. We therefore carried out a series of

additional analyses in an effort to understand and contextualize the nature of this result. As described in further detail within the Results section, we examined whether hesitation rate was predictive of misproduction rate at the passage level, in order to test for the possibility of a “speed-accuracy tradeoff”. We additionally performed a set of item-level analyses to investigate whether the relation between social anxiety symptoms and hesitations differed as a function of stimulus features, namely the relative lexical frequency of an error-marked word or its position relative to other words.

Results

Descriptive statistics are included in Table 2. All statistical tables were produced using the htmlTable (Gordon, 2014) and/or sjPlot (Lüdecke, 2024) packages and edited with the xml2 package (Wickham, Hester, et al., 2023).

Table 2: Descriptive statistics

	Hesitation rate	Misproduction rate	Comprehension accuracy	SCAARED Social
Mean	2.85%	2.62%	80.81%	5.84
SD	2.07%	1.82%	10.61%	4.45

Social anxiety symptoms predict passage-level hesitation rates

The model testing associations between social anxiety symptoms and hesitation rate identified a main effect of social anxiety symptoms (SCAARED-Social) on hesitation rate (p = 0.024, β = 0.242, SE = 0.104). In contrast, the model testing associations between social anxiety symptoms and misproduction rate identified no significant effects (p = 0.787).

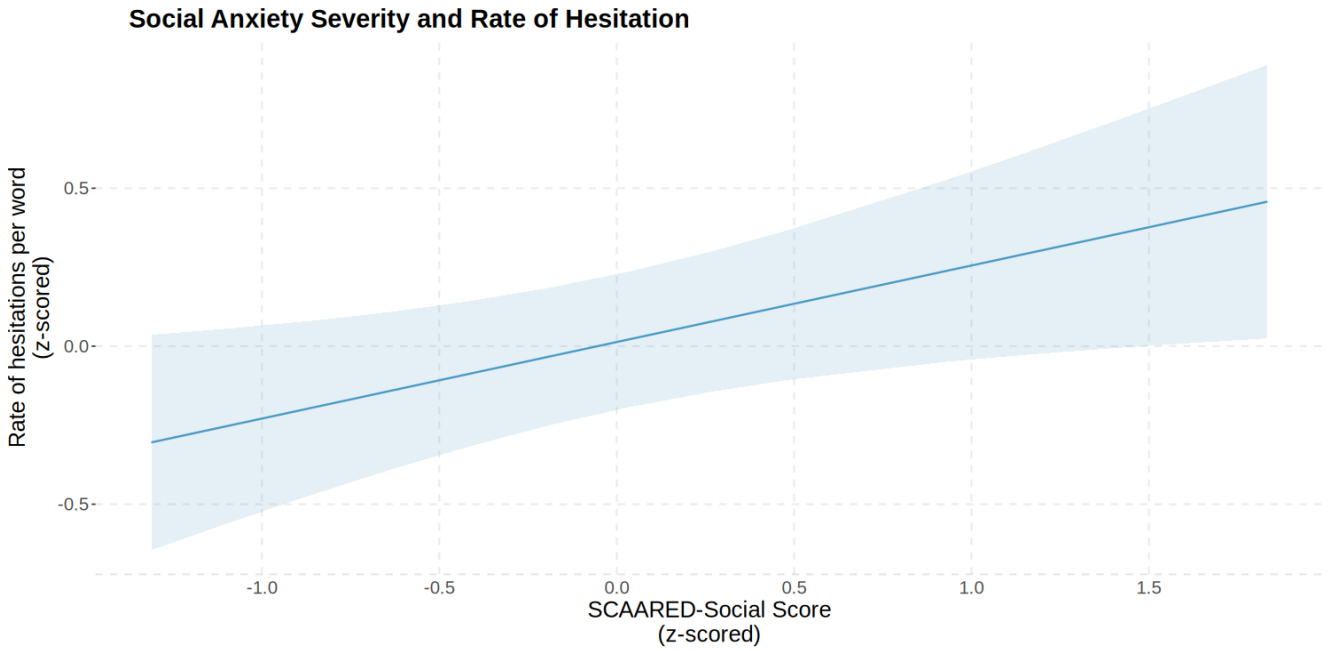

Figure 2. Hesitation rate across social anxiety symptom severity. Hesitation rate represents the z-scored fraction of words in a passage that were coded with a hesitation. SCAARED-Social Score is the z-scored social phobias subscore of the Screen for Adult Anxiety Related Disorders. Fitted values are connected as straight lines and shading denotes 95% confidence intervals.

Table 3: Model results predicting rate of hesitations with SCAARED-Social score

Predictors	*β*	*SE*	*df*	*CI*	*t*	*p*	
Intercept	0.01	0.11	881.00	-0.20 – 0.23	0.12	0.904	
SCAARED social	0.24	0.10	881.00	0.04 – 0.45	2.33	**0.020**	*

** p<0.05 ** p<0.01 *** p<0.001*

Passage-level hesitation rates are positively associated with misproduction rates

Given that social anxiety symptoms predicted hesitation rate (at the passage level), we sought to further understand and contextualize this result via additional, exploratory analyses. One possibility is that increased hesitations could be indicative of a speed-accuracy tradeoff that serves to reduce the rate of misproductions (Postma et al., 1990; Postma & Kolk, 1993). Alternatively, misproductions might lead to increased hesitations as a response to making a mistake (Danielmeier & Ullsperger, 2011). To test these ideas, and to evaluate whether any such relationship would be moderated (or reversed) by social anxiety symptoms, we fit a mixed effects model with misproduction rate as the outcome measure and hesitation rate and social anxiety symptoms, as well as their interaction, as fixed effects (with random intercepts for participant and passage). Although we did find that there was a main effect of hesitation

rate on misproduction rate, this association was positive ($p < 0.001$, $\beta = 0.146$, $SE = 0.035$). That is, in direct contrast with the notion that hesitations might indicate that readers are slowing down to avoid mis-speaking, individuals who committed misproductions at higher rates also hesitated more often. Moreover, the interaction term in this model was not significant ($p = 0.834$), suggesting that the positive relation between hesitation rate and misproduction rate did not significantly differ as a function of social anxiety symptoms.

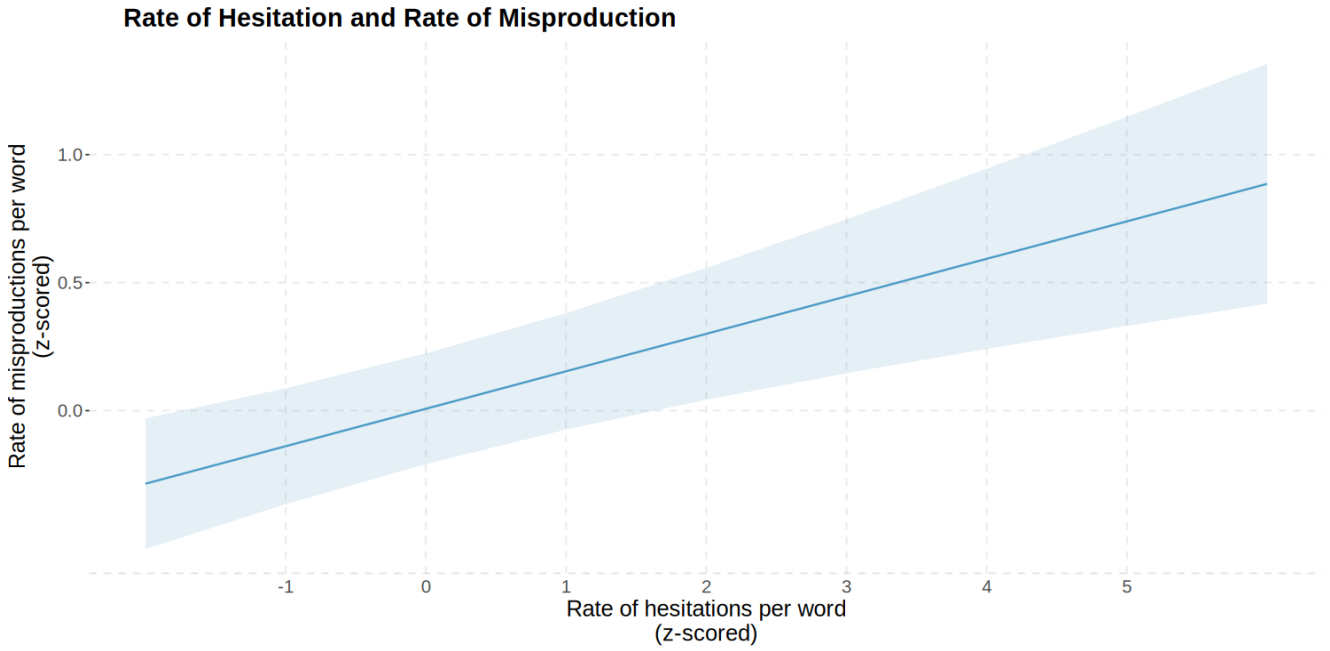

Figure 3. Relationship between misproduction rate and hesitation rate. Hesitation and misproduction rates represent the z-scored fractions of words in a passage that were coded with a hesitation or misproduction respectively. Fitted values are connected as straight lines and shading denotes 95% confidence intervals.

Table 4: Model results predicting rate of misproductions with rate of hesitations, SCAARED-Social score, and their interaction

Predictors	*β*	*SE*	*df*	*CI*	*t*	*p*	
Intercept	0.01	0.11	879.00	-0.21 – 0.22	0.07	0.947	
Hesitation rate	0.15	0.04	879.00	0.08 – 0.22	4.17	**<0.001**	***
SCAARED social	-0.06	0.09	879.00	-0.25 – 0.12	-0.66	0.511	
Hesitation rate × SCAARED social	-0.01	0.03	879.00	-0.07 – 0.06	-0.21	0.834	

** p<0.05 ** p<0.01 *** p<0.001*

Word-level analysis reveals a positive association between social anxiety symptoms and misproductions

We next sought to explore whether features of the text itself modified the association between hesitation rate and social anxiety symptoms. First, given that the frequency with which a word occurs in speech or writing relative to other words may impact the likelihood of hesitations more generally (Balota & Chumbley, 1984), we investigated whether the link between social anxiety symptoms and hesitation was modified by word frequency. That is, we were interested in determining whether increased hesitations in individuals high in social anxiety symptoms arise primarily from low-frequency words, similar to the general population, or if those high in social anxiety symptoms display a fundamentally different pattern of reading fluency. Second, we sought to determine whether a fine-grained frequency-informed analysis might reveal an association between social anxiety and misproductions that had not been visible at the passage level. These analyses were performed at the word level; thus, we fit two logistic, mixed effects models with the binary presence/absence of item-level hesitation or misproduction as the respective outcomes. Social anxiety symptoms, item-level word frequency (as defined above), and their interaction were entered as fixed effects, along with a random intercept for each of participant, passage, and word.

First, we note that these item-level analyses replicated the main effect of social anxiety symptoms on hesitations ($p = 0.005$, $\beta = 0.218$, $SE = 0.078$) while controlling for word frequency. We also observed a significant main effect of word frequency on hesitations ($p < 0.001$, $\beta = -0.444$, $SE = 0.042$) such that hesitations were more likely to occur with lower-frequency words. No significant interaction between social anxiety symptoms and word frequency was present ($p = 0.484$). The second model, which analyzed misproductions at the word level, revealed a similar, significant main effect of word frequency on the likelihood of a misproduction ($p < 0.001$, $\beta = -0.682$, $SE = 0.051$) such that the likelihood of a misproduction increased as word frequency decreased. As with the original, passage-level model, we found no significant main effect of social anxiety symptoms on misproductions ($p = 0.926$); however, this word-level analysis revealed a significant interaction between social anxiety symptoms and word frequency ($p = 0.045$, $\beta = -0.032$, $SE = 0.016$). Namely, while all individuals performed similarly in producing common, high-frequency words, the trend diverged as frequency decreased, such that individuals high in social anxiety symptoms were more likely than others to misproduce words that are unfamiliar or rare.

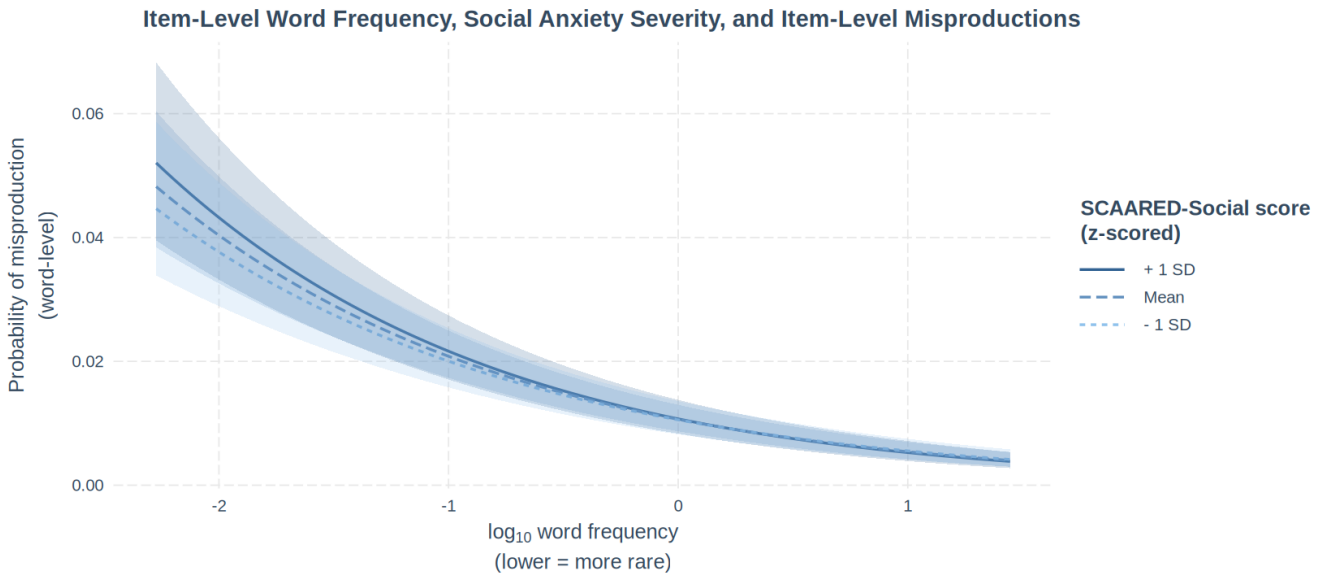

Figure 4. Item-level misproductions across word frequency for three levels of social anxiety symptom severity. At the item level, words are coded for misproductions as 0 (absence of a misproduction) or 1 (presence of a misproduction). A word's frequency reflects the z-scored, base-10 logarithm of one plus the number of times it occurs in the SUBTLEXus corpus. SCAARED-Social Score is the z-scored social phobias subscore of the Screen for Adult Anxiety Related Disorders, presented at the mean value and at one standard deviation above or below. Fitted values are connected as straight lines and shading denotes 95% confidence intervals.

Table 5: Model results predicting likelihood of word-level hesitation with word frequency, SCAARED-Social score, and their interaction

Predictors	*β*	*SE*	*df*	*CI*	*z*	*p*	
Intercept	0.02	0.00	Inf	0.01 – 0.02	-46.09	<**0.001**	***
Word frequency	0.64	0.03	Inf	0.59 – 0.70	-10.69	<**0.001**	***
SCAARED social	1.24	0.10	Inf	1.07 – 1.45	2.81	**0.005**	**
Word frequency × SCAARED social	1.01	0.01	Inf	0.98 – 1.04	0.70	0.484	

** p<0.05 ** p<0.01 *** p<0.001*

Table 6: Model results predicting likelihood of word-level misproduction with word frequency, SCAARED-Social score, and their interaction

Predictors	*β*	*SE*	*df*	*CI*	*z*	*p*	
Intercept	0.01	0.00	Inf	0.01 – 0.01	-44.24	<**0.001**	***
Word frequency	0.51	0.03	Inf	0.46 – 0.56	-13.35	<**0.001**	***
SCAARED social	1.01	0.08	Inf	0.86 – 1.18	0.09	0.926	
Word frequency × SCAARED social	0.97	0.02	Inf	0.94 – 1.00	-2.01	**0.045**	*

** p<0.05 ** p<0.01 *** p<0.001*

Word level analysis reveals that hesitations are more likely to immediately follow, not precede, misproductions

Given that hesitation and misproduction rates were positively associated at the passage level, we next sought to analyze the potential corresponding relations at the word level, including whether hesitations might more often occur either immediately before or immediately after a given misproduction. In other words, we sought to test whether hesitations may potentially predict subsequent misproductions, or alternatively, to test whether hesitations might possibly result from a given misproduction (i.e., post-error slowing; Danielmeier & Ullsperger, 2011; Jentzsch & Dudschig, 2009). We further examined whether any of these relations differed as a function of social anxiety symptoms. Thus, again at the item level, we fit a logistic mixed effects model predicting the presence or absence of a misproduction on a given word. In addition to social anxiety symptoms and the word frequency of the word in question, a new predictor was entered as a fixed effect expressing the relative position of the window searched for an adjacent hesitation (i.e., either within five words before or five words after the word in question). Each word in the text thus corresponded to two observations in this model, once for each direction (before or after, as defined by this variable) in which to search for a possible hesitation. The binary presence/absence of a hesitation in the window searched, as well as all possible interactions between the four predictors, were entered as fixed effects; subject and passage were entered as random intercepts. Consistent with previous models, results revealed a significant main effect of word frequency ($p < 0.001$, $\beta = -0.687$, $SE = 0.057$) on likelihood of word-level misproduction, and we observed a similar interaction with social anxiety symptoms in this model ($p = 0.025$, $\beta = -0.029$, $SE = 0.013$). No significant direct relationship was detected for the overall presence/absence of an adjacent hesitation (i.e., without considering its relative position; $p = 0.159$). Yet, as hypothesized, we identified a significant interaction between the presence/absence of an adjacent hesitation in the window searched and the relative position of this window ($p = 0.031$, $\beta = 0.082$, $SE = 0.038$). Follow-up analyses using the emmeans package (Lenth, 2025) demonstrated that the nature of this interaction was such that a misproduction was specifically more likely in the case that a nearby hesitation *was* present *and* came after the word in question (FDR-corrected $p = 0.039$), whereas the likelihood of an interaction did not differ based on the presence/absence of a hesitation before a misproduction (FDR-corrected $p = 0.317$). This result is compatible with an effect of post-error

slowing (Danielmeier & Ullsperger, 2011), which appears to be present in all individuals, given no further interactions with social anxiety symptoms. This analysis additionally uncovered a new word frequency effect: there was another significant interaction, such that misproductions were more likely than chance to be adjacent to a hesitation (without respect to its relative position), yet this was only the case for low-frequency words (p = 0.045; β = 0.082, SE = 0.038).

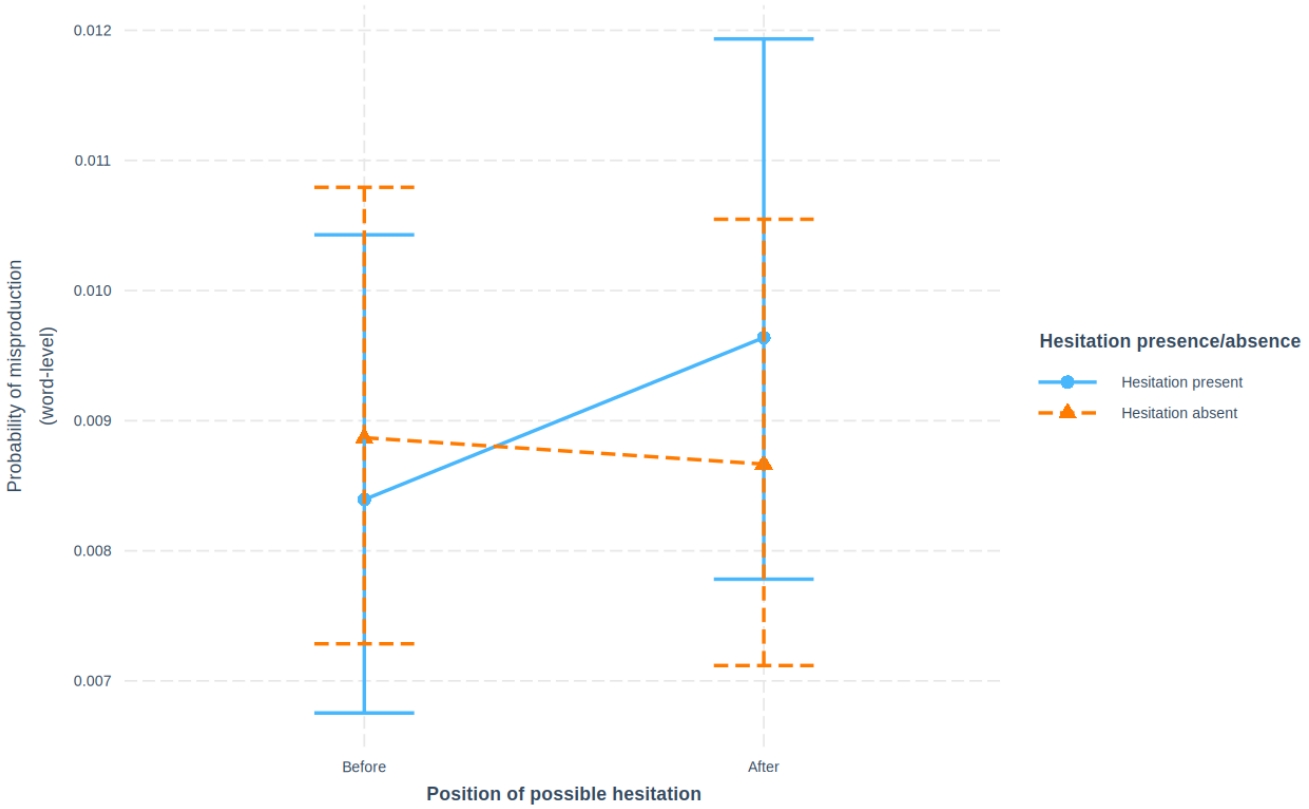

Figure 5. Item-level likelihood of misproductions as a function of hesitation presence before/after. Probability of a target word being a misproduction was predicted as a function of whether a hesitation occurred within 5 words of the target word, and whether any such hesitation occurred before the target word (during the preceding 5 words) vs. after the target word (during the following 5 words). Note that it was significantly more likely for the target word to contain a misproduction when it was followed by a hesitation, but did not differ based on whether it was preceded by a hesitation.

Table 7: Model results predicting likelihood of word-level misproduction with presence/absence of adjacent hesitation in relevant window, direction looked for hesitation presence/absence, word frequency, SCAARED-Social score, and their interactions

Predictors	*β*	*SE*	*df*	*CI*	*z*	*p*	
Intercept	0.01	0.00	Inf	0.01 – 0.01	-47.19	**<0.001**	***
Adjacent hesitation present	1.03	0.04	Inf	0.95 – 1.11	0.67	0.502	
Position of possible hesitation = after	0.99	0.01	Inf	0.96 – 1.02	-0.81	0.419	
Word frequency	0.50	0.03	Inf	0.45 – 0.56	-12.07	**<0.001**	***
SCAARED social	1.02	0.08	Inf	0.87 – 1.20	0.27	0.787	
Adjacent hesitation present × Position of possible hesitation = after	1.08	0.04	Inf	1.01 – 1.17	2.16	**0.031**	*
Adjacent hesitation present × Word frequency	0.94	0.03	Inf	0.88 – 1.00	-2.00	**0.045**	*
Position of possible hesitation = after × Word frequency	0.99	0.01	Inf	0.97 – 1.02	-0.73	0.467	
Adjacent hesitation present × SCAARED social	0.98	0.04	Inf	0.91 – 1.05	-0.56	0.572	
Position of possible hesitation = after × SCAARED social	1.00	0.01	Inf	0.97 – 1.03	0.05	0.958	
Word frequency × SCAARED social	0.97	0.01	Inf	0.95 – 1.00	-2.24	**0.025**	*
Adjacent hesitation present × Position of possible hesitation = after × Word frequency	1.07	0.04	Inf	1.00 – 1.14	1.94	0.052	
Adjacent hesitation present × Position of possible hesitation = after × SCAARED social	1.00	0.04	Inf	0.93 – 1.07	-0.08	0.938	
Adjacent hesitation present × Word frequency × SCAARED social	1.00	0.03	Inf	0.94 – 1.06	-0.03	0.979	
Position of possible hesitation = after × Word frequency × SCAARED social	1.00	0.01	Inf	0.97 – 1.02	-0.18	0.861	
Adjacent hesitation present × Position of possible hesitation = after × Word frequency × SCAARED social	1.01	0.03	Inf	0.95 – 1.08	0.46	0.648	

** p<0.05 ** p<0.01 *** p<0.001*

Discussion

The present study finds evidence that symptoms of social anxiety are associated with performance deficits during naturalistic reading aloud. At the passage level, we found that social anxiety symptoms were associated with increased hesitation rates, but not misproduction rates. At the word level, social anxiety symptoms were associated with increased hesitations *and* increased misproductions, but selectively among low-frequency words in the latter case. Moreover, among all participants, we found that misproduction rates were positively associated with hesitation rates at the passage level, and further analysis at the word level clarified that misproductions were more likely to have a hesitation after them than before. Hesitations in naturalistic reading aloud thus may reflect the *result* of misproductions, akin to a “post-error slowing” effect associated with performance monitoring to detect one’s mistakes while reading aloud (Danielmeier & Ullsperger, 2011). Therefore, for individuals high in social anxiety symptoms, increased hesitation rates may be indicative of a maladaptive form of increased performance monitoring (Jentzsch & Dudschig, 2009;

Notebaert et al., 2009; Wessel, 2018) that does not lead to subsequent improvements in performance.

We began with the idea that perhaps performance deficits in association with social anxiety were not consistently identified in prior work (Miers et al., 2009; Schneider & Turk, 2014; Spence et al., 1999) because, contrary to models of choking under pressure (Baumeister, 1984), heightened attention to performance might sustain or even improve surface performance. By contrast, in our initial models at the whole-passage level we find the opposite to be true: social anxiety symptoms were positively correlated with rates of disfluency (although no correlation was found with rates of misproductions). We sought to clarify whether these disfluencies were an indication of extra time spent internalizing the material or rather a deliberate attempt to buy time and prevent 'worse' errors in the upcoming text—a speed-accuracy tradeoff, as has been widely observed in speech fluency and other domains (MacKay, 1982). In order to determine whether such a strategy might explain the increase in hesitations seen in association with social anxiety symptoms, we probed the relationship between hesitations and misproductions. In direct contrast to those ideas, we found a positive main effect of hesitation rate on misproduction rate—and without significant interaction with social anxiety. Thus, hesitations appear not to be a helpful preventive measure against misproductions. This finding on its own was consistent with either an account of hesitations as reflecting distraction *caused* by an error (misproduction; Buzzell et al., 2017; Jentzsch & Dudschig, 2009; Notebaert et al., 2009) or with an account of hesitations as an attempt to stifle misproductions (Postma et al., 1990; Postma & Kolk, 1993) —merely an unhelpful or even maladaptive one. Additionally, the question of why hesitations were associated with higher social anxiety symptoms still remained unanswered.

To further investigate the link between hesitations and misproductions, we conducted additional positional analyses at the level of individual words. We found that misproductions were more likely to be followed by a hesitation, as opposed to preceded by one. This pattern is consistent with a “post-error slowing” effect, indicative of performance monitoring processes to self-detect one’s mistakes while reading aloud (Danielmeier & Ullsperger, 2011). Performance monitoring can lead to both adaptive and maladaptive outcomes (Danielmeier & Ullsperger, 2011; Wessel, 2018). However, in the current study, several findings point to our hesitation measure reflecting a maladaptive outcome of performance monitoring. First, at the

passage level, a higher hesitation rate was predictive of a higher misproduction rate. Second, at the word level, we found that a given word was more likely to contain a misproduction if it was followed by a hesitation (i.e., a post-error slowing effect). Finally, we did not identify any evidence at the word level to suggest that hesitations prior to a given word decreased misproduction likelihood for that word. Extending these interpretations to the finding that social anxiety symptoms were associated with higher hesitations rates (at both the passage and word level), our results converge on the interpretation that individuals high in social anxiety symptoms exhibit heightened self-monitoring (Barker et al., 2015; Hosseini et al., 2024; Lahat et al., 2014; Meyer et al., 2021). Crucially, this increase in performance monitoring appears to be maladaptive (Buzzell et al., 2017; Jentzsch & Dudschig, 2009; Notebaert et al., 2009), as it comes at the cost of reading fluency, with no observed benefit in terms of misproduction rate.

Finally, it should be noted that effects of social anxiety symptom severity in the incidence of misproductions were dependent on word-level features. At the passage level, when not considering word-level features, we did not identify any evidence for an association between social anxiety and misproduction rate. Only for our word-level analysis, when taking into consideration the familiarity of a given word (word frequency; Brysbaert & New, 2009), did any relationship between misproductions and social anxiety emerge. Specifically, we found that all individuals misproduced rare words more often than common ones, but the likelihood of misproducing rare words was even greater among individuals high in social anxiety symptoms. Thus, individuals high in social anxiety *did* in fact misproduce words more often than others—but they only did so significantly more than others when those words were low-frequency. Interpreting this effect is somewhat speculative. For example, it may be that individuals high in social anxiety symptoms are particularly sensitive to material that is unfamiliar (Boelen & Reijntjes, 2009). If this effect is primarily driven by those words that are completely unknown to the reader, one possibility is that perhaps those high in social anxiety have a more limited vocabulary, or are otherwise less successful than others in making a convincing educated guess about how a new word is pronounced. Alternatively, perhaps words that are unfamiliar but not altogether unknown drive this effect—such that doubts of their memory of a word's pronunciation taxes cognitive resources and leads to an error. Regardless if either of these accounts are correct, this result supports the presence of performance deficits in social anxiety, in line with prior work utilizing phonetic data (Rapee &

Lim, 1992; Silber-Varod et al., 2016). Moreover, it suggests that, consistent with more fine-grained analyses in prior work, such deficits are tied to the nature of the stimuli of the task (Schneider & Turk, 2014; Thompson et al., 2019), even within time windows as short as a few hundred milliseconds.

Broadly, this finding also reinforces the argument that fine-grained analyses are critical in detecting potential performance deficits within social settings in social anxiety. The observed interaction suggests that clear, albeit subtle performance deficits exist among individuals high in social anxiety in their verbal performance in the naturalistic setting of reading aloud. Future investigations should ideally employ measures that are quantitative, that are highly detailed, and that minimize or eliminate any elements of subjective observation of performance.

Summary

In this investigation, we found that individuals high in social anxiety symptoms displayed performance deficits in the naturalistic setting of reading aloud. Analyses at the passage level indicated that social anxiety symptoms were associated with increased rates of hesitations, but not of misproductions. However, when performing more fine-grained analyses at the word level, we found evidence that social anxiety symptoms were associated with increases in both hesitations and misproductions. Of note, the association between social anxiety symptoms and misproductions was fully dependent on taking into consideration word frequency (familiarity). That is, individuals higher in social anxiety were more likely than others to misproduce words, but only rare words. Finally, we observed that misproductions were more likely to precede hesitations, compatible with a post-error slowing phenomenon that is indicative of performance monitoring processes (Danielmeier & Ullsperger, 2011; Jentzsch & Dudschig, 2009). Future work should explore these questions in greater detail, to include investigations into additional stimulus features that may condition these relationships as well as neural measures. Broadly, the results demonstrate the utility of fine-grained measurement in studying social performance deficits and align with mechanistic accounts of hyperactive self-monitoring in social anxiety.

Acknowledgments

Research reported in this publication was supported by the National Institute of Mental Health of the National Institutes of Health under award number R21 MH131928. The authors have no conflicts of interest to report.

References

Alexander, J. M., & Buzzell, G. A. (2023). Emotional context and predictability in naturalistic reading aloud. *Emotion*. https://psycnet.apa.org/record/2024-08306-001

Balota, D. A., & Chumbley, J. I. (1984). Are Lexical Decisions a Good Measure of Lexical Access? The Role of Word Frequency in the Neglected Decision Stage. *Journal of Experimental Psychology. Human Perception and Performance*, *10*(3), 340–357.

Barker, T. V., Troller-Renfree, S., Pine, D. S., & Fox, N. A. (2015). Individual differences in social anxiety affect the salience of errors in social contexts. *Cognitive, Affective, & Behavioral Neuroscience*, *15*(4), 723–735. https://doi.org/10.3758/s13415-015-0360-9

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Baumeister, R. F. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology*, *46*(3), 610–620. https://doi.org/10.1037//0022-3514.46.3.610

Beidel, D. C., Turner, S. M., & Dancu, C. V. (1985). Physiological, cognitive and behavioral aspects of social anxiety. *Behaviour Research and Therapy*, *23*(2), 109–117. https://doi.org/10.1016/0005-7967(85)90019-1

Beidel, D. C., Turner, S. M., & Morris, T. L. (1999). Psychopathology of Childhood Social Phobia. *Journal of the American Academy of Child & Adolescent Psychiatry*, *38*(6), 643–650. https://doi.org/10.1097/00004583-199906000-00010

Blöte, A. W., Miers, A. C., Heyne, D. A., & Westenberg, P. M. (2015). Social Anxiety and the School Environment of Adolescents. In K. Ranta, A. M. La Greca, L.-J. Garcia-Lopez, & M. Marttunen (Eds.), *Social Anxiety and Phobia in Adolescents: Development, Manifestation and Intervention Strategies* (pp. 151–181). Springer International

Publishing. https://doi.org/10.1007/978-3-319-16703-9_7

Boelen, P. A., & Reijntjes, A. (2009). Intolerance of uncertainty and social anxiety. *Journal of Anxiety Disorders*, *23*(1), 130–135. https://doi.org/10.1016/j.janxdis.2008.04.007

Bridges, D., Pitiot, A., MacAskill, M. R., & Peirce, J. W. (2020). The timing mega-study: Comparing a range of experiment generators, both lab-based and online. *PeerJ*, *8*, e9414. https://doi.org/10.7717/peerj.9414

Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods*, *41*(4), 977–990. https://doi.org/10.3758/BRM.41.4.977

Buzzell, G. A., Beatty, P. J., Paquette, N. A., Roberts, D. M., & McDonald, C. G. (2017). Error-Induced Blindness: Error Detection Leads to Impaired Sensory Processing and Lower Accuracy at Short Response–Stimulus Intervals. *The Journal of Neuroscience*, *37*(11), 2895–2903. https://doi.org/10.1523/JNEUROSCI.1202-16.2017

Chavira, D. A., & Stein, M. B. (2005). Childhood Social Anxiety Disorder: From Understanding to Treatment. *Child and Adolescent Psychiatric Clinics*, *14*(4), 797–818. https://doi.org/10.1016/j.chc.2005.05.003

Danielmeier, C., & Ullsperger, M. (2011). Post-Error Adjustments. *Frontiers in Psychology*, *2*. https://doi.org/10.3389/fpsyg.2011.00233

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*(2), 336–353. https://doi.org/10.1037/1528-3542.7.2.336

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research*

Methods, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Flesch, R. (1948). A new readability yardstick. *Journal of Applied Psychology*, *32*(3), 221–233. https://doi.org/10.1037/h0057532

Fox, J. (2003). Effect displays in R for generalised linear models. *Journal of Statistical Software*, *8*(15), 1–27. https://doi.org/10.18637/jss.v008.i15

Fox, J., & Weisberg, S. (2019). *An R companion to applied regression* (3rd ed.). Sage. https://socialsciences.mcmaster.ca/jfox/Books/Companion/index.html

Gordon, M. (2014). *htmlTable: Advanced Tables for Markdown/HTML* (Version 2.4.3) [R]. https://cran.r-project.org/web/packages/htmlTable

Harris, P. A., Taylor, R., Minor, B. L., Elliott, V., Fernandez, M., O'Neal, L., McLeod, L., Delacqua, G., Delacqua, F., Kirby, J., & Duda, S. N. (2019). The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics*, *95*, 103208. https://doi.org/10.1016/j.jbi.2019.103208

Hosseini, K., Pettit, J. W., Soto, F. A., Mattfeld, A. T., & Buzzell, G. A. (2024). Toward a mechanistic understanding of the role of error monitoring and memory in social anxiety. *Cognitive, Affective, & Behavioral Neuroscience*. https://doi.org/10.3758/s13415-024-01198-5

Inderbitzen-Nolan, H. M., Anderson, E. R., & Johnson, H. S. (2007). Subjective versus objective behavioral ratings following two analogue tasks: A comparison of socially phobic and non-anxious adolescents. *Journal of Anxiety Disorders*, *21*(1), 76–90. https://doi.org/10.1016/j.janxdis.2006.03.013

Jalongo, M. R., & Hirsh, R. A. (2010). Understanding Reading Anxiety: New Insights from Neuroscience. *Early Childhood Education Journal*, *37*(6), 431–435. https://doi.org/10.1007/s10643-010-0381-5

Jentzsch, I., & Dudschig, C. (2009). Short Article: Why do we slow down after an error? Mechanisms underlying the effects of posterror slowing. *Quarterly Journal of Experimental Psychology*, *62*(2), 209–218. https://doi.org/10.1080/17470210802240655

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software*, *82*, 1–26. https://doi.org/10.18637/jss.v082.i13

Ladefoged, P. (1996). *Elements of Acoustic Phonetics*. University of Chicago Press.

Lahat, A., Lamm, C., Chronis-Tuscano, A., Pine, D. S., Henderson, H. A., & Fox, N. A. (2014). Early Behavioral Inhibition and Increased Error Monitoring Predict Later Social Phobia Symptoms in Childhood. *Journal of the American Academy of Child & Adolescent Psychiatry*, *53*(4), 447–455. https://doi.org/10.1016/j.jaac.2013.12.019

Lau, N., Zhou, A. M., Yuan, A., Parigoris, R., Rosenberg, A. R., & Weisz, J. R. (2023). Social Skills Deficits and Self-appraisal Biases in Children with Social Anxiety Disorder. *Journal of Child and Family Studies*, *32*(9), 2889–2900. https://doi.org/10.1007/s10826-021-02194-w

Lenth, R. V. (2025). *emmeans: Estimated marginal means, aka least-squares means* [Manual]. https://CRAN.R-project.org/package=emmeans

Long, J. A. (2024). *interactions: Comprehensive, user-friendly toolkit for probing interactions* [Manual]. https://doi.org/10.32614/CRAN.package.interactions

Losiak, W., Blaut, A., Klosowska, J., & Slowik, N. (2015). Social Anxiety, Affect, Cortisol Response and Performance on a Speech Task. *Psychopathology*, *49*(1), 24–30. https://doi.org/10.1159/000441503

Lüdecke, D. (2024). *sjPlot: Data visualization for statistics in social science* [Manual].

https://CRAN.R-project.org/package=sjPlot

MacKay, D. G. (1982). The problems of flexibility, fluency, and speed–accuracy trade-off in skilled behavior. *Psychological Review*, *89*(5), 483–506. https://doi.org/10.1037/0033-295X.89.5.483

Meyer, A., Mehra, L., & Hajcak, G. (2021). Error-related negativity predicts increases in anxiety in a sample of clinically anxious female children and adolescents over 2 years. *Journal of Psychiatry and Neuroscience*, *46*(4), E472–E479. https://doi.org/10.1503/jpn.200128

Miers, A. C., Blöte, A. W., Bokhorst, C. L., & Michiel Westenberg, P. (2009). Negative self-evaluations and the relation to performance level in socially anxious children and adolescents. *Behaviour Research and Therapy*, *47*(12), 1043–1049. https://doi.org/10.1016/j.brat.2009.07.017

Millward, R. E. (1977). Round Robin is not an endangered species. *Reading World*, *16*(4), 288–291. https://doi.org/10.1080/19388077709557376

Notebaert, W., Houtman, F., Opstal, F. V., Gevers, W., Fias, W., & Verguts, T. (2009). Post-error slowing: An orienting account. *Cognition*, *111*(2), 275–279. https://doi.org/10.1016/j.cognition.2009.02.002

Postma, A., & Kolk, H. (1993). The Covert Repair Hypothesis. *Journal of Speech, Language, and Hearing Research*, *36*(3), 472–487. https://doi.org/10.1044/jshr.3603.472

Postma, A., Kolk, H., & Povel, D.-J. (1990). On The Relation among Speech Errors, Disfluencies, and Self-Repairs. *Language and Speech*, *33*(1), 19–29. https://doi.org/10.1177/002383099003300102

R Core Team. (2025). *R: a language and environment for statistical computing* [Manual]. R Foundation for Statistical Computing. https://www.R-project.org/

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741–756. https://doi.org/10.1016/S0005-7967(97)00022-3

Rapee, R. M., & Lim, L. (1992). *Discrepancy Between Self- and Observer Ratings of Performance in Social Phobics*.

S1601: LANGUAGE SPOKEN AT HOME - Census Bureau Table. (n.d.). Retrieved August 2, 2024, from https://data.census.gov/table/ACSST1Y2021.S1601?g=050XX00US12086

Schneider, B. W., & Turk, C. L. (2014). Examining the Controversy Surrounding Social Skills in Social Anxiety Disorder: The State of the Literature. In *The Wiley Blackwell Handbook of Social Anxiety Disorder* (pp. 366–387). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118653920.ch17

Silber-Varod, V., Kreiner, H., Lovett, R., Levi-Belz, Y., & Amir, N. (2016). Do social anxiety individuals hesitate more? The prosodic profile of hesitation disfluencies in Social Anxiety Disorder individuals. *Proceedings of Speech Prosody 8*. Speech Prosody, Boston, MA. https://www.semanticscholar.org/paper/Do-social-anxiety-individuals-hesitate-more-The-of-Silber-Varod-Kreiner/6e61ea5608e816204e5a683a471b40f311865795

Spence, S. H., Donovan, C., & Brechman-Toussaint, M. (1999). Social skills, social outcomes, and cognitive features of childhood social phobia. *Journal of Abnormal Psychology*, *108*(2), 211–221. https://doi.org/10.1037/0021-843X.108.2.211

Strahan, E., & Conger, A. J. (1998). Social Anxiety and Its Effects on Performance and Perception. *Journal of Anxiety Disorders*, *12*(4), 293–305. https://doi.org/10.1016/S0887-6185(98)00016-4

Tavakoli, S., Matteo, B., Pigoli, D., Chodroff, E., Coleman, J., Gubian, M., Renwick, M. E. L.,

& Sonderegger, M. (2025). Statistics in Phonetics. *Annual Review of Statistics and Its Application*, *12*(1), 133–156. https://doi.org/10.1146/annurev-statistics-112723-034642

Thompson, T., Van Zalk, N., Marshall, C., Sargeant, M., & Stubbs, B. (2019). Social anxiety increases visible anxiety signs during social encounters but does not impair performance. *BMC Psychology*, *7*(1), 24. https://doi.org/10.1186/s40359-019-0300-5

Voncken, M. J., & Bögels, S. M. (2008). Social performance deficits in social anxiety disorder: Reality during conversation and biased perception during speech. *Journal of Anxiety Disorders*, *22*(8), 1384–1392. https://doi.org/10.1016/j.janxdis.2008.02.001

Wessel, J. R. (2018). An adaptive orienting theory of error processing. *Psychophysiology*, *55*(3), e13041. https://doi.org/10.1111/psyp.13041

Wickham, H., François, R., Henry, L., Müller, K., & Vaughan, D. (2023). *dplyr: A grammar of data manipulation* [Manual]. https://CRAN.R-project.org/package=dplyr

Wickham, H., & Henry, L. (2023). *purrr: Functional programming tools* [Manual]. https://CRAN.R-project.org/package=purrr

Wickham, H., Hester, J., & Ooms, J. (2023). *xml2: Parse XML* [Manual]. https://CRAN.R-project.org/package=xml2