Surprise Paper Supplement

# Supplement

## Experimental Task

Participants were told that the task involves learning how to speak to others, either through practice or observation. They were informed that they were in the first group (learning by doing), and that a second group would rate their performance based on the following criteria:

* How loud and clear their voice was
* How nervous they appeared
* Whether they stumbled over their words
* How clever they seemed
* How interesting they were
* How much they blushed

These criteria were adapted from the Observer Rating Questionnaires by Cartwright-Hatton et al. (2003) and are relevant for assessing performance and communication in socially anxious individuals.

Before each trial, participants were shown information about how critical or easy-going each virtual player had been in the past. This was displayed using a histogram, presented only once per virtual player to avoid over-reliance on these values. Additionally, virtual players’ profile photos showed either a neutral or a smiling (closed-lip) expression, based on findings from one of our pilot studies showing that neutral faces were perceived as more critical.To generate the virtual player profile picture stimuli we gave the following instructions to the volunteers:

*“Please take at least 3 photographs using your computer webcam. Ensure that the background is relatively simple, such as a bedroom, living room, or kitchen, and that no other people or identifiable information (student ID, passport, workplace logo etc.) are visible in the frame. In each photograph, please depict a neutral, happy, or threatening facial expression (ensuring the mouth is closed in all instances—i.e., smiling with a closed mouth). Maintain a comfortable posture as if you are engaged in a task on your computer. Feel free to send us multiple versions of each facial expression if you are uncertain about which ones are most appropriate.”*

Before each trial, participants also shared their expectations about how they think they will perform and received feedback from each virtual player after their performance (both were ratings between 0-100, from worst to best performance). In the first 4 trials, participants were presented the following:

1. The picture of a virtual player paired with a histogram, showing how they had previously rated others. There were 4 different virtual players in total, paired only once with their corresponding histograms on trials 1 to 4.
2. They were asked to predict how they think they will perform on a scale of 0-100 (from ‘Minimum’ to ‘Maximum’).
3. A picture they had to describe to the virtual player in 15 seconds while being video recorded. There was also a count down on the screen to help participants track the time. The picture of the virtual player was also presented on top of the screen.
4. They were then presented with feedback from the virtual player, which was on a scale of 0-100 (from ‘Minimum’ to ‘Maximum’).
5. They were asked to rate their anxiety and mood on a scale of 0-100 (from ‘Very relaxed’ to ‘Very nervous/uncomfortable’ for anxiety, and from ‘Very unhappy’ to ‘Very happy’ for mood).

For the remaining 44 trials, the same procedure was followed, except that virtual players were reintroduced using only their photo and name, no histogram was shown again.

Two practice trials were included before the main task. These trials were structurally identical but involved cartoon images instead of virtual player.

After completing all trials, participants answered the following questions (items 2–5 were open-ended):

1. “How stressful was this as a social situation?” on a scale of 0-100 (from ‘Not at all stressful’ to ‘Very stressful’)
2. “How did you feel during the task?”
3. “What was difficult and/or easy about this task?”
4. “How was the experience of being observed by the virtual players?
5. “What did you think of the virtual players and the scores they gave you?”

The following aspects were randomized between participants:

* Order of virtual player/histogram presentation in trials 1–4
* Order of mood and anxiety ratings
* Order of virtual player feedback across trials (while keeping the number and size of each PE constant across the task for all participants)

The final version of the task was informed by several pilot studies and a meta-analysis conducted prior to data collection. Details of these pilot studies, the meta-analytic findings, and additional task information are available in the preregistration document (<https://osf.io/73zsg/>).

## Participant Demographics

## Aim 1: Identify the computations underlying momentary mood and anxiety in our social task

### Model comparison results

#### Mood models

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| Table 1: Model comparison results for Mood models   | **Model** | **MAE** | **MSE** | **LOOIC** | **WAIC** | **R²** | **Rank** | | --- | --- | --- | --- | --- | --- | --- | | model 1 | 0.40 | 0.35 | 12,849.3 | 12,523.4 | 0.65 | 8 | | model 2 | 0.39 | 0.33 | 12,553.6 | 12,226.8 | 0.67 | 7 | | model 3 | 0.34 | 0.25 | 10,946.9 | 10,560.8 | 0.75 | 2 | | model 4 | 0.34 | 0.25 | 10,991.9 | 10,612.7 | 0.75 | 3 | | model 5 | 0.36 | 0.28 | 11,698.0 | 11,305.3 | 0.72 | 4 | | model 6 | 0.39 | 0.32 | 12,475.1 | 12,133.6 | 0.68 | 6 | | model 7 | 0.39 | 0.33 | 12,435.2 | 12,113.8 | 0.67 | 5 | | **model 8** | **0.32** | **0.22** | **10,351.9** | **9,967.1** | **0.78** | **1** | |

#### Anxiety models

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| Table 2: Model comparison results for Anxiety models   | **Model** | **MAE** | **MSE** | **LOOIC** | **WAIC** | **R²** | **Rank** | | --- | --- | --- | --- | --- | --- | --- | | model 1 | 0.32 | 0.22 | 10,335.6 | 9,991.7 | 0.78 | 7 | | model 2 | 0.31 | 0.21 | 10,036.1 | 9,749.9 | 0.79 | 4 | | model 3 | 0.31 | 0.20 | 9,988.4 | 9,610.6 | 0.80 | 3 | | model 4 | 0.31 | 0.21 | 10,174.4 | 9,782.2 | 0.79 | 5 | | model 5 | 0.35 | 0.26 | 11,460.7 | 11,111.2 | 0.74 | 8 | | model 6 | 0.31 | 0.21 | 10,176.5 | 9,826.2 | 0.79 | 6 | | model 7 | 0.30 | 0.20 | 9,622.3 | 9,279.6 | 0.80 | 2 | | **model 8** | **0.28** | **0.18** | **9,036.1** | **8,645.9** | **0.82** | **1** | |

### Group-level Posterior Parameter Estimates for Model 8

#### Mood

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Table 3: Group-level Posterior Parameter Estimates - Mood   | **Parameter** | **Mean** | **SE** | **HDI Low** | **HDI High** | **Rhat** | | --- | --- | --- | --- | --- | --- | | *Intercept* | -0.04 | 0 | -0.16 | 0.08 | 1.01 | | *Social Feedback* | 0.22 | 0 | 0.19 | 0.26 | 1.00 | | *Positive PE* | 0.01 | 0 | 0.00 | 0.03 | 1.00 | | *Negative PE* | -0.01 | 0 | -0.02 | 0.01 | 1.00 | | *γ* | 0.93 | 0 | 0.91 | 0.95 | 1.00 | | *σ* | 0.41 | 0 | 0.38 | 0.43 | 1.00 | |

#### Anxiety

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| Table 4: Group-level Posterior Parameter Estimates - Anxiety   | **Parameter** | **Mean** | **SE** | **HDI Low** | **HDI High** | **Rhat** | | --- | --- | --- | --- | --- | --- | | *Intercept* | 0.25 | 0 | 0.13 | 0.37 | 1.01 | | *Social Feedback* | -0.09 | 0 | -0.11 | -0.07 | 1.00 | | *Positive PE* | -0.04 | 0 | -0.06 | -0.03 | 1.00 | | *Negative PE* | 0.04 | 0 | 0.02 | 0.06 | 1.00 | | *γ* | 0.93 | 0 | 0.92 | 0.95 | 1.00 | | *σ* | 0.38 | 0 | 0.36 | 0.40 | 1.00 | |

### Model fits for 16 randomly-chosen participants

#### Mood

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| Figure 1: Reported and predicted mood across trials for 16 randomly-chosen participants. Each panel shows z-scored values across trials. Reported mood is shown in grey and predicted mood in blue. Predicted values are derived from the posterior mean of a hierarchical Bayesian model. |

#### Anxiety

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| Figure 2: Reported and predicted anxiety across trials for 16 randomly-chosen participants. Each panel shows z-scored values across trials. Reported anxiety is shown in grey and predicted mood in red. Predicted values are derived from the posterior mean of a hierarchical Bayesian model. |

### Posterior Predictive Checks for Model 8

We conducted posterior predictive checks (PPCs) to evaluate the fit of Model 8 to participants’ mood and anxiety ratings. Using the posterior predictive distribution generated from the fitted Stan model, we compared reported mood and anxiety responses with model-generated predictions across multiple posterior draws. As shown in the histograms, the observed data fall within the range of simulated data, indicating that the models adequately capture key features of the mood and anxiety response distributions across trials. This visual inspection supports the plausibility of the model’s assumptions and predictive performance.

#### Mood

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| Figure 3: Posterior Predictive Checks Model 8 - Mood |

#### Anxiety

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| Figure 4: Posterior Predictive Checks Model 8 - Anxiety |

## Aim 2: Explore how these computations vary with individual differences in mental health symptoms

### Distributions of Social Anxiety (SA) Symptoms

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| Table 5: Distribution of LSAS scores by participant group. LSAS scores were categorized into severity bands based on age group: adolescent-specific thresholds were applied to school participants aged 14–18, and adult-specific thresholds were used for all other groups. Severity categories range from ‘No Social Anxiety’ to ‘Very Severe.’ The histogram displays the distribution of total LSAS scores within each group, with color indicating the corresponding severity category. |

### Distributions of Depression (DEP) Symptoms

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| Table 6: Distribution of depression scores by participant group. Depression symptoms were assessed using the CES-D for all groups except school participants aged 14–18, who were assessed using the RCADS. The CES-D scores range from 0 to 60, while RCADS scores range from 0 to 30. Depression categories were determined using standard cutoffs: scores ≥16 on the CES-D and gender- and age-specific thresholds on the RCADS. |

### Group-level Posterior Parameter Estimates for Model 8 with SA effects.

The following tables show the group-level parameters estimated from the modified model that includes a main effect for SA, as well as interaction effects of SA for all parameters.

#### Mood

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| Table 7: Group-level Posterior Parameter Estimates for Model 8 with SA effects - Mood   | **Parameter** | **Mean** | **HDI Low** | **HDI High** | **Rhat** | | --- | --- | --- | --- | --- | | *Intercept* | -0.04 | -0.16 | 0.06 | 1.00 | | *Social Feedback* | 0.22 | 0.19 | 0.25 | 1.00 | | *Positive PE* | 0.01 | -0.00 | 0.03 | 1.00 | | *Negative PE* | -0.00 | -0.02 | 0.01 | 1.00 | | *γ* | 0.93 | 0.91 | 0.95 | 1.01 | | *σ* | 0.39 | 0.36 | 0.42 | 1.00 | | *SA* | -0.17 | -0.84 | 0.54 | 1.00 | | *Intercept x SA* | -0.18 | -0.90 | 0.49 | 1.00 | | *Social Feedback x SA* | 0.04 | 0.00 | 0.07 | 1.01 | | *Positive PE x SA* | 0.01 | -0.01 | 0.03 | 1.00 | | *Negative PE x SA* | -0.01 | -0.02 | 0.00 | 1.00 | | *γ x SA* | -0.02 | -0.16 | 0.11 | 1.00 | | *σ x SA* | 0.03 | -0.05 | 0.10 | 1.00 | |

#### Anxiety

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| Table 8: Group-level Posterior Parameter Estimates for Model 8 with SA effects - Anxiety   | **Parameter** | **Mean** | **HDI Low** | **HDI High** | **Rhat** | | --- | --- | --- | --- | --- | | *Intercept* | 0.28 | 0.16 | 0.39 | 1.00 | | *Social Feedback* | -0.09 | -0.11 | -0.07 | 1.00 | | *Positive PE* | -0.05 | -0.06 | -0.03 | 1.00 | | *Negative PE* | 0.05 | 0.03 | 0.07 | 1.00 | | *γ* | 0.93 | 0.92 | 0.95 | 1.00 | | *σ* | 0.36 | 0.34 | 0.38 | 1.00 | | *SA* | 0.19 | -0.48 | 0.90 | 1.00 | | *Intercept x SA* | 0.20 | -0.53 | 0.85 | 1.00 | | *Social Feedback x SA* | -0.04 | -0.06 | -0.02 | 1.00 | | *Positive PE x SA* | -0.01 | -0.03 | 0.00 | 1.00 | | *Negative PE x SA* | 0.00 | -0.01 | 0.02 | 1.00 | | *γ x SA* | -0.05 | -0.17 | 0.05 | 1.00 | | *σ x SA* | 0.04 | -0.03 | 0.10 | 1.00 | |

### Posterior distributions of Pearson correlations between participant-level parameter estimates and SA scores

To assess the relationship between each model parameter and the SA scores, we computed the posterior distribution of Pearson correlation coefficients () between each parameter’s posterior samples and participants’ SA scores. For each parameter, we report the mean correlation, the 95% highest density interval (HDI), and the probability of direction (i.e., the proportion of the posterior supporting a positive or negative effect). This analysis provides a Bayesian estimate of the strength and certainty of the association between each parameter and SA scores.

#### Mood

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| Table 9: Posterior correlations distributions between participant-level parameters and SA scores - Mood   | **Correlation** | **Mean r** | **HDI Low** | **HDI High** | **P(Direction)** | | --- | --- | --- | --- | --- | | *Intercept x SA* | -0.228 | -0.649 | 0.271 | 78.8 | | *Social Feedback x SA* | 0.154 | 0.116 | 0.197 | 100.0 | | *Positive PE x SA* | -0.038 | -0.139 | 0.065 | 75.9 | | *Negative PE x SA* | -0.077 | -0.209 | 0.059 | 87.1 | | *γ x SA* | -0.087 | -0.255 | 0.068 | 84.5 | | *σ x SA* | -0.057 | -0.089 | -0.024 | 100.0 | |

#### Anxiety

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| Table 10: Posterior correlations distributions between participant-level parameters and SA scores - Anxiety   | **Correlation** | **Mean r** | **HDI Low** | **HDI High** | **P(Direction)** | | --- | --- | --- | --- | --- | | *Intercept x SA* | 0.321 | -0.165 | 0.700 | 87.2 | | *Social Feedback x SA* | -0.274 | -0.329 | -0.217 | 100.0 | | *Positive PE x SA* | -0.058 | -0.152 | 0.030 | 89.3 | | *Negative PE x SA* | 0.065 | -0.043 | 0.165 | 88.7 | | *γ x SA* | -0.110 | -0.261 | 0.047 | 91.5 | | *σ x SA* | 0.064 | 0.027 | 0.099 | 100.0 | |

### Posterior Predictive Checks for Model 8 with SA effects

We performed PPCs to assess the fit of the modified winning model incorporating SA as both a main effect and in interaction terms. As before, we compared observed mood and anxiety responses with model-generated predictions across multiple posterior draws. The checks confirm that the inclusion of SA terms does not compromise model fit and continues to capture key distributional features of the observed data.

#### Mood

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| Figure 5: Posterior Predictive Checks Model 8 with SA effects - Mood |

#### Anxiety

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| Figure 6: Posterior Predictive Checks Model 8 with SA effects - Anxiety |

### Group-level Posterior Parameter Estimates for Model 8 with DEP effects.

The following tables show the group-level parameters estimated from the modified model that includes a main effect for Depression Symptoms (DEP), as well as interaction effects of DEP for all parameters.

#### Mood

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| Table 11: Group-level Posterior Parameter Estimates for Model 8 with DEP effects - Mood   | **Parameter** | **Mean** | **se\_mean** | **HDI Low** | **HDI High** | **Rhat** | | --- | --- | --- | --- | --- | --- | | *Intercept* | -0.04 | 0 | -0.14 | 0.07 | 1.01 | | *Social Feedback* | 0.22 | 0 | 0.19 | 0.26 | 1.00 | | *Positive PE* | 0.01 | 0 | 0.00 | 0.03 | 1.00 | | *Negative PE* | 0.00 | 0 | -0.02 | 0.01 | 1.00 | | *γ* | 0.93 | 0 | 0.91 | 0.95 | 1.01 | | *σ* | 0.39 | 0 | 0.36 | 0.42 | 1.00 | | *DEP* | -0.19 | 0 | -0.85 | 0.53 | 1.00 | | *Intercept x DEP* | -0.18 | 0 | -0.85 | 0.53 | 1.00 | | *Social Feedback x DEP* | 0.01 | 0 | -0.03 | 0.04 | 1.00 | | *Positive PE x DEP* | 0.00 | 0 | -0.01 | 0.02 | 1.00 | | *Negative PE x DEP* | -0.01 | 0 | -0.03 | 0.00 | 1.00 | | *γ x DEP* | -0.07 | 0 | -0.21 | 0.07 | 1.00 | | *σ x DEP* | -0.03 | 0 | -0.10 | 0.05 | 1.00 | |

#### Anxiety

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| Table 12: Group-level Posterior Parameter Estimates for Model 8 with DEP effects - Anxiety   | **Parameter** | **Mean** | **se\_mean** | **HDI Low** | **HDI High** | **Rhat** | | --- | --- | --- | --- | --- | --- | | *Intercept* | 0.28 | 0 | 0.16 | 0.39 | 1.02 | | *Social Feedback* | -0.09 | 0 | -0.11 | -0.06 | 1.00 | | *Positive PE* | -0.05 | 0 | -0.06 | -0.03 | 1.01 | | *Negative PE* | 0.05 | 0 | 0.03 | 0.06 | 1.00 | | *γ* | 0.93 | 0 | 0.92 | 0.95 | 1.00 | | *σ* | 0.36 | 0 | 0.34 | 0.38 | 1.00 | | *DEP* | 0.17 | 0 | -0.49 | 0.87 | 1.00 | | *Intercept x DEP* | 0.17 | 0 | -0.53 | 0.83 | 1.00 | | *Social Feedback x DEP* | -0.02 | 0 | -0.04 | 0.00 | 1.00 | | *Positive PE x DEP* | 0.00 | 0 | -0.02 | 0.01 | 1.00 | | *Negative PE x DEP* | 0.01 | 0 | -0.01 | 0.03 | 1.00 | | *γ x DEP* | 0.02 | 0 | -0.10 | 0.13 | 1.00 | | *σ x DEP* | 0.03 | 0 | -0.04 | 0.09 | 1.00 | |

### Posterior distributions of Pearson correlations between participant-level parameter estimates and DEP scores

To assess the relationship between each model parameter and the DEP scores, we computed the posterior distribution of Pearson correlation coefficients () between each parameter’s posterior samples and participants’ DEP scores.

#### Mood

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| Table 13: Posterior correlations distributions between participant-level parameters and DEP scores - Mood   | **Correlation** | **Mean r** | **HDI Low** | **HDI High** | **P(Direction)** | | --- | --- | --- | --- | --- | | *Intercept x DEP* | -0.193 | -0.804 | 0.523 | 69.6 | | *Social Feedback x DEP* | 0.026 | -0.018 | 0.072 | 87.4 | | *Positive PE x DEP* | 0.002 | -0.115 | 0.110 | 51.9 | | *Negative PE x DEP* | -0.178 | -0.349 | -0.009 | 97.9 | | *γ x DEP* | -0.116 | -0.332 | 0.096 | 85.2 | | *σ x DEP* | -0.072 | -0.110 | -0.034 | 100.0 | |

#### Anxiety

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| Table 14: Posterior correlations distributions between participant-level parameters and DEP scores - Anxiety   | **Correlation** | **Mean r** | **HDI Low** | **HDI High** | **P(Direction)** | | --- | --- | --- | --- | --- | | *Intercept x DEP* | 0.175 | -0.493 | 0.776 | 68.6 | | *Social Feedback x DEP* | -0.188 | -0.255 | -0.121 | 100.0 | | *Positive PE x DEP* | -0.023 | -0.118 | 0.072 | 68.3 | | *Negative PE x DEP* | 0.083 | -0.048 | 0.203 | 90.5 | | *γ x DEP* | 0.020 | -0.155 | 0.179 | 60.5 | | *σ x DEP* | 0.102 | 0.060 | 0.141 | 100.0 | |

### Posterior Predictive Checks for Model 8 with DEP effects

We performed PPCs to assess the fit of the modified winning model incorporating DEP as both a main effect and in interaction terms. The checks confirm that the inclusion of DEP terms does not compromise model fit and continues to capture key distributional features of the observed data.

#### Mood

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| Figure 7: Posterior Predictive Checks Model 8 with DEP effects - Mood |

#### Anxiety

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| Figure 8: Posterior Predictive Checks Model 8 with DEP effects - Anxiety |

To be added:

* traceplots
* parameter recovery?
* Distributions of SA and DEP

Cartwright-Hatton, S., Hodges, L., & Porter, J. (2003). Social anxiety in childhood: the relationship with self and observer rated social skills. *Journal of Child Psychology and Psychiatry*, *44*(5), 737–742. <https://doi.org/10.1111/1469-7610.00159>