Psychophysiological modelling of heart rate and skin conductance in observational fear conditioning

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Introduction

Emotional responses are frequently acquired through observation of the pain and fear reactions exhibited by other persons exposed to aversive stimuli, as opposed to direct aversive experiences. This is the premise for studies in vicarious fear conditioning, which can be traced back at least to the 1960s (1). Recently, a formal experimental protocol of Observational Fear Conditioning has been proposed (2). According to this protocol, the participant (Observer) first watches a recording of another person (Demonstrator) undergoing an aversive conditioning procedure (two neutral visual stimuli are presented, and one of them is paired with an electric shock to the forearm). Subsequently, the Observer is informed that they will undergo the same procedure in order to test their emotional responses to the conditioned stimuli alone.

Previous studies used this protocol to explore various aspects of vicarious acquisition of fear. In particular, they demonstrated that social learning of threat and safety is more effective when the Demonstrator belongs to the same racial group as the Observer (3) and that it can be influenced by social biases, such as the Demonstrator being a supporter of the same soccer team (4).

The above considerations led us to designing the currently ongoing fMRI study, with two groups (variants), 30 participants each, which differed by participants' relationship and observation process:

a) Demonstrator and Observer are friends, video is streamed live
b) Demonstrator and Observer are strangers, video recordings are used.

In addition to fMRI, we acquire pulse oxymetry and skin conductance data. These measurements provide information complementary to MRI and can provide a link to other, psychophysiological experiments. This poster describes the preliminary analysis of skin conductance and heart rate, with an emphasis on available methodologies.

Observational Fear Conditioning

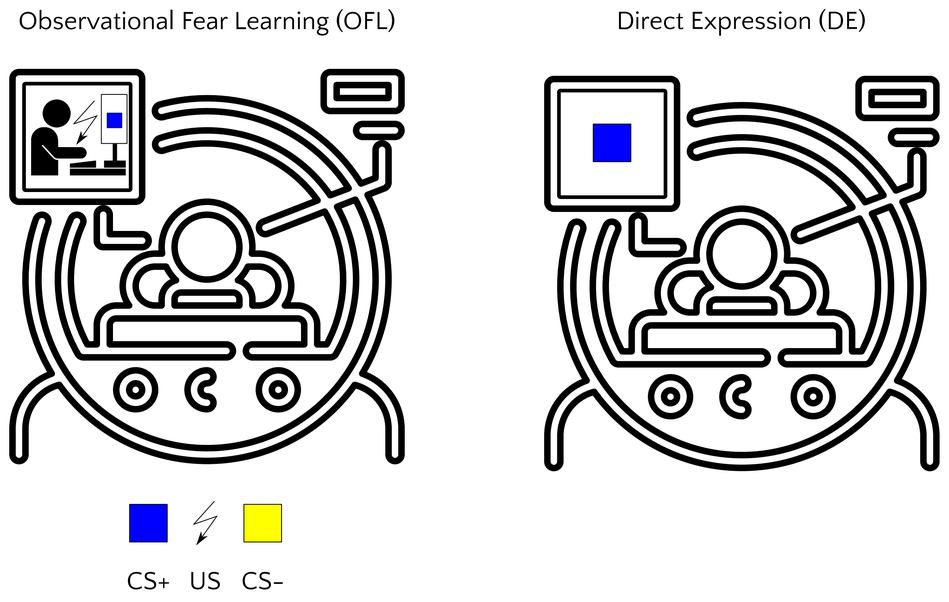

Figure 1. During Observational Fear Learning, the participant (Observer), who is in the MRI scanner, watches another person (Demonstrator) perform a conditioning task, where one visual cue (CS+) is paired with electric shocks with 50 % probability, while the other cue (CS-) is not. Later, during Direct Expression, the same CSs are presented to the Observer, but no shocks are administered. Figure was created using icons designed by freepik and wanicon from Flaticon.

Psychophysiological Modelling

Psychophysiological signals are typically analysed by different variants of peak scoring. However, in current experiment we are planning to employ psychophysiological modelling (5) instead. This approach relies on predefined models linking psychological variables, neural activity and physiological signals. During analysis, such models are "inverted", i. e. model paramers are fitted so that the modelled time series (based on stimulus timings) most closely resembles the observed time series. Obtained parameters are then used as the basis for inference. We are using methods implemented in PsPM toolbox (http://pspm.sourceforge.net/).

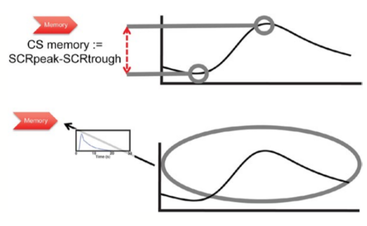

Figure 2. Operational analysis (top) assumes that selected data features are “equivalent” to a psychological variable, where the selection of data features is often based on informal models. Psychophysiological modeling (bottom) estimates the most likely psychological variable, given the entire data time series and a standard (experiment-invariant) response model. Figure and description taken from (5).

Skin Conductance Responses

We have analysed Skin Conductance Responses in both stages of the experiment. During Observational Fear Learning we are interested in responses to the observational US (i. e. shock to the demonstrator), as this stimulus facilitates fear acquisition / learning. During Direct Expression we are interested in the differential response to CS+ / CS- presented directly to the Observer, as this response relates to the conditioned fear.
We performed peak-vs-baseline scoring of responses and analysed them using Repeated Measures ANOVA in R (ez v4.4 package). For both stages found a significant main effect of stimulus (OFL: $F = 25.86$, $p < 0.001$; DE: $F = 10.17$, $p = 0.003$), but no effect of group and no interaction.
Results reported for N=16 (friend group) and N=15 (stranger group) participants.
We plan to repeat the analysis using PsPM once all data are collected.

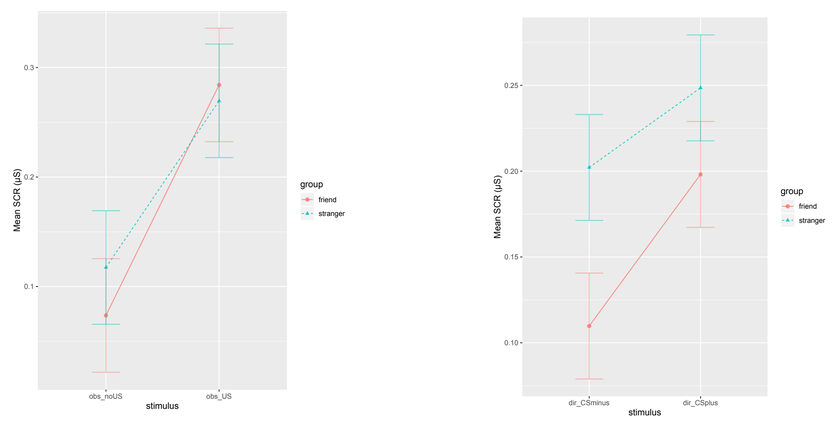

Figure 3. Averaged Skin Conductance Responses during Observational Fear Learning (left) and Direct Expression (right) stages. Error bars show Fisher's Least Significant Difference.

Heart Rate

We analysed the Direct Expression stage testing for fear-conditioned bradycardia, for which an experimentally validated (6) model is available in PsPM. Bradycardia is assessed in a continuous time series created by interpolating instantaneous heart period, obtained (in our case) from pulse oximeter recording.
We analysed Heart Period Response parameter estimates for CS+ and CS- using Repeated Measures ANOVA, in a way analogous to Skin Conductance. We found no signifficant effects of either group or stimulus and no interaction between these factors.
Results reported for N=22 (friend group) and N=19 (stranger group) participants.
Given that the skin conductance data indicate quick extinction of fear during the Direct expression stage, we plan to repeat the analysis using a trimmed time series.

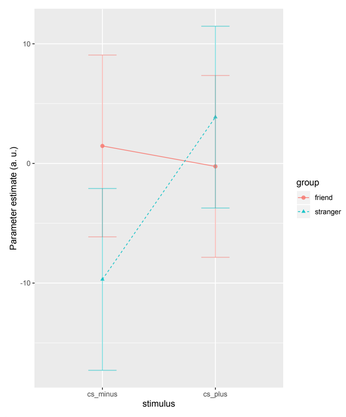

Figure 4. Averaged parameter estimates for Heart Period Response during Direct Expression stage. Error bars show Fisher's Least Significant Difference.

Conclusions

Skin Conductance Responses indicate that **vicarious fear conditioning is equally effective for known and unknown demonstrators**.
No effects were observed for Heart Period Responses, but further inspection of this modality is required.
Obtained results provide information complementary to fMRI.

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This project is funded by National Science Centre, grant 2015/19/B/HS6/02209