Temporal Unpredictability Increases Amygdala Activation and Decreases Trust

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This work was supported by NIH P50-MH069315.

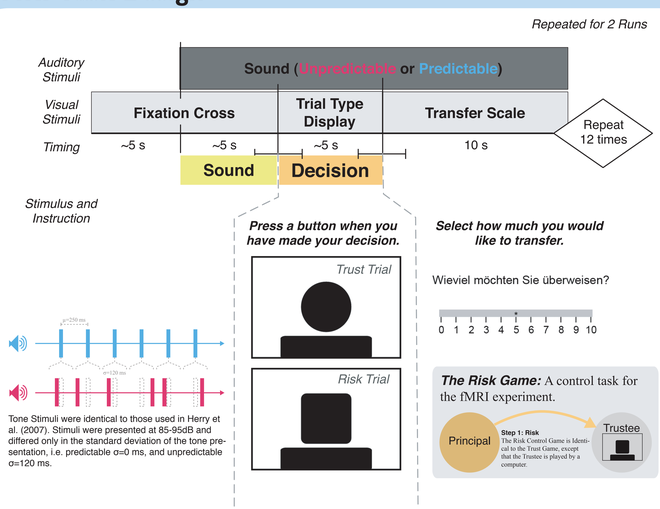
This work was supported by the University Research Priority Program on the Foundations of Human Social Behavior.

Experiment and Rationale

- Trust is ubiquitous in human society and is critical for interpersonal interaction.
- Recent work investigating the biological bases of trust suggests the amygdala plays a critical role in the decision to trust a stranger (Winston et al., 2002; Engell et al., 2007; Todorov, 2008; Adolphs et al., 1998; Baumgartner et al. 2008).
- If amygdala activation does in-fact cause a decrease in trust behavior, we should be able to alter trust by experimentally altering amygdala activity.
- **In our study we examined the effect of experimentally induced amygdala activation on trust behavior in a simple economic game, called the Trust Game.**

In the Trust Game, we gave participants (Proposers) 10 Monetary Units (MU's; paid in Swiss Franc's) and offered them the opportunity to invest any number of MU's in an anonymous individual designated as the trustee. For each MU invested by the participant, the trustee received 3 MU's that they could distribute between themselves and the participant as they saw fit. If the participant believes the trustee to be trustworthy they will maximize their gains by investing all of their MU's, whereas if the participant believes the trustee to be untrustworthy they retain the most MU's by investing nothing.

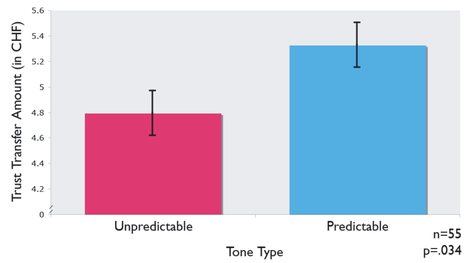
fMRI Task Design



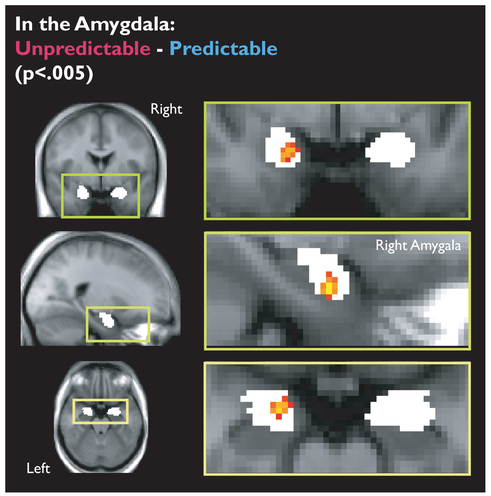
Tone Stimuli were identical to those used in Herry et al. (2007). Stimuli were presented at 85-95dB and differed only in the standard deviation of the tone presentation, i.e. predictable σ=0 ms, and unpredictable σ=120 ms.

The Unpredictable Tone Decreases Trust

In our experiment, while Principals (n=55) were making this decision we exposed them to unpredictably spaced auditory stimuli, which are known to activate the amygdala (Herry et al., 2007). Results demonstrated a main effect of tone-type on trust behavior, such that Principals trusted less when exposed to an unpredictable tone (seen in pink) as compared to a predictable tone (seen in blue; $t(53)=2.176$, $p=.034$). This was not true for a matched risk-task which approximately half the subjects engaged i (data not shown).

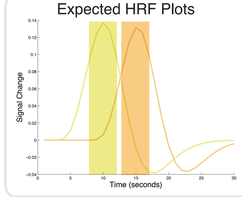


The Unpredictable Tone increases Amygdala Activation



In order to visualize this effect, we plotted the average trial for the peak voxel when the subject was hearing an unpredictable tone (seen in pink) and a predictable tone (seen in blue). Note the significant increase in unpredictable tone induced activation during the "sound period."

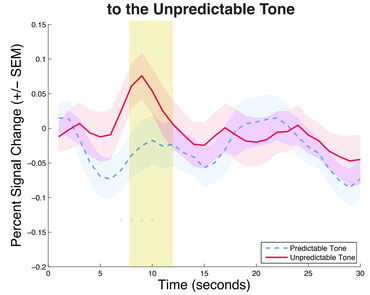
Expected HRF Plots



The expected time-course for the "sound period" and "decision period," seen in yellow and orange respectively.

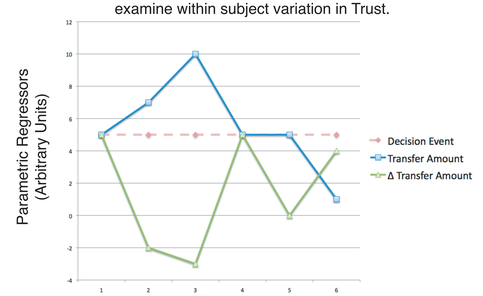
Approximately half the subjects who underwent behavioral testing played the trust game while undergoing fMRI (n=28). Each individual's fMRI data was slice-time, and motion corrected, before being transformed to MNI space using SPM5. All statistical analyses were performed using fmristat. Data were modelled with three events during each trial, the "sound period" (indicated in yellow), the "decision period" (indicated in orange), and the "transfer period." Analysis of fMRI data during the "sound period" (seen in yellow) demonstrated a main effect of tone-type on amygdala activation, such that BOLD in some amygdala regions was greater when participants were exposed to an unpredictable tone (seen in pink), relative to a predictable tone (seen in blue; $p<.005$, voxel-wise). Other regions showing this effect include, bilateral Auditory cortex and Left Dorsolateral Prefrontal Cortex while Mid-Cingulate Cortex and the Right Precunius show the inverse relationship, i.e. more activation during the "sound period" in response the predictable tone.

Increased Amygdala Activity in response to the Unpredictable Tone

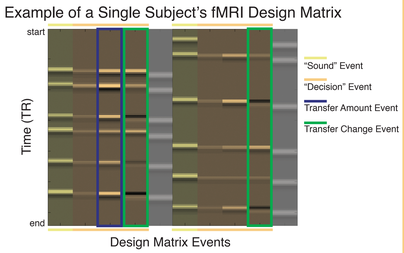


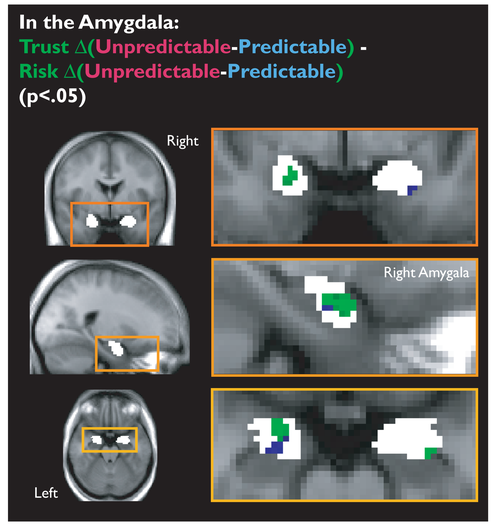
Within Subject Decreases in Trust are Predicted by Amygdala Activation

Parametric regressors were convolved with the HRF to examine within subject variation in Trust.



Example of a Single Subject's fMRI Design Matrix

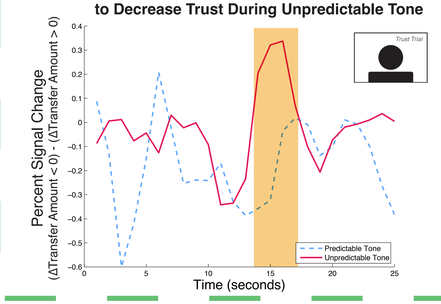




Approximately half of the fMRI subjects (n=15) showed sufficient variability to examine within-subject predictors of trust-behavior. In order to investigate the within subject correlates of trust behavior, we created parametrically modulated regressors which reflected Transfer Amount (seen in dark blue), an indicator the absolute level of trust, and the change (Δ) in Transfer Amount (seen in green), taken as an indicator of a local-baseline corrected level of trust. Both of these parameters were convolved with the canonical hemodynamic response function (hrf) and added to the single subject design matrix for these subjects. Across subject analyses controlling for gray-matter probability (see Oakes et al., 2007) demonstrated both parameters were significantly-correlated with regions within the amygdala ($p<.05$, voxelwise).

For display purposes, we plotted event-related decision time-course for the difference between trials where the ΔTransfer Amounts were greater than zero as compared to those in which the Δ Transfer Amounts were less than zero, from the amygdala regions where ΔTransfer Amount parameter was significant (seen in green). In this plot, the orange area indicates the decision period, and increased values suggest more activation when an individual transfers less money.

Increased Amygdala Response when Deciding to Decrease Trust During Unpredictable Tone



- We found that, compared to a predictable tone, an unpredictable tone decreased trust and increased amygdala activity.
- We found that trial by trial decreases in trust during the unpredictable tone condition were associated with increased amygdala activation.
- **These data suggest that task-irrelevant manipulation of amygdala activity influences the decision to trust.**