How the brain trades speed and accuracy

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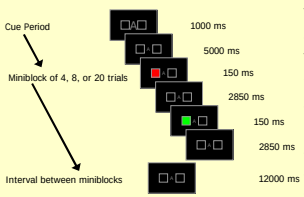
Introduction

- Speed-accuracy tradeoff (SAT) refers to the fact that when we focus on speed, we tend to make errors; when we focus on accuracy, we tend to be slow.
- Computational models of decision-making assume that "evidence" accumulates from a baseline to threshold; SAT is implemented by a manipulation of the distance between baseline and threshold
  - Greater distance – accuracy emphasis
  - Smaller distance – speed emphasis.
- Empirical evidence is lacking. We sought to test the notion that speed emphasis was associated with increased baseline activation in decision- and response-related areas.

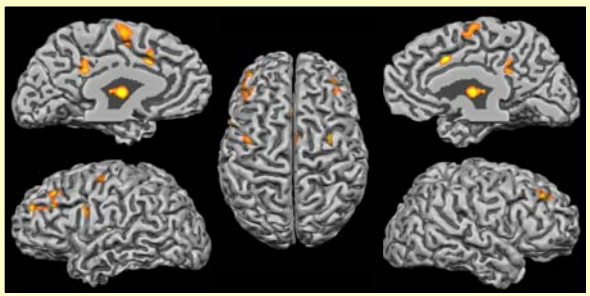
Methods

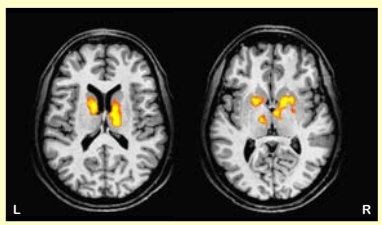


- Differential activation to cues should reflect adjustment of threshold or baseline.
- Whole-brain scan*SAT repeated measures ANOVA, $P<.001$, using first 6 scans following each cue.

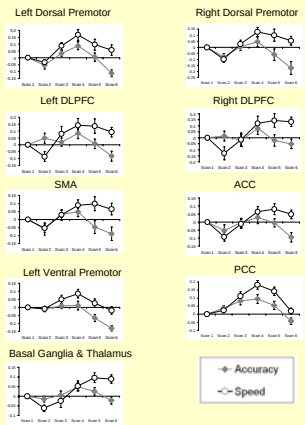
- Simon task with cues followed by "miniblocks" of trials.
- Red or green square presented left or right of fixation point
- Participants (N = 20) are instructed to ignore location and respond to color with left or right index finger button press
- Congruent if presentation side and response hand match, incongruent when opposite side
- Stimulus duration = 150 ms, ITI = 2850 ms
- 2/3 congruent, 1/3 incongruent

Results - Cues





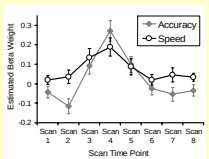
Region of interest	BA	Volume (mm^3)	x, y, z
Supplementary Motor Area	6	1017	-2, -6, 60
Left dorsal premotor cortex	6	277	-38, -7, 55
Right dorsal premotor cortex	6	578	34, -7, 59
Anterior cingulate cortex	32/24	986	0, 15, 39
Left DLPFC	8/9	676	-39, 39, 37
Right DLPFC	8/9	546	37, 38, 42
Left ventral premotor cortex	6/44	985	-53, 3, 27
Posterior cingulate cortex	31	9511	0, -40, 31
Basal ganglia / thalamus		986	1, -2, 12



- In all of these areas, activity was greater to speed cues than to accuracy cues.
- Post-hoc tests were performed, using sustained and transient regressors throughout each miniblock. These showed that for all of these areas (except PCC), greater activation under speed emphasis was sustained (controlling for transient activations related to Simon task).

Results – Simon stimuli

Deconvolution analysis of the dorsal premotor cortices corresponding to contralateral responses showed that response-related activation was associated with a decreased baseline but increased transient response ($P <$ .001), consistent with the notion that more activation is needed to reach response threshold.



Conclusions

- Speed emphasis is associated with increased baseline activation of decision- and motor related areas.
- Increased baseline activation is observed in entire prefrontal (caudate, VA, DM of thalamus) and premotor (CMA, SMA, PMC, putamen, VL of thalamus) cortico-striato-thalamo-cortical loops.
- DLPFC activation most likely provides top-down support, increasing the baseline activation under speed emphasis, most likely via caudate.
- Transient response-related activation is greater under accuracy emphasis.
- The results support the assumptions of computational models.