The effect of object state-changes on event processing: Do objects compete with themselves?

Nicholas C. Hindy[1], Gerry T.M. Altmann[2] & Sharon L. Thompson-Schill[1]
[1]University of Pennsylvania, [2]The University of York

INTRODUCTION

Events often entail changes in state of individual objects. How do we maintain distinct representations corresponding to the 'before' and 'after' of a described event?

On reading "*the squirrel will crack the acorn*", we must keep track of multiple representational instantiations of the acorn –before it was cracked, and after. Conversely, reading "*the squirrel will sniff the acorn*" requires only a single (unchanged) instantiation of the acorn.

The left inferior frontal gyrus (LIFG) has previously been demonstrated to be central in resolving competition amongst incompatible representations of a stimulus, as produced by an ambiguous word or a garden-path sentence (e.g., Hindy et al., 2009; January et al., 2009). To test the hypothesis that multiple object instantiations compete when an object is changed from its original state, we examined fMRI activity within LIFG across three tasks: (i) an event comprehension task; (ii) a Stroop interference functional localizer; and (iii) a sentence comprehension functional localizer.

METHODS

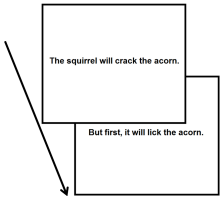
STIMULI

2 (object change) x 2 (temporal order) within-subjects factorial design

Condition labels: SI=single instantiation; MI=multiple instantiation (cracked vs. uncracked); TR=temporal resequencing

A. The squirrel will sniff the acorn. But first, it will lick the acorn. **[SI, TR]**
B. The squirrel will sniff the acorn. And then, it will lick the acorn. **[SI]**
C. The squirrel will crack the acorn. But first, it will lick the acorn. **[MI, TR]**
D. The squirrel will crack the acorn. And then, it will lick the acorn. **[MI]**

EVENT COMPREHENSION TASK



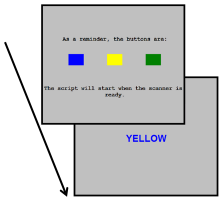
N = 16 (9 female)

135 trials (30 trials of each condition & 15 catch trials)

Each trial lasted 6 sec: first sentence presented for 3 sec, followed by second sentence for 3 sec

Ss responded when the second sentence was implausible given the first sentence.

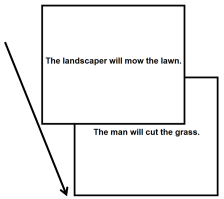
FUNCTIONAL LOCALIZERS



Stroop Interference

Task
Conflict trials interspersed with neutral trials (e.g., "farmer"). Ss pressed button to indicate font color of each word.

fROI
15 most responsive LIFG* voxels for contrast of conflict trials vs. neutral trials



Sentence Comprehension

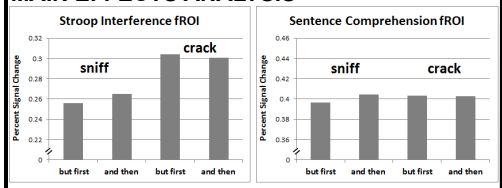
Task
12 sentence & 12 nonword blocks. Ss responded when consecutive trials had related sentences or identical nonwords.

fROI
15 most responsive LIFG voxels for contrast of sentence blocks vs. nonword blocks

*LIFG defined in Talairach space using probabilistic maps of BA44 & BA45 (Amunts et al., 1999)

LIFG

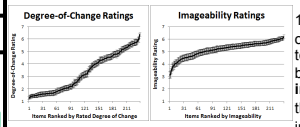
MAIN EFFECTS ANALYSIS



Main effect of object change: $F(1,15) = 4.80$ ($p<.05$), but not temporal order in Stroop fROI

No main effects or interactions in sentence comprehension fROI

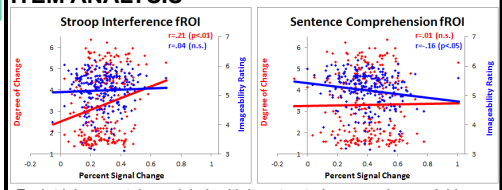
RATED STIMULUS DIMENSIONS



1st sentence of each item rated on **degree of change** (extent to which the object is changed by the event) and **imageability** (extent to which the action elicits a clear mental image)

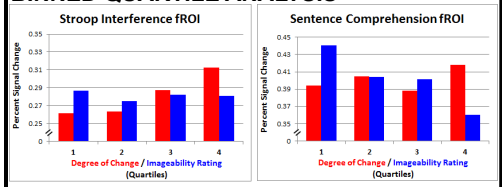
Stroop Interference fROI **Sentence Comprehension fROI**

ITEM ANALYSIS



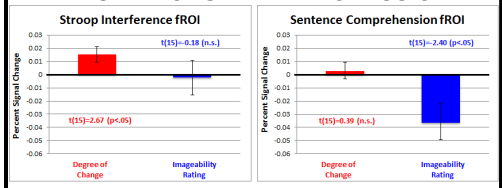
Each trial separately modeled, with item treated as a random variable. Best-fit lines displayed for degree of change (red) & imageability (blue).

BINNED QUARTILE ANALYSIS



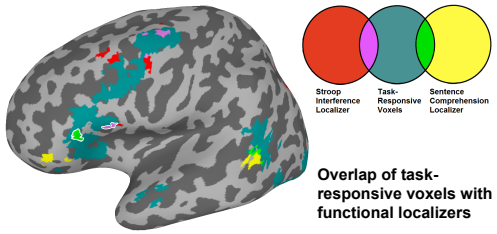
Data binned according to either degree-of-change rating or imageability rating of corresponding stimuli. Each bin includes 30 trials.

AMPLITUDE MODULATED REGRESSION



For either degree of change or imageability, separately modeled mean fMRI response for each time series, & the degree to which the response was modulated in accord with the rating scores.

WHOLE-BRAIN



Overlap of task-responsive voxels with functional localizers

Clusters of at least 15 contiguous voxels. Maps thresholded to display single largest LIFG cluster for each functional localizer (t>3 for Stroop; t>6.65 for Sentence). Task-responsive voxels have t>8.5 for all conditions vs. baseline.

DISCUSSION

Tracking objects across events requires maintaining multiple representations of the same object in different states (Altmann & Kamide, 2009). We demonstrate that this component of event cognition elicits a neural response in LIFG that overlaps with increased activation for incongruent trials in a Stroop color naming task, and does not overlap with increased LIFG activation seen during a sentence comprehension localizer.

Through analysis of rated stimulus norms, we further observe that activity corresponding to functional localizers is separately modified by variations in distinct stimulus dimensions. The degree to which an object is changed through an event modulates the percent signal change in the Stroop interference fROI, while the rated imageability of an event modulates percent signal change in the sentence comprehension fROI. The imageability effect in the sentence comprehension fROI converges with recent evidence for greater activation in middle LIFG for words with lower imageability or concreteness ratings (e.g., Bedny & Thompson-Schill, 2006). The object-change effect in the Stroop interference fROI is the first neural evidence for interference between multiple representations of the *same* entity in different states.

LINGERING QUESTIONS

Graded or Probabilistic?
(i) Could be that the more an object is changed, the more semantic dimensions will be in conflict between the instantiations.
(ii) Could be that the more an object is changed, the greater the probability that a new representation of the object will be constructed & will compete for attention with the initial representation.

Object or Action?
(i) Conflict may be between action-independent object representations.
(ii) Conflict may be tied directly to abstract representations of the actions.

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CONTACT

Nicholas Hindy: hindy@psych.upenn.edu
http://www.psych.upenn.edu/stslab/
http://homepage.mac.com/gerry_altmann/