

## Evidence for shared conceptual structure for psychological and physical events

Natural language is characterized by systematic correspondences between meaning and form: e.g., causal agents=transitive subjects. This tight correspondence has led to the hypothesis that how we structure a sentence is determined by the meaning, or the conceptual content, that we wish to convey. But this hypothesis runs into problems when the same meaning appears to be encoded in two different syntactic structures, as in the case of emotions (1-2).

- (1) Sally feared/hated/loved Max
- (2) Max frightened/angered/delighted Sally

Such examples call into question the prevalence of systematic mappings from semantics to syntax. However, just as the words *car*, *automobile*, and *sedan* may all refer to the same vehicle but have distinct meanings, two sentences can refer to the same event but have different meanings because they pick out different *construals*, or conceptualizations, of the event.

Recent theories of semantic representation characterize these construals as structured representations that include both a verbal root and one or more primitive predicates (for review and discussion, see Levin & Rappaport Hovav, 2005). These primitive predicates encode aspects of meaning that are present in many different verbs, and can be used in combination (by embedding one predicate within another) to form more complex semantic structures (3-4).

- (3) The vase broke: [y BECOME <STATE><sub>broken</sub>]
- (4) Sally broke the vase: [x CAUSE [y BECOME <STATE><sub>broken</sub>]]

Critically, for these types of structures, the argument that is highest in the semantic tree becomes the subject of a sentence (which is the highest argument in the syntactic tree), while the argument that is lower in the semantic tree becomes the direct object. Thus, differences in structural prominence are preserved in the linking from semantics to syntax. This approach provides a straightforward solution to the linking problem posed by emotion verbs (5-6).

- (5) Sally feared Max: [y BE [<EMOTIONAL STATE><sub>fear</sub> ABOUT x]]
- (6) Max frightened Sally: [x CAUSE [y BE <EMOTIONAL STATE><sub>fear</sub>]]

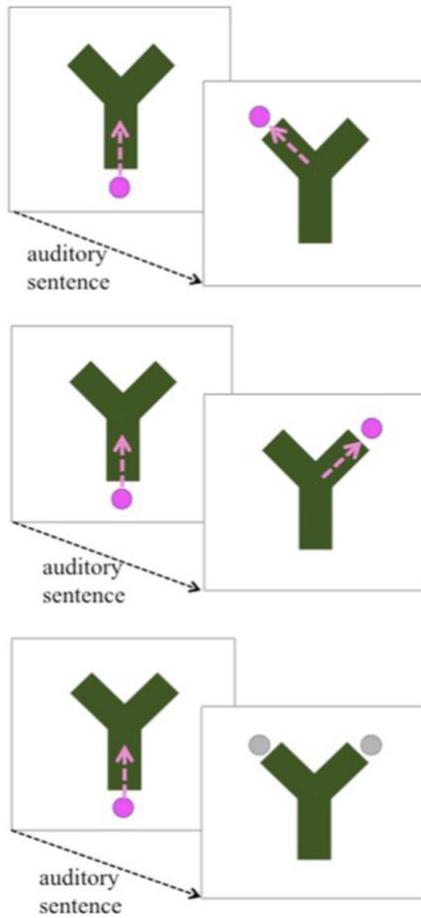
This theory of (verb) meaning makes several predictions. The first is that language users should perceive *frighten* verbs as more causal than *fear* verbs. Recent work confirms this (Hartshorne et al., 2016). Second, if these two kinds of verbs are categorially different, participants should readily learn a rule that differentiates them. Third, on this hypothesis, the distinction between emotion verbs (5-6) is parallel to the distinction between non-causal and causal physical events (3-4). Thus, if participants learn a rule that applies to *frighten* verbs (but not *fear* verbs), we should expect them to extend it to the causal physical events (but not non-causal ones).

**Methods:** Our task is based on Wittenberg et al.'s (2017) implicit categorization procedure (Fig. 1). On each trial, a Y-shaped tube appeared on the screen. A pink ball entered the tube at its base as a sentence played. On training trials, *frighten* verbs always came out one side, and *fear* verbs always came out the other side (unbeknownst to the participants). On test trials, the ball "got stuck," and participants had to guess which side the ball would have come out of by clicking on the corresponding circle. We recorded participants' anticipatory eye gazes and analyzed them using non-parametric cluster-based permutation tests (Maris & Oostenveld, 2007).

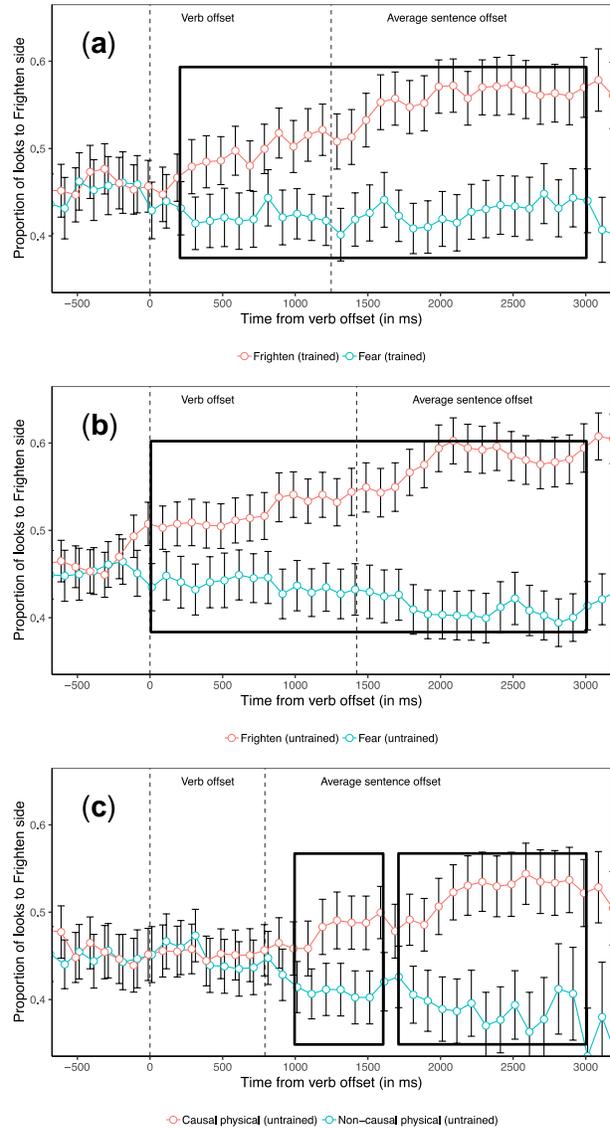
**Results:** Our hypotheses were confirmed. (1) Participants (N=60/64) learned to associate each side of the screen with the correct landing site for trained psych verbs ( $p < .001$ ; Fig. 2a), and, critically, (2) they extended this rule to untrained psych verbs ( $p < .001$ ; Fig. 2b) and to physical event verbs ( $ps \leq .02$ ; Fig. 2c). Specifically, when they heard a causal physical event, participants looked more to the side of the screen associated with *frighten* verbs.

These results provide evidence that language relies on a representation of CAUSE that is broad enough to encompass both physical and psychological causation.

**Figure 1.** Schematic of paradigm (source: Wittenberg et al., 2017).



**Figure 2.** Eye-tracking results for (a) trained psych verbs, (b) untrained psych verbs, and (c) untrained physical event verbs. Rectangles indicate significant clusters.



**References:**

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2. Levin, B., & Rappaport Hovav, M. (2005). *Argument realization*. Cambridge: Cambridge University Press.
3. Maris, E., & Oostenveld, R. (2007). Nonparametric statistical testing of EEG- and MEG-data. *Journal of Neuroscience Methods*, 164(1), 177-190.
4. Wittenberg, E., Khan, M., & Snedeker, J. (2017). Investigating thematic roles through implicit learning: Evidence from light verb constructions. *Frontiers in Psychology*, 8, 1089.