Real-world event knowledge modulates the use of tense cues in event comprehension

Event comprehension is one of the key components of understanding sentence meaning, and involves the coordination of semantic, pragmatic, and world knowledge information. We report a study that investigates the interplay of verb semantics, tense, information-structure, and real-world event knowledge in guiding how people comprehend events where verb semantics does not entail (pre-specify) a certain end state. Our results point to a close integration of linguistically-encoded semantic cues (paste/future tense) and non-linguistic knowledge about real-world event structure during online sentence processing.

Background It has been suggested that future vs. past tense modulates the formation of an event representation in which the event has yet to be realized (future tense) or has already been realized (past tense): A transitive event in past tense (e.g. *The boy ate the cake*) leads people to focus on the **end state** of the object (e.g. empty plate), whereas future tense (e.g. *The boy will eat the cake*) leads people to focus on the **initial state** of the object (e.g. cake slice, [1]).

Research questions. We investigate how event representations are modulated by (a) tense, (b) non-linguistic real-world knowledge, and (c) information-structure (specifically, topicality):

(a) Previous experiments on tense have focused on verbs that *entail* a change in the object state (e.g. destruction verbs: [1]; change-of-state verbs: [2]; reversible action verbs & creation verbs: [3]). What is less well-understood is whether tense exhibits such a modulating effect in events that are *ambiguous* about object state change. We investigate this with activity verbs (specifically, verbs of impact by contact, e.g. *hit, whack*). These verbs do not entail that the object undergoes change-of-state (e.g. *hitting* a window does not entail that the window breaks.) In studying event comprehension, it is important to understand how various kinds of information about the event (e.g. temporal and discourse-level information) are integrated when verb semantics does not (pre)-determine/specify the end phase of the event.

(b) Although activity verbs form a linguistically uniform class (e.g. [5]), there is a lot of variability in the real-world situations they can describe. Different activity verbs (e.g. *tap* vs. *strike*) and verb + object combinations (e.g. *kick the sandcastle* vs. *kick the wooden door*) are associated with different levels of expectation toward a changed end state. We test how this likelihood of end-state (rooted in non-linguistic event knowledge) modulates use of other cues.

(c) Building on prior work (e.g. [4]) that found discourse-level effects, we also investigate whether the topicality status of the object modulates expectations toward a changed end state.

Hypotheses We predict that tense and the object's topicality status will modulate expectations of a changed end state. However, we do not predict these factors to have equally strong effects across-the-board. We hypothesize that people will make more use of tense and topicality cues when real-world knowledge does not lead them to strongly expect a particular outcome.

Event type norming We created 24 [verb-object-adjective] triplets (see Table 1) where the adjective is a potential changed state of the object as a result of the action denoted by the verb.

Table 1: End-state likelihood norming study

Example stimuli
[WHACK – the watermelon] / *cracked* If you imagine a situation that is related to [WHACK – the watermelon], how likely are you to imagine that **the watermelon** gets **cracked**? *not likely at all* 1 2 3 4 5 6 7 *extremely likely*

A norming task ($n_{participant}$=35) allowed us to identify (i) 12 events that are *ambiguous* about whether the changed end state obtains (mean rating=4 on a 7-point scale) and (ii) 12 events where the *expectation for a changed end state is high* (mean rating=5.54).

Methods and Design We conducted a lexical decision experiment ($n_{participant}$=106, n_{item}=24; 12 ambiguous events;12 high end-state likelihood events). Participants were first presented with an introductory sentence that manipulated the discourse topic and a second sentence where tense is manipulated (Table 2).

Table 2: Pre-lexical decision sentences

Example stimuli (2 x 2 condition, discourse topic (subject vs. *object*) x tense (*past* vs. future)
Talking about {John/*the watermelon*}: "John {*whacked*/will whack} the watermelon."

After each item, people were presented with a lexical decision task on an adjective that was a potential (changed) end-state of the object (e.g. *bruised*). We analyzed how (i) topic structure (topic=subject/object) and (ii) tense of the preceding sentence (past/future) influence reaction time (RT) for lexical decision on the adjective. The more an event description leads a participant to expect a changed end-state, the faster they should be to recognize the adjective as a word.
Results When the sentence described an **ambiguous event**, the lexical decision RTs were faster when the sentence was in past tense than when it was in future tense (*lmer*, t=2.6, see *Fig. 1*). This effect, however, was not observed when the sentence described a **high end-state likelihood event** (see *Fig. 2*). There was no effect of discourse topic with either event type.

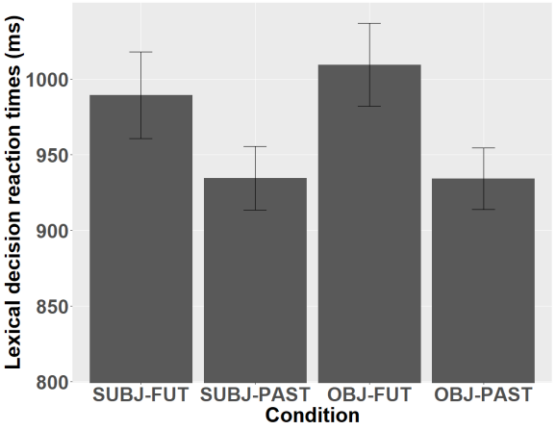

Figure 1: Lexical decision reaction times for ambiguous events (n_{item}=12)

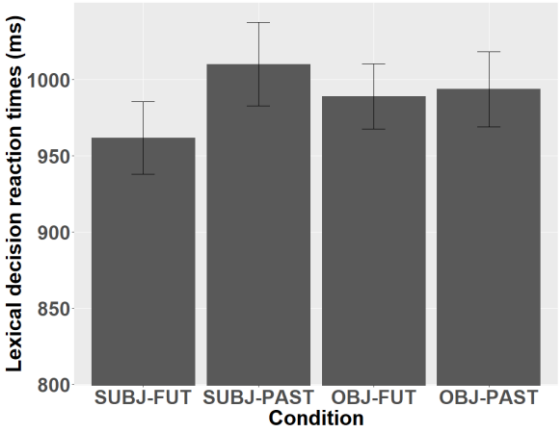

Figure 2: Lexical decision reaction times for high end-state likelihood events (n_{item}=12)

Discussion How do linguistic and non-linguistic cues beyond verb class modulate expectation about a changed end state? The strength of tense cues is modulated by event type based on non-linguistic knowledge: People turn to tense cues only when real-world knowledge does *not* provide a strong expectation for a particular end state. By using verbs that do not entail an end state, we saw that the impact of tense is not equal for all event types, even within a linguistically uniform verb class. This suggests that non-linguistic knowledge about real-world situations that a verb can describe can have strong effects on how people comprehend potentially ambiguous events.

References

[1] Altmann & Kamide 2007. The real-time mediation of visual attention by language and world knowledge: Linking anticipatory (and other) eye movements to linguistic processing. *JML*. [2] Kang 2015. Establishing object-state representation in language comprehension: Evidence from picture verification, eye-tracking and ERPs. PhD Thesis. Univ. of York. [3] Krass 2017. Investigating how anticipation of object states drives event comprehension. MA Thesis. UConn. [4] Lee & Kaiser to appear. Semantic decomposition of verbs and the processing and production of result states. *CLS 55*. [5] Rappaport Hovav & Levin 1998. Building verb meanings. In *The projection of arguments: Lexical and compositional factors*.