



Brief article

Intersentential coreference expectations reflect mental models of events

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ABSTRACT

Comprehenders' perception of the world is mediated by the mental models they construct. During discourse processing, incoming information allows comprehenders to update their model of the events being described. At the same time, comprehenders use these models to generate expectations about who or what will be mentioned next. The temporal dynamics of this interdependence between language processing and mental event representation has been difficult to disentangle. The present visual world eye-tracking experiment measures listeners' coreference expectations during an intersentential pause between a sentence about a transfer-of-possession event and a continuation mentioning either its Source or Goal. We found a temporally dispersed but sustained preference for fixating the Goal that was significantly greater when the event was described as completed rather than incomplete (*passed* versus *was passing*). This aligns with reported offline sensitivity to event structure, as conveyed via verb aspect, and provides new evidence that our mental model of an event leads to early and, crucially, proactive expectations about subsequent mention in the upcoming discourse.

1. Introduction

When we process discourse, we create mental models of the events being described (Johnson-Laird, 1983; Van Dijk & Kintsch, 1983). We use incoming linguistic information, together with our knowledge of the world, to incrementally update these models as the discourse progresses. Subtle differences in linguistic choices can have measurable effects on our mental representations of a situation. For example, events described with imperfective-marked verbs (e.g., *Leah was passing the salt to Eve*) are construed as ongoing, with attention distributed across event participants, whereas perfective aspect (*Leah passed the salt to Eve*) evokes an event as completed, bringing participants associated with its end state into the focus of attention (Madden & Ferretti, 2009; Magliano & Schleich, 2000; Moens & Steedman, 1988). In the domain of reference processing, this focus of attention on an event participant is linked to the probability of that participant being rementioned in the next sentence. An ambiguous pronoun following a perfective-marked transfer-of-possession event (e.g., *Leah passed the salt to Eve. She...*) is preferentially interpreted as referring to the Goal of the transfer event (Eve), who is now in possession of the transferred object, rather than the Source (*Leah*; Stevenson, Crawley, & Kleinman, 1994). Importantly, when the verb is marked with imperfective (*was passing*), this Goal

preference decreases (Kehler, Kertz, Rohde, & Elman, 2008; Rohde, Kehler, & Elman, 2006), consistent with more equal focus on participants in a mental model of an *ongoing* event.

In this paper we investigate this interdependence between language processing and our mental representations of events, probing the timecourse over which our situation models inform our processing of reference. This question has been addressed extensively for events and situations described with Implicit Causality verbs (IC; Garvey & Caramazza, 1974; Hartshorne, 2014), where a long-standing debate centers on whether these referential biases emerge before, at, or after a pronoun in contexts involving inferences about the event's cause (see Koornneef, Dotlaçil, van den Broek, & Sanders, 2016, for review).¹ One possibility is that these biases depend on the referential expression, such that a pronoun prompts comprehenders to consult their current situation model, and the distribution of attention to event participants in that model influences their referential choices. This could explain findings from story continuation experiments in which manipulations of IC status or grammatical aspect influenced participants' referential choices when they wrote completions for sentences starting with an ambiguous pronoun (Kehler et al., 2008). It is also compatible with findings from an ERP study by Ferretti, Rohde, Kehler, and Crutchley (2009), in which participants read sentences containing perfective- or

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¹ IC verbs are interpersonal predicates whose meaning and use crucially involve a primary attribution of cause to one event participant. The syntactic position of the causally-implicated referent distinguishes subject-biased IC verbs (*Max frightened Ben because he...* [bias to Max]) and object-biased IC verbs (*Max feared Ben because he...* [bias to Ben]; Ferstl, Garnham, & Manouilidou, 2011), at least with an explicit *because* (cf. Koornneef & Sanders 2013).

imperfective-marked transfer-of-possession verbs with protagonists of different gender (e.g., *Sue handed/was handing the timecard to Fred*), and a subsequent sentence-initial pronoun (*He/She*) immediately disambiguated reference. Ferretti and colleagues reported an enhanced P600 at the pronoun when it matched the gender of the Source (*Sue*) following perfective but not imperfective events. This indicates comprehenders had more difficulty integrating the pronoun when its reference (forced by gender-marking) jarred with the status of that referent in their situation model (for similar effects on reading time in contexts with IC verbs, see Koornneef & Van Berkum, 2006, and Koornneef & Sanders, 2013).

Another account of these findings, and the one advocated by Ferretti, Rohde and colleagues, postulates a proactive bias whereby comprehenders' situation models exert an influence on referential processing independent of the presence of a particular referential form. More specifically, comprehenders may continually draw on their current situation models to generate expectations about who or what is likely to be mentioned next in the upcoming discourse. If and when a pronoun is encountered, its interpretation is then in part a function of the expectancies built up prior to that point. Such proactive 'thinking ahead' characterizes coreference models like the Expectancy Hypothesis (Arnold, 2001) as well as a more recent Bayesian approach (Kehler et al., 2008)—in both cases, properties of the discourse may directly or indirectly influence comprehenders' expectations about subsequent mention of a referent. This would be consistent with evidence of prediction in language processing that has accrued at other levels of linguistic representation, including morphophonology, syntax, and semantics (e.g., Federmeier, 2007; Kuperberg & Jaeger, 2016).² For example, when hearing *The boy will eat the...*, listeners look more at edible than inedible objects in a visual array, and this preference emerges before they hear the noun (...*cake*) (Altmann & Kamide, 1999). There is good evidence that listeners look at referents when they are named, or when there is syntactic and/or semantic information signaling that they are about to be named (Kamide, Scheepers, & Altman, 2003; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). In all of these cases, the relevant cue (e.g., *eat*) can be pinpointed in the speech signal, and looking behavior predicted and examined in well-defined timeframes immediately following that cue.

Pinpointing the cue that focuses attention on referents in a mental model is less straightforward. Presumably the construction of event representations emerges from a complex combination of cues. This makes it challenging to detect effects of these models on gaze allocation because of their potential to be more widely distributed over time. Indeed, visual world eye-tracking experiments that test for predictive looks contingent on IC bias have produced inconsistent results (Cozijn, Commandeur, Vonk, & Noordman, 2011; Itzhak & Baum, 2015; Pyykkönen & Järviö, 2010). Our study targets anticipatory coreference processing, but we use a cue whose effects emerge in a different way from those in IC studies. In IC experiments, the reported bias to a causally-implicated referent is taken to reflect the assignment of thematic roles. We hold constant thematic role, and indeed all referent properties typically enumerated in the pronoun interpretation literature, while manipulating grammatical aspect on the verb. The assignment of Source and Goal roles does not vary, nor do their grammatical roles, their relative recency, their parallelism with a subsequent subject pronoun, etc. We manipulate nothing about the pragmatic status or morphosyntactic encoding of the referents at all (i.e., the types of referent properties typically implicated in next-mention expectancies and assessed in corpus studies; Arnold 1998); rather aspectual effects arise via a manipulation of the completed/ongoing nature of the event and the repercussions that has on the discourse and the comprehenders'

model thereof. Note that an effect of aspect need not arise in all contexts. It is only when the status of an event is ongoing that it has the capacity to minimize the relevance of a protagonist associated with the end state. A coreference model for capturing such behavior would therefore depend on conditional activation of certain factors, particularly those for which the causal relationship with pronoun interpretation is indirect (see Kehler & Rohde, 2017). This makes comprehenders' potential use of this cue all the more impressive for real-time computation regarding upcoming next mention. Crucially our study targets the *anticipatory* use of aspect, extending beyond the integration effects reported in prior coreference work on aspect. To test for a potentially broadly distributed effect of aspect on listeners' next-mention expectations in transfer-of-possession contexts, we measure looks to event participants during an intersentential pause before the onset of a subsequent sentence.

2. Method

2.1. Participants

Sixty-three University of Hawai'i students who identified as native speakers of English participated after giving informed consent. Data from 7 participants was excluded prior to analysis due to eyetracker calibration difficulty ($n = 4$), non-normal vision or hearing ($n = 2$), or noise interference ($n = 1$). Data from 3 participants was excluded after data inspection, due to insufficient data points in the eye gaze record (see Section 2.3), leaving 53 participants (28 females, mean age 23) in the final analysis. The study was approved by the UH Human Studies Program.

2.2. Materials and procedure

Linguistic stimuli consisted of two-sentence discourses followed by a question, as in (1). In the 20 experimental items, context sentences contained a transfer-of-possession verb in a double-object construction. A 2×2 Latin Square design manipulated grammatical *Aspect* in the context sentence (perfective/imperfective) and *Reference* of the subject pronoun in the continuation (Source/Goal of context sentence, disambiguated through gender), with 5 items per condition distributed across 4 lists, each presented in two orders. Six practice items and 40 fillers were analogous to the experimental items in their overall structure (context-continuation-question) but described non-transfer-of-possession events (half perfective, half imperfective). Continuations in fillers started with pronouns referring to human or non-human participants in the context sentence. In experimental items, the final question asked about the referent of the gender-disambiguating pronoun in the continuation. Questions in fillers asked about different aspects of the context or continuation sentences. (See Appendix A for materials.) All materials were recorded by a female native speaker of American English using a clear speaking style.³ Visual scenes contained 3 areas of interest (AOIs), representing the Source, Goal and Theme (Fig. 1, panel A). Location of AOIs was counterbalanced across items.

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| (1) Donald {brought/was bringing} Melissa a fancy drink. | [context sentence] |
| {He/She} obviously liked hosting parties. | [continuation] |
| Who liked hosting parties? | |

The experiment utilized an SMI RED250 eye-tracker sampling at 250 Hz. Each trial began with a 2000 ms display of the visual scene, followed by the context sentence ($M = 2856$ ms, $SD = 277$), a 2500-ms intersentential pause, the continuation sentence ($M = 2755$ ms,

² While the extent of the role that prediction plays in language processing is under current debate (Huettig & Mani, 2016; Nieuwland et al., 2017), the contribution of a proactive component to human cognition is widely agreed upon (Bar, 2007).

³ The pronunciation of the auditory materials and timing of all stimuli (see below) were chosen to be appropriate for second-language learners of English, who participated in a related experiment, while still natural for native speakers of English. Sample recordings are available at: <http://www2.hawaii.edu/~aschafer/snds.html#GTRS3>

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