Brief article

Knowing *what*, *where*, *and when*: Event comprehension in language processing

Anuenue Kukona [a,*], Gerry T.M. Altmann [b], Yuki Kamide [a]

[a] School of Psychology, University of Dundee, Dundee DD1 4HN, UK
[b] Department of Psychology, University of York, York Y010 5DD, UK

A B S T R A C T

We investigated the retrieval of location information, and the deployment of attention to these locations, following (described) event-related location changes. In two visual world experiments, listeners viewed arrays with containers like a bowl, jar, pan, and jug, while hearing sentences like "The boy will pour the sweetcorn from the bowl into the jar, and he will pour the gravy from the pan into the jug. And then, he will taste the sweetcorn". At the discourse-final "sweetcorn", listeners fixated context-relevant "Target" containers most (jar). Crucially, we also observed two forms of competition: listeners fixated containers that were not directly referred to but associated with "sweetcorn" (bowl), and containers that played the same role as Targets (goals of moving events; jug), more than distractors (pan). These results suggest that event-related location changes are encoded across representations that compete for comprehenders' attention, such that listeners retrieve, and fixate, locations that are not referred to in the unfolding language, but related to them via object or role information.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

There is increasing interest in event comprehension (e.g., Radvansky & Zacks, 2011; Zwaan & Radvansky, 1998). In the current study, we investigated verbs like "move" and "transfer", which describe events that result in location changes. Crucially, these events create a number of challenges for language comprehenders: for example, they have to update their representation of an object's location, represent an object in multiple locations (before and after an event), and if necessary retrieve the situationally-appropriate location from memory at the expense of other locations. We used the visual world paradigm (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) in order to investigate the

consequences of location change on the retrieval of location information, and the deployment of attention to these locations. Our aim was to address whether the distinct event-relevant locations *compete* for comprehenders' attention: when comprehenders retrieve a location from memory that is referred to in the language input, do they direct their attention exclusively to it, or do they divide their attention between it and other (e.g., event-related) locations?

There is some evidence that locations may compete in this way. Hoover and Richardson (2008) presented listeners with a burrowing creature that moved between, and presented spoken facts at, different locations in a display (unrelated to location). When listeners were asked about one of the facts, they fixated the fact's associated location more than unvisited locations. However, they also fixated the creature's other visited locations, despite not being queried by the question. Creature locations that were not directly

* Corresponding author. Tel.: +44 1382384617.
E-mail address: a.b.bakerkukona@dundee.ac.uk (A. Kukona).

referred to thus competed with context-relevant ones, with listeners dividing their attention between the two.

Altmann and Kamide (2009), however, observed a very different pattern with *described*, rather than (visually) *perceived*, location changes. Listeners viewed scenes with objects like a glass (on the floor), table, and bookshelf, followed by a blank screen, and sentences like "The woman will put the glass onto the table. Then, she will pick up the bottle, and pour the wine carefully into the glass". During the discourse-final "the glass", listeners fixated the (prior position on the screen of the) table more than the glass, suggesting that they had "updated" their representation of its location. However, listeners showed no bias for pre-move locations, which did not differ from distractors. These results suggest that object locations that were not directly referred to were suppressed, and that listeners were directing their attention exclusively to context-relevant ones.[1] Intriguingly, they did observe more *anticipatory* fixations to pre-move locations than distractors during "the wine carefully into"; however, this effect preceded "the glass" and could reflect low-level priming of the (previously depicted) glass by "pour" or "wine", rather than location competition.

Further evidence that comprehenders' representations of objects before and after event-related changes can generate competition comes from Hindy, Altmann, Kalenik, and Thompson-Schill (2012). They found in a series of fMRI studies that described *state* changes (e.g., "...crack the acorn" vs. "...sniff the acorn") generate brain-based competition: they found greater activation for event-related state changes in brain regions that were also highly activated during a colour Stroop task (a behavioural task that gives rise to signature conflict effects in frontal cortex). Hindy et al. argued that conflict arose in these brain regions because of the requirement to select between the before and after states of the changed objects. Although Hindy et al. found evidence for conflict, it is unclear whether there are behavioural consequences of such conflict. Moreover, unlike pure changes of state, changes in location entail a relationship between the object (which changes) and an external cue (which does not). The aim of the work we report below is to explore how event-related *location* changes impact on *attention*, and what the *time course* of event-related competition is. We address both of these issues in the current study.

In two experiments, listeners viewed visual arrays with containers like a bowl, jar, pan, and jug (see Fig. 1), while they heard sentences like (1) followed by (2):

(1a) The boy will pour the sweetcorn from the bowl into the jar, and he will pour the gravy from the pan into the jug.
(1b) The boy will pour the sweetcorn into the jar from the bowl, and he will pour the gravy into the jug from the pan.
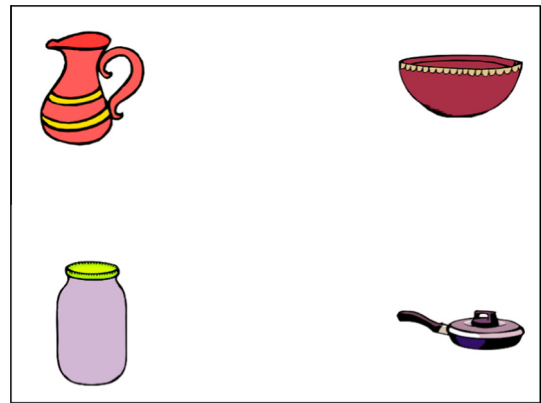(2) But first/And then, he will taste the sweetcorn/gravy.

Fig. 1. Example visual array from Experiments 1 and 2. Listeners heard sentences like "The boy will pour the sweetcorn from the bowl into the jar, and he will pour the gravy from the pan into the jug. But first/And then, he will taste the sweetcorn".

In (1), the movement of two critical referents ("sweetcorn" and "gravy") was described. In (2), "But first" referred to the "source" location of the discourse-final noun before the event, and "And then" referred to its "goal" location after the event.[2] Crucially, neither critical referent (the sweetcorn or the gravy) was depicted in the visual array; thus, listeners were not biased to fixate depicted locations, but had to rely *exclusively* on described information. Additionally, on half of trials the discourse-final noun was the first mentioned critical referent, and on the other half the second; thus, listeners could not anticipate which would be referred to. Consequently, the current experiments differed from Altmann and Kamide (2009) in two crucial ways: (1) there were no visual cues to critical referents to bias those locations; and (2) listeners could not anticipate the discourse-final noun, and potentially *resolve* any competition prior to reference to an object. Finally, on half of trials critical referents were described as moving *from* the source location *into* the goal location (1a), and on the other half *into* the goal location *from* the source location (1b); thus, order of mention was also not a cue to location.

During the discourse-final noun ("sweetcorn"), we expected most fixations to be to context-relevant "Target" locations. However, the current experiments also allowed us to address two forms of competition. First, whether listeners fixate object-associated (sweetcorn-associated) locations that are not directly referred to. We refer to this as *object*-based competition, because the competing location ("Object competitor") is associated with the same *object* as the Target. Second, whether listeners fixate other source locations when the Target is a source (after "But first"), and other goal locations when it is a goal (after "And then"). We refer to this as *role*-based competition, because the competing location ("Role competitor") plays the same *role* as the Target (as source or goal). If both

---

[1] Conversely, when scenes and sentences were presented *concurrently*, listeners fixated the (depicted) glass more than the table, which they argue stems from listeners' bias to fixate depicted locations.

[2] "Location" information in the current experiments entailed both "spatial" (*x*, *y*-coordinates) and "entity" (containers at those coordinates) components.