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The impact of co-occurrence and context on the prediction of long-distance separable prefixes

Daniel R. Walter [a,*], Brian MacWhinney [b]

[a] Emory University Oxford College, USA
[b] Carnegie Mellon University, USA

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ABSTRACT

Current inquiry into language processing focuses on predictive capabilities in anticipating words. This study investigates the predictability of separable verb prefixes in German, when they occur in sentence final position, often with much intervening material. Forty-nine speakers of German completed a cloze-task to measure their ability to predict missing sentence-final separable prefixes. The results are compared to statistics drawn from a corpus that show German speakers accurately predict sentence-final prefixes and accuracy is strongly correlated to both cue strength between particular prefix-verb pairs and the effect of contextual clues. The discussion links this work to the implications for evolutionary advantages of prediction via alignment and the ability to use corpora both for the creation and assessment of language testing procedures.

1. Introduction

Recent studies have placed an increased focus on the ability of listeners to predict upcoming verbal elements. Functional approaches to language acquisition such as the Competition Model (Bates and MacWhinney, 1987; MacWhinney, 2014), connectionism (Baronchelli et al., 2013), and usage-based linguistics (Bybee, 2010; Ellis et al., 2015) all support a view of language skills that emerge from statistical patterns in the input (Erickson and Thiessen, 2015). Studies have shown how frequency and statistical associations can facilitate word recognition (Balota and Spieler, 1999), syntactic processing (Spivey and Tanenhaus, 1998) and production fluency (Yoshimura and MacWhinney, 2007). Due to our shared experiences, the recurrence of distributional patterns through usage is largely shared across individuals, especially within communities that interact within a shared social space. While individuals share much linguistic input in a particular setting, each individual lives a different life with different experiences and different interlocutors and sources of language input. As Hoey (2005) points out, each individual has his or her own encounters over their lifetime, which result in an individual's particular statistical network of language cues, entrenched patterns, and primings. In sum, the underlying forces of cue strength, frequency, and validity play a major role in a person's ability to accurately predict upcoming words, and these forces vary by individual.

Within psycholinguistics, research related to speakers' ability to predict upcoming words has typically focused on words in close proximity, often immediately next to one another; for example, in studies looking at gender cues (Friederici and Jacobsen, 1999) or size of language knowledge (Mani and Heuttig, 2012). This study expands the literature by

* Corresponding author.
E-mail address: walterd08@gmail.com (D.R. Walter).

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investigating the predictability of separable verb prefixes in German when they occur separated from the verb in sentence final position, often with a large amount of intervening material. These separable prefixes are mostly members of a closed class of about 60 words (prepositions and adverbs) that are bound to particular verb stems, with the exception of a few prefixes that cannot stand alone (*e.g. dar-* and *inne-*). When the stem of the verb appears in the inflected, second-position of a sentence, the prefix is most often placed in clause-final position. Often the meaning of the prefix-verb combination is idiosyncratic and not a simple semantic combination. Thus, speakers cannot fully interpret the meaning of the verb until they reach the end of the clause, which creates a long-distance dependency between the two parts of the prefix-verb complex. Since most verbs can have multiple separable prefixes, with a few exceptions, such as *ausmerzen* and *abkanzeln*, it is unlikely that a person could know with absolute certainty what the sentence final prefix should be. While the verb itself establishes the probability of particular prefixes, the additional sentence-internal context adds to and changes these probabilities, and therefore the probabilities for and against particular prefixes are continuously changing as more and more of the sentence is revealed. The results of the current study show that German speakers are able to accurately predict sentence-final prefixes, and that accuracy is strongly correlated to both cue strength between particular prefix-verb pairs and the effect of other contextual clues.

2. Literature review

2.1. Language processing and prediction

An emphasis on the role of prediction in language processing has both waxed and waned over the past fifty years. Van Petten and Luka (2012) noted that in the 1960s, researchers (Miller and Isard, 1963; Tulving and Gold, 1963) emphasized the extent to which listeners "generate hypotheses about upcoming words." In the same vein, Goodman (1967) referred to reading as a "psycholinguistic guessing game". However, in the 1980s, researchers (Forster, 1981) noted that, in general, the cloze probability for any given following word is so small that general use of prediction must be a fairly unlikely behavior with a "low payoff", which was the idea that prediction used up significant mental resources with only a small likelihood of success. This critical stance held sway until the late 1990s, when advances in research technology, including eye-tracking and event related potential (ERP) methods, brought the idea of prediction back into the picture (Van Petten and Luka, 2012).

A new wave of research into predictive linguistic behaviors has put a focus on the dynamic nature of prediction. Theories in language processing, such as the Competition Model (Bates and MacWhinney, 1987; Mitsugi and MacWhinney, 2016), neural network modeling (Christiansen and Chater, 1999) and surprisal theory (Hale, 2006), point to an online, continual process where probabilities are being calculated during the entire process as new sentential elements are being introduced, and that these probabilities are being refined and corrected as more and more of a sentence is processed.

As a recent example of the way in which speakers use lexically specific data to predict upcoming words, Arai and Keller (2013) studied the effects of verb-specific information. In their study, the researchers used a visual world experiment (Tanenhaus and Spivey-Knowlton, 1996) modeled after Altmann and Kamide (2007), in which participants listen to sentences and view a scene that contains the target items, as well as distractor items. Participants' eye-movements were tracked to detect whether certain verbs, such as *eat*, were more likely to drive attention to food items in the picture than verbs like *move.* Like Altmann and Kamide (2007), Arai and Keller (2013) found that verb-specific information aided in participants' abilities to narrow down and ultimately predict direct objects. In addition, Arai and Keller (2013) found that this verb-specific information can be used to avoid garden path ambiguity.

While visual world studies provide evidence that predictive behaviors do take place, one shortcoming of this type of study compared to real-world processing is the limited number of items from which one has to predict. Because the visual world studies limit the possible items that could be used in the sentences, it is difficult to tell whether predictive behaviors are limited to scenarios with ample context and limited choices, or if speakers make these predictions in a more general way as a basic part of language processing. While this question is still unanswered, these findings indicate that speakers are not only integrating syntactic structure to predict upcoming words, but also word-specific semantic information.

ERP studies have provided further evidence for online lexical prediction. These studies have observed brain sensitivity to semantically inappropriate words (Federmeier and Kutas, 1999; Kutas and Hillyard, 1980, 1983) and to words that fail to agree morphologically with other expected words (Tokowicz and MacWhinney, 2005; Dusias and Sagarra, 2007). These effects can be generated both by lexical and discourse contexts (Otten and Van Berkum, 2008).

The majority of the studies reviewed above have examined the prediction of open-class words (i.e. nouns, verbs, adjectives) from other open-class words. Problems regarding the complexity of predictions within this domain were at the focus of the critique of prediction models in the 1980s (Jackendoff, 2002). However, it is also possible that closed-class words that are closely associated with open-class words could play a major role in prediction. For example, in a sentence like *John picked ____ the book*, the word *up* immediately comes to mind, whereas *John put ____ the book*, elicits the opposition direction of *down.*

From the previous example, the connection between verb and prepositional choice is quite clear, but there is a problem. In these two sentences, the prepositions *up* and *down* are only obvious in print because we can see that the preposition occupies