Journal of Memory and Language 69 (2013) 18–35

Contents lists available at SciVerse ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Possibly all of that and then some: Scalar implicatures are understood in two steps

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ARTICLE INFO

Article history:
Received 7 May 2012
revision received 19 February 2013
Available online 26 March 2013

Keywords:
Pragmatics
Scalar implicatures
Inference
Psycholinguistics
Mouse-tracking

ABSTRACT

Scalar implicatures often incur a processing cost in sentence comprehension tasks. We used a novel mouse-tracking technique in a sentence verification paradigm to test different accounts of this effect. We compared a two-step account, in which people access a basic meaning and then enrich the basic meaning to form the scalar implicature, against a one-step account, in which the scalar implicature is directly incorporated into the sentence representation. Participants read sentences and used a computer mouse to indicate whether each sentence was true or false. Three experiments found that when verifying sentences like "some elephants are mammals", average mouse paths initially moved towards the true target and then changed direction mid-flight to select the false target. This supports the two-step account of implicatures. We discuss the results in relation to previous findings on scalar implicatures and theoretical accounts of pragmatic inference.

Introduction

To communicate efficiently, speakers often imply information instead of explicitly stating it. Consider this exchange:

(1A) Nowadays, teenagers are tethered to their smart phones.
(1B) Some are.

Here, B is a teenager who distances himself from people of his age who seemingly never put down their mobile phones. By saying, "some are," he confirms that there are indeed teenagers who match A's description. More importantly for the purposes of this paper, he also implies that there is a significant group of teenagers who do not use their phones excessively.

In order to understand inferences like those above, the listener must know which of an infinite number of potential inferences the speaker intended her to draw. Moreover, for the sake of efficiency and communicative fluency, the inferences must be derived in a very short space of time. Grice's (1975, 1989) maxims of communication describe abstract principles that could guide the listener in drawing inferences. However, something like Grice's maxims might be realized by any number of processing mechanisms. In this paper, we test between two processing models of scalar implicatures (see also, Bott & Noveck, 2004; Breheny, Katsos, & Williams, 2006; Huang & Snedeker, 2009). The first model assumes the listener derives the implicature in a single processing step – a one-step model – and the second assumes the listener initially derives a literal, or basic, meaning, and then enriches this to form the implicature – a two step model.

The structure of the paper is as follows. We first introduce scalar implicatures in more detail and present a summary of the relevant linguistic literature. We then present the two processing models in more detail and discuss how they account for previous findings on processing scalar

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0749-596X/$ - see front matter
http://dx.doi.org/10.1016/j.jml.2013.02.003

implicatures. Finally, we introduce the paradigm that we use to test between the models and describe three experiments that test the model predictions.

Scalar implicatures

The inference in (1) is an example from a broader group of inferences known as *scalar implicatures* (see Geurts, 2010, for a thorough discussion). When B says "Some are," in (1) he implies that *not all* teenagers use their phones excessively. This inference can be described using Grice's (1975) Cooperative Principle and general reasoning abilities. According to the Gricean explanation, the listener first computes some sort of basic meaning for what was said (e.g. "at least some…"). This is contrasted with more informative and relevant things that the listener could have said instead, if they had been true. For example, in (1B) the speaker said, "some are," but he could have said, "all are", which would have been more informative and relevant. Relying on the Cooperative Principle, the listener assumes that the speaker would have used the more informative statement if it were true. Because the speaker did not, the listener infers that *all* must not hold. Finally, by combining what the speaker said, "some are," with the *not all* inference, the listener arrives at the final interpretation, *some but not all are*.

In general, scalar implicatures occur when a speaker uses a weak element from a scale of elements ordered in terms of semantic strength (a *semantic* or *Horn* scale; see Horn, 1972, 1989). Under these circumstances the listener is licensed to infer that the stronger elements in the scale do not hold. For example, *some*, *many*, *all*, form a semantic scale, *some* < *many* < *all*, with *all* being the strongest, most informative element (whenever *all X* is true, *some X* and *many X* are also true, but not the reverse). Use of *some* can therefore imply the negation of *many* and *all*. Other examples of semantic scales and their associated implicatures include, *may* < *must*, where the use of *may* can imply *not must*; *or* < *and*, where *or* can imply *not and*, and *warm* < *hot*, where *warm* implies *not hot*. Indeed, any set of elements can become part of a semantic scale and generate scalar implicatures in a suitable context, as in the scale, *handsome* < *handsome and intelligent*, that arises from speaker A saying, "John's handsome and intelligent" and speaker B responding with, "Well, he's handsome," (see Carston, 1998). As with other pragmatic phenomena, scalar implicatures are defeasible, or cancellable (e.g., "some are… in fact all of them are."). Defeasibility distinguishes scalar implicatures from entailments, but unlike other pragmatic phenomena, scalar implicatures often occur in very structured semantic environments (see e.g., Chierchia, 2004). For example, scalar implicatures do not arise when used in the antecedent of the conditional ("If some of the children are in the classroom,…"), and they interact systematically with negation, such as the *some* implication that arises when a speaker says *not all*, as in "Not all of the children are in the classroom." Thus scalar implicatures involve interactions between semantic and pragmatic considerations, providing a unique domain in which to employ insights from two often separate disciplines of study (see Horn, 2006, "The border wars").

In psycholinguistic investigations of how scalar implicatures are processed, most work has considered a processing adaptation of Neo-Gricean theory (e.g., Gazdar, 1979; Levinson, 2000), known as the *default model*. According to Levinson, for example, quantificational determiners such as *some* are associated with alternative constructions in memory (e.g., *all* and *many*). The contrast between the expression used (e.g. "some") and an alternative construction that was not used automatically leads to the implicature (e.g., *not all*). In the processing literature this has been taken to mean that scalar implicatures should arise on every occasion in which a scalar term occurs, but that subsequently the implicature is sometimes cancelled (e.g., Bott & Noveck, 2004; Breheny et al., 2006; Huang & Snedeker, 2009). In other words, the implicature arises by default. Although this work is important, and we discuss it in more detail below, our approach to processing of scalar implicatures takes a different tack. Instead of asking whether the implicature is derived by default even when it is not required, we ask how that derivation takes place: does deriving an implicature involve a single processing step, or are there multiple steps?

One-step versus two-step processing models

We suggest a distinction between, on the one hand, computing a basic meaning and then enriching it to form a different meaning, and on the other, computing the completed meaning in a single processing step. We refer to the former as two-step models, and the latter as one-step models.

Two-step models are those in which an initial semantic interpretation forms a basis from which a distinctly different meaning is eventually derived. Several different theories are possible; the most obvious being a processing version of a Gricean account. Under this view, a listener must first compute the literal meaning of the sentence and its possible alternatives (Step 1), and then, assuming the speaker is informative and reliable, the listener enriches the literal meaning with the implicature (Step 2). The output of Step 1 is necessary to execute Step 2. Alternatively, the default implicature model (as described above), in which the implicature is always derived but sometimes cancelled, is also an example of a two-step model, albeit with Step 1 corresponding to the implicature and Step 2, after cancelling, corresponding to the literal meaning. Other examples include a model in which the decision to proceed onto Step 2 processing is not contingent on the output of Step 1 but nonetheless automatically follows it. The common theme running through two-step models is that some form of meaning is used as a basis to derive a different, second meaning.

One-step models, on the other hand, do not assume multiple, sequential processing steps. Necessary computations can be made in parallel and the appropriate scalar interpretation can be incorporated into the sentence in a single processing step, rather like constraint-based models of processing in which contextual, grammatical and other factors are all computed in parallel to provide the best guess at the appropriate interpretation (e.g., Bates & MacWhinney, 1989; MacDonald, Pearlmutter, & Seidenberg, 1994; van