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The Neuropragmatics of 'Simple' Utterance Comprehension: an ERP Review

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1 Introduction

As part of a more general rapprochement between linguistics and the rest of cognitive science, pragmaticists are increasingly borrowing methods from the toolkit of psycholinguistics. Most often, these are behavioural methods, like self-paced reading and eye-tracking. But interest in the use of neurocognitive methods, such as EEG, MEG and fMRI, is also growing rapidly. As might be expected, the handful of pragmatically inspired neurocognitive experiments to date usually address hot topics in pragmatics, such as scalar implicatures (e.g., Noveck & Posada 2003) or negation (e.g., Nieuwland & Kuperberg in press). Furthermore, there is growing interest in the neurocognition of superficially rich 'non-literal' uses of language, such as irony or metaphors (e.g., Coulson 2004; Blasko & Kazmerski 2006). For a young (actually, a baby) discipline such as neurocognitive pragmatics, focusing on currently hot pragmatic issues makes eminent sense. On the other hand, whenever there's language, there's pragmatics, right? That is, presumably even the most simple declarative statement requires some pragmatic reasoning for its interpretation.

Pragmatics is often defined as the study of how linguistic properties and contextual factors interact in the interpretation of utterances (Sperber & Noveck 2004; Levinson 1983). One of the major puzzles for the field is how listeners and readers seemingly effortlessly go beyond 'coded meaning' to arrive at what the speaker had actually meant to convey. Part of this puzzle is that, whereas linguists have lots of time to ponder possible interpretations, much of the everyday pragmatic computation has to be over and done with after a second or so.

To understand the processing machinery behind this requires the use of measures that can track cognitive operations rapidly, as they unfold. It is largely for this reason that experimental pragmatics is turning to self-paced reading, eye-tracking, and, more recently, EEG. With respect to the latter type of data, it is of course an empirical issue which of the many distinctions debated over in semantics and pragmatics will show up in observable brain responses – there is no principled argument to be made here. All we can say is that the processes or representations postulated as *effective* ingredients of real language use should at some level map onto specific neural dynamics. As such, they may or may not be picked up in the EEG (Van Berkum 2004).

In this chapter, I review my EEG research on comprehending 'simple' sentences in context. This work, conducted with many collaborators, did not originate in pragmatic theory, but arose out of a desire to scale up the neurocognition of language to somewhat more complex arenas of language use. Largely due to constraints on neuroimaging designs, the typical paradigm in this field is one in which participants read a simple declarative sentence amidst many other unrelated ones flashed by on the ERP lab's computer monitor. Alternatively, they hear a list of unrelated spoken sentences pronounced by a deliberately unobtrusive, invisible speaker. We know that even in such impoverished situations people tend to process for meaning, and this has allowed the field to make progress on various aspects of sentence-level interpretation. At the same time, however, it will be obvious that pragmatic questions about how sentence meaning is modulated, enriched, possibly even co-*defined* by extra-sentential context cannot easily be addressed in the standard paradigm.

The review is organized around four questions. In section 2, when and how do extra-sentential factors (e.g., the prior text, the identity of the speaker, the value system of the comprehender) affect the incremental sentence interpretation processes indexed by the so-called N400 component of the ERP? In section 3: when and how do people identify the referents for expressions such as *he* or *the review*, and how do referential processes interact with sense and syntax? In section 4: how *directly pragmatic* are the interpretation-relevant ERP effects reported here? In section 5: do readers and listeners anticipate upcoming information? In the current review, I focus on pragmatically relevant ERP findings and their implications for theories of language understanding. For a tutorial review of the more technical ins and outs of using ERPs to study language comprehension in discourse contexts, see Van Berkum (2004).

2 Making sense of words

2.1 Text as context

ERP research on utterance interpretation took off with the discovery of the N400 effect, a negative deflection in the ERP that emerged around 250 ms after a written nonsensical word and peaked at about 400 ms, with a maximum over the back of the head. (e.g., *He spread the warm bread with socks*; Kutas & Hillyard 1980). Because this specific effect was not elicited by a typographic anomaly (*He spread the warm bread with BUTTER*) or a syntactic anomaly (*He spread the warm bread with besides*), it was taken to reflect some aspect of how words are related to their interpretive context.[1] Follow-up experiments soon confirmed this, and made clear that N400 effects actually reflected graded modulations of an underlying N400 *component*, elicited by every content word, with an amplitude that increases to the extent that the word is less easy to integrate into the sentence-semantic context (see Kutas, Van Petten & Kluender 2006, for a review).

In our first ERP study on context-dependent interpretation (Van Berkum, Hagoort & Brown 1999; see St. George, Mannes & Hoffman 1994, for a related earlier study) we asked if words that were nonsensical with respect to the prior text (e.g., *promote* in figure 16.1), rather than the local sentence, would elicit the same N400 effect. Of course, the answer had to be yes – after all, why would the processing consequences of the anomalies in *The lecturer had committed plagiarism. He was promoted.* and in *The lecturer that had committed plagiarism was promoted.* be fundamentally different? And indeed, discourse-dependent and 'sentence-internal' semantic anomalies elicited the exact same N400 effect, at the same time.

A spoken-language replication of this expected result (Van Berkum, Zwitserlood, Brown & Hagoort 2003) did drive home another point: the wider interpretive context – now in the easily manipulable form of a prior text – is brought to bear on utterance understanding extremely rapidly. That is, with spoken words, the brain responds to the fit between word and wider context well before people have actually heard the end of the word. So, in the example of figure 16.1, hearing something as short as *pro...* rather than *sa...* is already enough for an N400 effect to begin to emerge, even though none of these strings by itself pins down a specific word.

Importantly, the N400 effect is *not* a simple anomaly detector. *Every* content word elicits an N400 component, which decreases in size when the word fits the context better, in a graded way. For example, relative

In dismay, the faculty dean called the lecturer and the professor (the two lecturers) to his office. This was because the lecturer (one of the lecturers) had committed plagiarism, and the professor (the other one) had faked some of his research data. The dean told the ***lecturer*** *that* ***there*** *was ample reason to* ***sack****/promote him.*

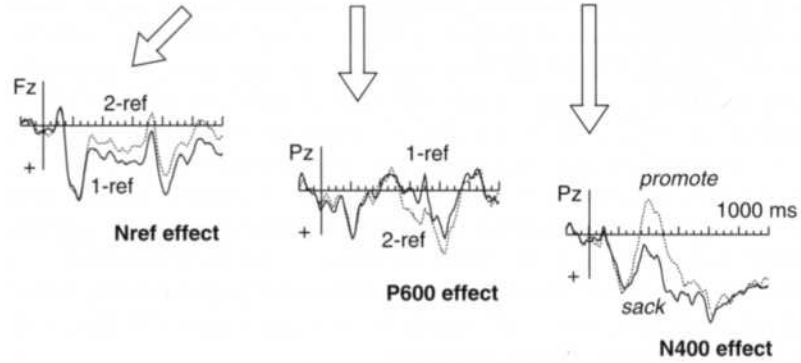

Figure 16.1 Discourse-dependent referential, syntactic, and semantic ERP effects. From left to right: An Nref effect to a discourse-induced referential problem (in the 2-referent version of the story, 'lecturer' is ambiguous), a P600 effect to a discourse-induced syntactic problem (the provisional relative-clause analysis temporarily pursued at *that* in the 2-referent context is subsequently ruled out by *there*), and an N400 effect to a discourse-induced semantic problem (*promote* does not fit the wider story context). The example item is shown here in several variants (1- and 2-referent contexts, coherent/anomalous ending), but any one participant saw just a single version. ERP waveforms are time-locked to the presentation of the written critical word (0 ms) and are shown for 1200 ms each. Negative voltage is up in this and all following figures. All data were obtained in a single reading experiment (see Van Berkum *et al.* 1999a, b, c).

to a coherent word like *sack*, an equally coherent but somewhat less expected word like *report* also elicits a larger N400 (Otten & Van Berkum 2007; see also figure 16.5 for another example). The implication is that in contrast to a recent suggestion (Geurts in press), we can take these ERP modulations to reflect something about the normal computations involved in understanding sentences in context. In section 4, I examine what that 'something' might be.

Two follow-up projects refined our understanding of discourse-dependent N400 effects. First, in an experiment in which we controlled for the impact of specific prime words (e.g., *plagiarism* directly activating *to sack* in lexical memory; Otten & Van Berkum 2007), we showed that text-dependent N400 effects cannot simply be explained by basic word-to-word associative priming, and that at least part of the effect critically hinges on the exact message conveyed by the

prior text (see also, e.g., Camblin, Gordon, & Swaab 2007). Second, when we pitted a cartoon-like discourse context against local sentence-internal animacy constraints, by for example embedding *the peanut was in love* in a cartoon-like discourse context featuring an amorous peanut, the discourse-supported but animacy-violating critical predicate *in love* elicited a smaller N400 than an animacy-respecting but discourse-inappropriate alternative predicate *salted* (Nieuwland & Van Berkum 2006a), showing that in this case, discourse-contextual fit completely overruled local animacy requirements in driving the N400. This is not to say that real-world constraints cannot have their own, independent effect on N400 amplitude (e.g., see Hald, Steenbeek-Planting & Hagoort 2007; Federmeier & Kutas 1999). However, in coherent discourse, the N400 is usually highly sensitive to how things fit what is being talked about right now, even if it happens to be some imaginary world with happy peanuts, donkeys, or unicorns.

2.2 The speaker as context

Many theorists have pointed out that the computation of what is said (the proposition expressed) is not a strictly semantic affair, and requires pragmatic input (e.g., Carston 2002; Clark 1996; Levinson 2000). One of the most obvious examples is indexical resolution, in which the expression is anchored to a basic set of pragmatic indices (or deictic parameters) which include the particular speaker, the addressee(s), and the time and place of utterance (Levinson, 1983). In a recent ERP experiment (Van Berkum, Van den Brink, Tesink, Kos & Hagoort 2008), we explored when and how knowing who the speaker is impacts on the understanding of an unfolding sentence. In the study, people heard utterances whose content sometimes did not match probabilistic inferences supported by the speaker's voice, as in sentence (1) in a female voice, (2) in an adult voice, and (3) delivered with an 'upper-class' accent.

(1) I always rent movies with lots of *violence* in them.
(2) On Saturday I spent the whole afternoon playing *marbles* on the street.
(3) I have a big *tattoo* on my back.

As shown in figure 16.2, speaker-inconsistent critical words (in bold italics for expository purposes only) elicited a small but reliable N400 effect, beginning at 200–300 ms from acoustic word onset. This reveals that listeners rapidly classify speakers on the basis of their

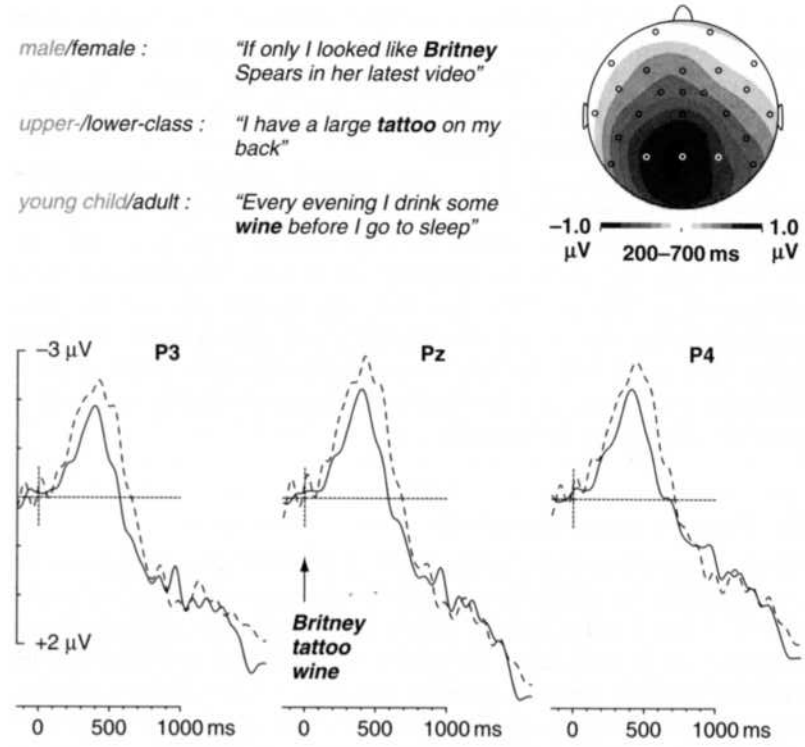

Figure 16.2 An N400 effect of speaker-message inconsistency. ERPs to words whose meaning did (solid) or did not (dotted) easily fit voice-based inferences about the speaker, pooled across three speaker dimensions. Speaker-mismatching words elicited a small but reliable N400 effect. Acoustic onset of the critical word is at 0 ms.

voices, and anchor the utterance to the speaker immediately, somehow using their knowledge of the speaker's probable sex, age, and social stratum to evaluate the plausibility of what is being asserted.

Interestingly, what makes *I have a large tattoo on my back* in a stereotypically upper-class voice odd is not just the social class identification but the stereotypical intuition that (Dutch) upper-class behaviour tends not to include getting a tattoo, an intuition that only becomes relevant when the listener hears the word *tattoo*. The large majority of our items were like this: they hinged on defeasible social stereotypes about what speakers of a certain age, sex and social stratum are likely to do (and say about themselves), and the exact relevant aspect of that

stereotype became apparent at the critical word only. This suggests that relevant assumptions about the speaker can be brought to bear on language processing extremely rapidly, even in very open-ended situations (e.g., *I have a big...*). In section 5, I discuss how basic long-term memory mechanisms might help out here.

One unresolved issue is whether this speaker–message mismatch effect critically hinges on classic indexical resolution, of the type where indexical pronouns like *I* or *my* are variables instantiated by the actual speaker. We used these pronouns deliberately to maximize the probability of a relevant effect. However, I suspect that, say, hearing a 5-year old child offhandedly mention the laws of motion will also generate an N400 effect. This would be in line with the eminently sensible idea that every utterance is automatically indexed to its speaker, regardless of whether there is a first-person pronoun or not.[2]

2.3 Personal values as context

When defining pragmatics as the study of how linguistic properties and contextual factors interact in the interpretation of utterances, 'context' usually denotes 'information'. Information about the issue under discussion, who is speaking, what's been said and why, and what can be assumed to be in common ground (see, e.g., Roberts 2004). However, in everyday language use, people don't just infer speaker meaning, they also often care about what's being asserted or implied. So, when Herb Clark expresses *I'm hot* in a card game with his son (Clark 1997), Herb's son is probably not just inferring that he's about to lose – he'll also have certain feelings about this. If he strongly values winning, he may feel bad, but if he had decided he was finally going to let his poor dad win for once, he may actually feel great.

The traditional demarcation lines in cognitive science define all of the latter as post-perceptual, post-inferential *consequences* of computing statement and speaker meaning. So why care about them in a paper on language understanding? The critical assumption that justifies this perspective is that processes involved in language interpretation are insensitive to how the listener might feel about certain things: these processes are just delivering the message for other neural systems to work with. But what if this assumption is wrong? What if how we feel about things can actually influence the way in which we extract the message? Or, more radically, what if the affective valence of, say, a spider, a cute-looking kitten, suicide bombers or euthanasia is part of the meaning of the concept? Good and bad is rooted in relevance to survival and well-being (Damasio 2004; Cacioppo, Larsen, Smith & Berntson 2004) – in my view, this makes valence a prime candidate for the set of 'semantic primitives'. Furthermore, if the valence of concepts is stored as part of their meaning (cf. Morris, Squires, Taber & Lodge 2003), the affective valuation of an unfolding statement becomes an integral part of computing its meaning.[3]

Several everyday observations could be taken to suggest that valuation and language interpretation are intimately related. For example, most of us will have experienced the situation where you need to read a text that you're really not interested in, or actually dislike. For me, texts about insurance, mortgage and other financial affairs do the trick. I know they are sometimes important, so I do occasionally read them. But even with well-designed non-legal texts, as I read through them, really doing my best, nothing seems to happen – I hear the voice in my head, but it is as if the words just don't come together. As if my deep lack of interest in these matters simply caps the computation of speaker meaning at some level. Another example might be that if you hear something you really don't want to hear about, it doesn't sink in at first – you really need to hear it again. Furthermore, and related, some people simply cannot take a compliment, as if, due to how they feel about themselves, they are simply unable to compute the speaker's benign meaning.

Now, none of these informal observations is particularly compelling. However, they at least indicate that there might be something interesting here. One problem in systematically exploring these issues is that because language, valence and the associated feelings/emotions are studied in relatively unconnected disciplines, there is little theory that connects the three (but see Jackendoff 2007a: chapter 3, for an initial attempt). Another problem is that it is not so easy to find arenas of language use in which the interaction between language and valence can be studied systematically. To explore these matters (Van Berkum, Holleman, Nieuwland, Otten, & Murre in press), we recorded EEG as two groups of respondents with opposing moral value systems filled out an opinion poll on morally relevant issues. Critical statements were designed to be strongly consistent or inconsistent with the average moral value system of members of a relatively strict Dutch Christian party, referred to here as *SC-group* respondents. Examples (with the critical word in italics for expository purposes):

(4) I think euthanasia is an *acceptable* course of action
(5) Watching TV to relax is *wrong* in my opinion
(6) If my child were homosexual, I'd find this *easy* to accept.

We presented these statements to SC-group respondents and to non-Christian respondents with sufficiently contrasting moral value systems (*NC-group*), and asked them to indicate their agreement on a four-point 'agree' – 'disagree' scale. We measured EEG during initial reading only, before any response was given.

As can be seen in figure 16.3, words where the statement began to clash with the reader's moral value system (e.g., for SC-group respondents, *I think euthanasia is an acceptable...*) elicited an immediate brain response, starting at 200 ms after the morally offending word. Part of the neural response was an ERP effect commonly elicited by emotionally arousing stimuli (the so-called *Late Positive Potential*; Cacioppo, Crites, Berntson & Coles 1993). The result of interest here, however, is that

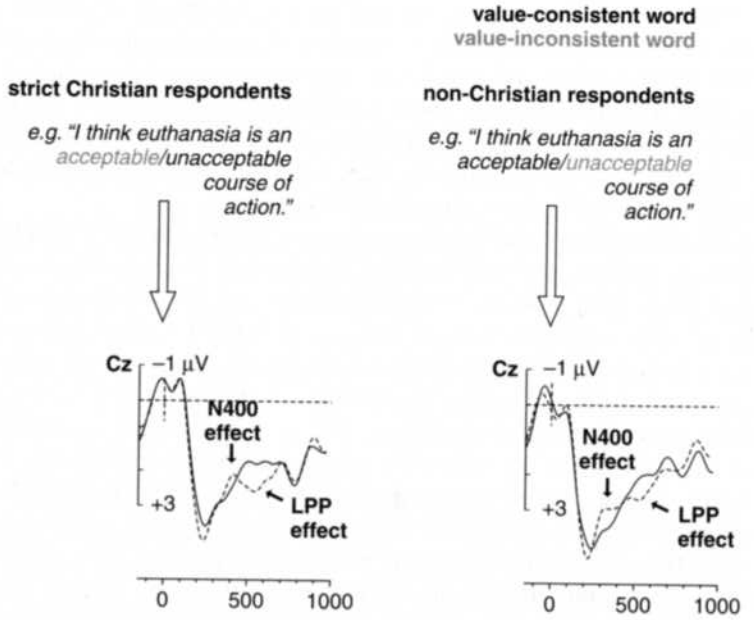

Figure 16.3 ERP effects of morally objectionable words. ERPs to value-consistent (solid) and value-inconsistent (dotted) critical words in opinion poll statements, for members of a relatively strict Dutch Christian party (left), as well as a nonreligious control group with opposing moral value systems. Morally objectionable words are rapidly perceived as emotionally aversive (LPP effect) and affect the ongoing semantic analysis (N400 effect); the two effects partially overlap and, because of their opposite polarity, partially cancel out each other. Written word onset is at 0 ms.

for both groups of respondents, morally offending words also elicited a small N400 effect, with a classic centroparietal maximum, and peaking at exactly 400 ms. This suggests that a person's values are not just brought to bear on language processing extremely rapidly, but that the associated affective evaluation actually *modulates* some aspect of the language-driven early semantic analysis itself.

What is going on here, and why should this be of interest to pragmatics? One possibility is that strongly value-inconsistent words rapidly deliver an unpleasant message, and as such briefly trigger a more extensive semantic analysis (see Holt, Lynn & Kuperberg in press, for a comparable interpretation). Such rapid feedback from downstream affective valuation to initial 'cold' interpretation should be of interest to anybody working on language understanding. A more radical possibility is that, if valence is part of a concept's core *meaning*, valence-dependent clashes are unexpected or odd – and therefore complicate the basic sense-making process – in the same way as *He spread the warm bread with socks*. Note that the latter brings person-dependent valence right into the semantics, if you will – a possibility that should engage pragmaticists *and* semanticists.

At this point, we cannot rule out a somewhat more mundane possibility: to the extent that a respondent indexically resolves these statements to him- or herself (*I think that...*), value-inconsistent words may also render the statement 'False' for the respondent at this point, which would briefly intensify or complicate the incremental sense-making process (see Fishler, Bloom, Childers, Arroyo & Perry 1984; Hagoort, Hald, Bastiaansen & Petersson 2004; Nieuwland & Kuperberg in press, for similar N400 effects of truth value). But whatever the answer might be, the current N400 effect reveals an immediate impact of personal values on early sense-making in language. Furthermore, because people can *expect* to read many statements they will not agree with in an opinion poll, we are apparently dealing with a relatively autonomous, non-controlled brain response. Such compulsory language-value interaction can be taken to challenge the classic cognitive science idea that interpretation and valuation are neatly separated.

3 Identifying discourse referents

3.1 The Nref effect

As might have been expected for a process as complex as language interpretation, the N400 is not the only game in town. A second

pragmatics-relevant ERP effect, associated with establishing reference, first showed up in a study that examined the interaction between pragmatic factors and syntactic parsing (Van Berkum, Brown, & Hagoort 1999a). In this study, we embedded sentences with a critical singular definite NP, such as *The dean told the lecturer*..., in a wider discourse that had either introduced a single referent (e.g., one lecturer), or that had made available two equally salient referents (e.g. two lecturers). As illustrated in the left part of figure 16.1, referentially ambiguous written nouns elicited a characteristic relatively long-lasting negativity right at the ambiguous word, emerging at about 300 ms over the front of the head.

Several follow-up studies revealed that referentially ambiguous spoken nouns, spoken pronouns and written pronouns all elicited the same sustained frontal negativity or *Nref* effect (see Van Berkum, Koornneef, Otten, & Nieuwland 2007, for review). Furthermore, the phenomenon reflects a relatively smart mechanism: in a context in which, say, one of the two mentioned lecturers has just fled from the building, *The dean told the lecturer* does not elicit the effect, even though the episodic memory of the discourse does contain *two* lecturers (Nieuwland, Otten, & Van Berkum 2007). Thus, based on the unfolding sentence as well as prior text, readers and listeners can rapidly work out which are the conceptually *suitable* referents.

The relatively rapid onset of these effects, at ~300–400 ms after noun or pronoun onset, in mid-sentence, indicates that readers and listeners rapidly and incrementally try to resolve referential expressions. Furthermore, because the Nref effect is a sustained shift that is largest over the front of the head, and as such clearly different from the N400 effect, we can infer that different aspects of language interpretation are handled by at least partly different networks in the brain. This inference was confirmed in a recent fMRI study, where referential ambiguity and semantic anomaly recruited almost totally non-overlapping neural networks (Nieuwland, Petersson, & Van Berkum 2007).

One might object that these phenomena are of marginal interest only, because how the system deals with problems need not be how it handles its normal business (cf. Geurts in press). However, the Nref effect displayed in figure 16.1 also emerged in entirely felicitous sentences where the referentially ambiguous noun was followed by a post-nominal restrictive relative clause (... *the lecturer that had committed plagiarism*...). Such constructions are neither uncommon nor deeply problematic; as with many other ambiguities in language, the one at hand is temporary, arising out of the workings of an eager left-to-right incremental

processing system. Thus, rather than indexing a non-representative response to an anomaly, the Nref effect is reflecting the brain's natural inclination to immediately relate every shred of new information to what is known already. With this analysis in hand, the difference between how the brain handles an unexpected word (like *The dean shot the lecturer*) and how it handles an insufficiently specific referential expression (like *The dean sacked the lecturer* with two equally eligible lecturers in context) provides an interesting constraint on models of understanding. One thing it rules out, for example, is the simple notion that all problems with interpretation would send the comprehender into the same type of Gricean inferencing (evidenced by, say, the N400), to try to reconstruct why the speaker is not being more cooperative.

The Nref findings also have a clear implication for the dominant semantic-pragmatic theory on resolving referential expressions, i.e. Discourse Representation Theory (Kamp & Reyle 1993; Geurts 1999). In particular, since DRT is concerned with how mental representations are modified by, and provide a context for, a specific utterance (Geurts & Beaver 2007), our findings indicate that in the context of (7a) and its schematic DRT representation (7b), the variables v and w in a subsequently unfolding utterance (8b) are linked to (7b) immediately, without awaiting the remainder of the sentence. That is, the incoming information is linked to prior DRSs on a word-by-word basis.

(7) a. In dismay, the faculty dean called the two lecturers to his office. This was because one of them had committed plagiarism, and the other one had faked some of his research data.
b. [x, y, z; dean(x), lecturer(y), lecturer(z), dismayed(x), ...]

(8) a. The dean told the lecturer...
b. [v, w; dean(v), lecturer(w), told(v,w...)...]

Furthermore, as shown by Nieuwland, Otten & Van Berkum (2007), the processes that immediately try to resolve w are not blindly sensitive to the formal availability of [...y, z; lecturer(y), lecturer(z)...], but immediately take into account which antecedents are *really* available (e.g., you cannot have a face-to-face conversation with somebody who has just left the scene). What this might tell us about the direct source of the Nref effect is an issue we briefly return to in section 4.

3.2 How does reference interact with sense?

Perhaps unsurprisingly, the above Nref observations also reveal that fixing the referent for some referential expression is constrained by the sense of the critical word at hand (e.g., *lecturer*). This is in line with standard thinking about reference resolution, according to which syntax and coded word meanings initially determine specific configurations of word senses (*the lecturer, a lecturer*), and referential processing is at least in part conditional upon the result. Additional support for this idea comes from the relative timings of the Nref and N400 effects. Word-elicited N400 effects almost always have a relatively crisp onset somewhere between 150–300 ms, rise steeply until 400–500 ms, and typically return to baseline around 800–1000 ms. The Nref effects observed so far typically begin to develop around 300–400 ms (sometimes much later), and they are much more sustained voltage shifts or 'slow waves', without a sharp peak, and often lasting to at least 1200 ms (see, e.g., figure 16.1). This relative timing seems to make sense.[4]

Also relevant here is a recent ERP study (Nieuwland & Van Berkum 2008) in which nouns embedded in a short story could be semantically anomalous, referentially ambiguous, or both (e.g., *The dean ate the lecturer* in a story about two equally salient lecturers). These doubly problematic nouns elicited a clear N400 effect, indicating a problem with how the coded meaning fit the story context. However, they did not elicit an Nref effect, presumably indicating that people did not engage in additional inferencing to disambiguate reference. Again, this seems to fit a standard story in which sense-dependent processing precedes (and sometimes pre-empts) referential computations.

Of course, it is easy to come up with cases where referential concerns can in the end overrule coded meaning, as in *The museum felt that the old girl was historically unique* referring to a recently restored World War II Sherman tank (Van Berkum *et al.* 2007). Our current results do not speak to whether such referential modulations of word sense come about as part of later 'post-semantic' pragmatic computations (the standard Gricean account), or as part of rapid pragmatic intrusions.[5]

3.3 How does reference interact with syntax?

As for how establishing reference interacts with *syntax*, the ERP evidence actually suggests a rapid bidirectional interaction. On the one hand, with two equally eligible antecedents in context, the basic Nref effect on singularly marked words like *lecturer* or *he* demonstrates that morphosyntax can constrain reference. On the other hand, two ERP studies in which we specifically explored the interaction of referential and syntactic analyses reveal that the former can sometimes also guide the latter.

First, and in line with earlier suggestions (e.g., Altmann & Steedman 1988), the ERP data indicate that if readers or listeners do not know who or what is being referred to, this can immediately affect their ongoing syntactic analysis (Van Berkum, Brown & Hagoort 1999a,b). For instance, when *the lecturer* in *The dean told the lecturer that...* is referentially ambiguous, people tend to analyse the subsequent word *that* as starting a relative clause that will tell them which lecturer was meant (e.g., *... the lecturer that had committed plagiarism*) rather than as starting some other syntactic structure (e.g., *... that there was ample reason to sack him*). We know this is the case because if the sentence then continues with the latter after all, we see the typical ERP effect to a syntactic problem (the so-called *P600* effect, see figure 16.1). In fact, and critical here, the conceptual 'pull' of referential ambiguity is so strong that it can even briefly lure people into pursuing a relative clause analysis in cases where this is ungrammatical, prohibited by the gender of the relative pronoun (see Van Berkum, Brown & Hagoort 1999b for details). Thus, reference can sometimes temporarily outweigh syntax.

Another piece of evidence for the power of reference comes from an ERP study in which we examined the use of verb-based implicit causality information (Van Berkum *et al.* 2007). When asked to complete a sentence fragment such as *David praised Linda because...*, readers and listeners will be inclined to continue the sentence with something about Linda, e.g., *... because she had done well*. However, after *David apologized to Linda because...*, people tend to continue with something about *David* instead. In 'person-1 VERB-ED person-2 *because...*' constructions, interpersonal verbs like *praise* and *apologize* thus supply information about whose behaviour or state is the more likely immediate cause of the event at hand. Because this information is conveyed implicitly as part of the meaning of the interpersonal verb, it is usually referred to as *implicit causality*. In our experiment, we tested how rapidly readers were using this probabilistic information to constrain their interpretation, this by continuing the sentence with a bias-inconsistent pronoun (9a), and comparing the processing at this pronoun to its bias-consistent control (9b).

(9) a. David praised Linda because he...
    b. Linda praised David because he...

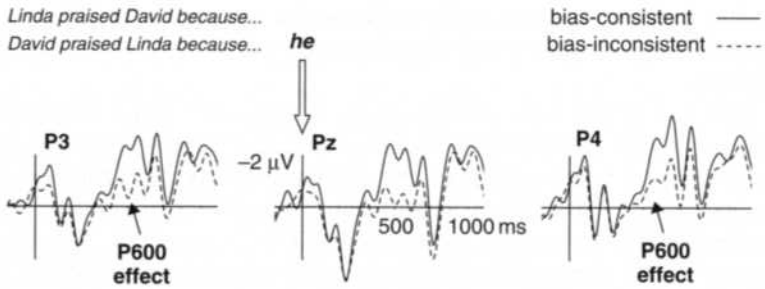

Figure 16.4 P600 effect to pronouns inconsistent with referential expectations. ERPs to singular pronouns whose gender-marking was consistent (solid) or inconsistent (dotted) with the implicit causality bias of a preceding verb. Bias-inconsistent pronouns elicit a P600 effect, suggesting that the semantic/referential bias briefly caused readers to blame the syntax. Onset of the written pronoun is at 0 ms.

As shown in figure 16.4, bias-inconsistent pronouns elicited a P600 effect. In line with other evidence (Osterhout & Mobley 1995; Van Berkum *et al.* 2004), we take this to indicate that as readers encountered the verb, their expectation for the sentence to continue with something about the person being praised was so strong that an expectation-inconsistent pronoun was momentarily taken as a syntactic error. In other words, readers briefly blamed the syntax. Note that the masculine pronoun is not only syntactically legal (as a free pronoun it can refer to any male entity), but it actually *has* a locally available antecedent. As with the previous study, and in line with other ERP evidence (e.g. Kim & Osterhout 2005), this indicates that the combined force of semantic and referential factors can sometimes temporarily outweigh the syntax.

Now, syntax does probably win out in the end, in both of these studies. But that doesn't mean that, as explicitly proposed by 'syntax-first' or 'syntactocentric' models (e.g., Friederici 2002) and tacitly assumed in standard models of pragmatics, that syntax is rigidly defining the playground for semantics and pragmatics *at every moment of processing*. Comprehenders are trying to deal with multiple levels of linguistic structure simultaneously, without always giving one of them absolute priority (cf. Trueswell & Tanenhaus 2005; Jackendoff 2002)

4 How *directly* pragmatic are these ERP effects?

So, several ERP effects can tell us something about the immediate context-sensitivity of sentence understanding. But does this mean that

these effects are *direct* signatures of pragmatic processes? And if so, which ones? The P600 seems predominantly sensitive to unexpected or erroneous syntactic and other structured sequences (Osterhout, Kim & Kuperberg in press), and is not reliably observed when interpretation is problematic, such as in standard cases of semantic anomaly or referential ambiguity. Although the case for a pragmatic source of the P600 remains to be examined, I currently do not see this as the best place to start – the N400 and Nref effects are much more obviously related to meaning. Little is known about about the Nref effect so far, and I will only briefly address it here. However, we know enough of the N400 to examine the case more thoroughly. As will be seen, the issue is complex and, hence, its treatment relatively lengthy. With an increasing number of experimental pragmaticists getting ready to conduct their first ERP experiments, however, making the N400–pragmatics link explicit should in the end pay off.

Of course, the question presupposes that we know how pragmatic processing is organized, internally and relative to semantic processing – the very issues hotly debated in pragmatics and semantics. A practical approach is to start from what seems more or less the standard view, and take it from there. The standard view (see, e.g., Levinson, 2000: figure 3.1; Garrett & Harnish 2007: figure 1) is that utterances such as *I finally managed to rewrite that difficult paper* have a timeless, context-invariant 'sentence meaning' ('coded meaning'), computed by retrieving relatively stable word meanings from lexical memory and combining them in a grammatically constrained, structured higher-order representation. However, it is also generally agreed upon that the result of such lexicon- and grammar-driven sense-making is an extremely incomplete representation of the meaning of an utterance. Amongst the additional mechanisms required to arrive at something more useful are mechanisms of contextual disambiguation (e.g., what is the relevant sense of *difficult* or *paper*) and fixing reference (who's speaking, and which paper?). In addition, most theorists agree on the necessity of a wide range of other mechanisms for refining, expanding, or otherwise enriching the contents of what is said (so that, for example, the meaning of *some of the guests have left* is expanded with *but not all of them*, and such that *the ham sandwich at table six* can be taken to refer to a customer). Furthermore, at some point listeners will go beyond what is said and recover the conversational implicatures, i.e., infer what the speaker really meant but did not even approximately say (e.g., such that *John's command of English is excellent* can be taken to mean that John is a mediocre student, that he would make a fine translator, that he

understood something he heard, or that he has no excuse for the sloppy paper he wrote; example from Bach 2006).[6]

Which of the many mechanisms involved are *directly* responsible for generating the N400 and Nref effects reviewed here? For simplicity – and glossing over many alternative ways to draw the lines here – let me group them into *semantic memory retrieval, semantic composition, pragmatic enrichment,* and *recovering implicatures*. To foreshadow the analysis, I will argue that the N400 most likely reflects semantic memory retrieval, and that the Nref effect might more directly reflect pragmatic inferences, in this case involved in the enrichment of what is said.

4.1 The N400 effect: some important additional observations

A tacit working assumption underneath most of the N400 studies reviewed in section 2 was that the N400 *directly* indexes a difficulty in incrementally constructing the structured conceptual representations that are at the heart of language comprehension (see Jackendoff, 2007b or 2002, for a concrete idea of such conceptual structure building). Listeners who have heard enough of *tattoo* to retrieve its meaning from long-term memory, for example, would find it more difficult to merge this information with the structured conceptual representation built for *I have a big* spoken in a stereotypically 'upper-class' accent than with the representation built for *I have a big* spoken in a stereotypically 'lower-class' accent. The hypothesis that the amplitude of the N400 directly reflects the difficulty in semantic composition (and perhaps aspects of pragmatic enrichment, e.g., word-sense disambiguation) is often referred to as the 'integration view' (Kutas & Federmeier 2000).

The pragmatic N400 effects reviewed in section 2 are sometimes taken to strongly support this integration hypothesis, and to exclude other possibilities. However, there is an important alternative reading of the N400 that can also account for these observations. According to the semantic memory retrieval hypothesis (Kutas & Federmeier 2000; Kutas *et al.* 2006), 'N400 amplitude is a general index of the ease or difficulty of retrieving stored conceptual knowledge associated with a word (or other meaningful stimuli), which is dependent on both the stored representation itself, and the retrieval cues provided by the preceding context' (Kutas *et al.* 2006: 669). This account holds that, after for example having heard *I have a big* in a stereotypically 'upper-class' accent (instead of a more 'common' accent), listeners find it more difficult to retrieve the meaning of *tattoo* from long-term memory.

If integration and memory retrieval are inextricably intertwined, just two sides of the same coin (see Coulson & Federmeier in press, for such a proposal), the difference between adopting either hypothesis about the N400 doesn't matter all that much. However, nature may not be that accommodating. In complex information-processing systems that make use of long-term memory to preserve and abstract over instances of past computations, the distinction between memory retrieval and dynamic computation ('integration') seems difficult to avoid (Newell 1990). Unfortunately, neither the memory retrieval account nor the integration account of the N400 component is particularly well-specified. For example, under the memory retrieval hypothesis, what remains to be specified is *how* exactly rich pragmatic context can facilitate or hinder retrieval of word meanings. Also, under the integration hypothesis, one can ask which of the many components jointly contributing to sentence and speaker meaning (e.g., Levinson 2000; Garrett & Harnish 2007) should be associated with the N400. Because psycholinguistic N400 research has by and large not made much contact with modern semantic and pragmatic theory (nor, for that matter, with theories about general memory), the latter questions are yet to be thoroughly addressed. Several empirical observations about the N400 seem immediately relevant, though.

First, N400 effects can also be obtained by semantically odd combinations that are *non-linguistic*, such as an unexpected turn of events in a film clip (e.g., a guy in front of the bathroom mirror putting shaving cream on his chin, and then picking up a rolling pin; Sitnikova, Kuperberg & Holcomb 2003) or a cartoon-like picture sequence (West & Holcomb, 2002). Although one could perhaps make an argument that such materials, offered to participants in the context of an experiment, are in a sense acts of ostensive communication, interpreting a result like this as uniquely and directly reflecting the computation of Gricean speaker meaning seems a little far-fetched.[7] Instead, the result suggests that the N400 is more generally sensitive to meaning, regardless of whether it involves 'non-natural' speaker meaning or non-communicative 'natural meaning'. These non-linguistic N400 effects do tend to have a somewhat more anterior distribution than their word-elicited counterparts. But this variation is generally taken to reflect differences in where in the brain the relevant conceptual information is represented, rather than differences in the fundamental nature of the processes reflected by the N400 (e.g. Kutas & Federmeier 2000).

Second, N400 effects begin to emerge around 150 ms into the spoken word, after having heard only two or three phonemes, and often well

before the spoken word has become acoustically unique (Van Petten, Coulson, Rubin, Plante & Parks 1999; Van den Brink, Brown & Hagoort 2006; Van Berkum *et al.*, 2003). A related finding is that words embedded in other spoken words, such as *pay* and *pain* in *champagne*, modulate the word-elicited N400 as a function of their fit to the sentential context (Van Alphen & Van Berkum in press). It is not impossible to imagine two or perhaps more parallel drafts of coded meaning being considered simultaneously (see Jackendoff 2007b, for an example), so these findings by themselves do not speak against the N400 being uniquely tied to semantic composition or relatively resource-free aspects of pragmatic enrichment. However, it seems less likely to suppose that listeners incrementally embark on Gricean inferencing to compute conversational implicatures for each of many possible words simultaneously.

Third, N400 effects can occur automatically, in situations where people are not aware of the fact that a communicative stimulus is presented to them. For example, when subliminally presented target words like *table* cannot be consciously identified, and therefore elicit random semantic category decisions, these words nevertheless elicit an N400 effect when primed with the wrong semantic category (e.g., body part vs. furniture; Stenberg, Lindgren, Johansson, Olsson & Rosén 2000). Again, although in the end depending on how automatic Gricean inferencing is, it seems unlikely that such effects are the consequence of, say, inferring a conversational implicature.

Finally, the amplitude of the N400 is sensitive to lexical or lexico-conceptual factors such as repetition, word frequency, associative word-word priming, the number of orthographically similar words, and concreteness (see Kutas *et al.* 2006 for a review), factors that have little to do with semantic structure composition, pragmatic enrichment or implicature derivation. For example, when words are presented in isolation, outside of any remotely communicative context, a rare word elicits a larger N400 than a frequently occurring word (e.g., Van Petten & Kutas 1990). Also, the first presentation of a word in such lists elicits a larger N400 than the second presentation (e.g., Van Petten, Kutas, Kluender, Mitchiner & McIsaac 1991). And a word with many orthographic neighbours – such as *dime*, which resembles *time*, *lime*, *dine*, *dame*, *dome* etc. – elicits a larger N400 than a word with only few neighbours (e.g., Holcomb, Grainger, & O'Rourke 2002). Although the impact of such factors is often attenuated and sometimes even eliminated in richer contexts, the fact that they modulate the N400 speaks against an account in which the N400 *critically* hinges on semantic composition, pragmatic enrichment, or inferring implicatures. Although the N400 might be sensitive to the latter, it clearly reflects a more general mechanism.

This analysis suggests that the integration view, when formulated in terms of structure-sensitive compositional, enriching and/or inferential processes, cannot be the right story. The *memory retrieval* perspective proposed by Kutas and colleagues (Kutas & Federmeier 2000; Kutas *et al.* 2006) appears to be in a much better position to explain both the context-dependent and the just mentioned lexical observations. However, within this retrieval account, a number of additional N400 observations remain difficult to handle. First, the N400 is also increased when the word's coded meaning has strong *valence*. For example, value-laden words in otherwise neutral stories elicit enhanced N400 responses (Holt, Lynn & Kuperberg in press; see also Bernat, Bunce & Shevrin 2001), and so do words that in particular sentential contexts clash with one's personal value system (Van Berkum *et al.* in press). Furthermore, the N400 has been found to increase when coherent words are accented (Li, Hagoort, & Yang 2008), and when coherent words are preceded by a hesitation (Corley, McGregor & Donaldson 2007), suggesting that apart from valence, a marked delivery also attracts deeper semantic processing. Conversely, the impact of anomalous words on the N400 can apparently be eliminated under certain shallow-processing conditions, such as when they are scenario-relevant and prosodically unstressed, i.e., presented as given information (Nieuwland & Van Berkum 2005; Bohan, 2008). For example, in a story about a tourist and a stewardess arguing over an overweight suitcase, offhandedly pronounced severe anomalies such as *The stewardess told the suitcase to...* did *not* elicit an N400 effect (Nieuwland & Van Berkum 2005). What seems to be needed is an account in which the retrieval of a word's 'coded' meaning indexed by the N400 is not just modulated by contextual expectations, but can also be regulated by such things as focus, a marked delivery or its relevance to values.

4.2 The multiple-cause intensified retrieval (MIR) hypothesis

Taken together, the above observations lead me to the following hypothesis for how the N400 relates to language interpretation:

(i) INTENSIFIED RETRIEVAL OF STORED CONCEPTUAL KNOWLEDGE. The amplitude of the word-elicited N400 reflects the computational resources used in retrieving the *relatively invariant 'coded' meaning(s)* stored in semantic long-term memory[8] for, and made available

by, the word at hand. In non-communicative settings, such as with a video of a man preparing to shave and then picking up a rolling pin, the object- or event-elicited N400 effect analogously reflects the additional computational resources needed to retrieve the object's or event's natural meaning.

(ii) MULTIPLE CAUSES OF INTENSIFIED MEMORY RETRIEVAL. At least two different factors can cause word-elicited semantic memory retrieval to become more resource-intensive.

(a) CONTEXTUALLY DISFAVOURED FEATURES. One is the mismatch between the word-generated coded meaning(s) and expectations raised by the relevant interpretive context at the time the word is read or heard (the typical trigger in standard N400 mismatch experiments). Relative to contextually favoured features, the retrieval of contextually unsupported features will simply be more difficult. This is because of how long-term memory works: with *converging* retrieval cues from both the prior/wider context and the current word, information stored in long-term memory is more easily brought to bear on dynamic computation, but with divergent or even conflicting cues, retrieval will be harder (I will return to this later).

(b) RELEVANCE SIGNALS. However, semantic retrieval can also be intensified if certain 'relevance signals' indicate the need for deeper or more detailed processing. Such signals include the strong valence associated with the word's coded meaning in a particular context, a marked delivery (e.g., linguistic focus, uncommon choice of words, a pre-word hesitation),[9] and quite likely also the detection of unexpected meaning itself.[10] The additional effort invested in semantic memory retrieval in these cases presumably involves the retrieval of a richer set of semantic features and associations from the semantic memory representation of the word at hand. However, a more elaborate memory resampling of the coded meaning of mismatching *contextual* concepts can also not be excluded.

(iii) MULTIPLE CAUSES FOR CONTEXTUAL EXPECTATIONS – THE INTERPRETIVE BACKGROUND AS A MIXED BAG. A wide variety of information sources can contribute to the interpretive background against which the next word comes in. This mixed bag can include: (a) associatively or semantically related prime words, (b) scenario-based knowledge about the world activated by (one or more words in) the preceding text, (c) a mental representation of the sensory context, e.g., visual or auditory scene, (d) the coded and pragmatically enriched meaning – 'what is said' – computed for the unfolding sentence heard so far, (e) the Gricean speaker meaning – 'what is meant' – inferred for the unfolding sentence heard so far, (f) a mental model of the situation being discussed, and (g) some metalinguistic representation of the discourse, e.g. its register, the interlocutors involved, and the goals being pursued. *All* of this can raise conceptual expectations that can be met by the next word to varying degrees, with a better fit giving a smaller N400. In section 5, I return to the mechanism(s) underneath such expectations.

4.3 So how about pragmatics, then?

Note that in the MIR hypothesis, claim (iii) is what links the N400 to pragmatics – but only indirectly. In particular, what I propose is that pragmatic modulations of the N400 come about *not* because the N400 at hand directly reflects a rich compositional-semantic and/or Gricean analysis to make sense of the word's coded meaning in this particular context, but simply because the semantic and pragmatic (speaker meaning, situation model update, etc.) implications of the *preceding* words have already been computed, and, together with other immediately available cues (such as the visual scene) now simply define a less or more helpful interpretive background within which to *retrieve* (or select a suitable) coded meaning for the critical word. Although admittedly somewhat vague, it should be possible to formalize such rich incremental context in terms of a mentalistic dynamic theory of interpretation, such as Discourse Representation Theory (Kamp & Reyle 1993; Geurts, 1999). In DRT terms, for instance, *I have a big...* spoken in a male upper-class voice should generate a rich discourse representation structure that includes the assumed speaker, the indexically resolved statement up to that point, and the associated plausible speaker meaning, with each of the discourse entities (upper-class-guy) and predicates (*have*, *big*) making available relevant – and possibly stereotype-mediated – encyclopedic knowledge stored in semantic long-term memory. This then is the interpretive background against which the coded meaning of *tattoo*, rather than, say, *cigar*, elicits intensified processing.

This proposal does raise an interesting question. If the word-elicited N400 itself reflects the early retrieval of invariant meaning from long-term memory, and if pragmatic inferences can only shape contextually defined expectations *giving rise to* N400 mismatch effects, how far

does this remove us from the 'integration account' of this component, the idea that the N400 directly indexes the incremental construction of a sensible interpretation for the unfolding utterance? For reasons discussed above, the N400 is unlikely to *directly* index semantic composition and enrichment in the compositional structure-sensitive sense of, say, Jackendoff (2002, 2007b), or the algorithmic derivation of speaker meaning based on Gricean rules (Levinson 2000; Wilson & Sperber 2004). But note that like other animals, we can also make sense of the world around us in a way that does *not* depend on things like recursion, variable binding, operator scope, or precise scalar implicatures. Such sense-making is presumably intricately intertwined, perhaps even identical, with the cued *retrieval* of stored conceptual information from our content-addressable semantic (and episodic) long term memory. And surely this more general memory-based sense-making system will not be switched off in humans just because they also happen to have compositional semantics and Gricean pragmatics (cf. Kuperberg 2007, for a similar two-stream perspective). So *in this particular way*, I think a memory retrieval account of the word-elicited N400 can actually be equated with sense-making or 'integration'.[11]

The core of the MIR proposal is that the N400 directly reflects whatever sense-making is achieved through 'primitive' memory-based analysis (pattern recognition and pattern completion, if you will), but only indirectly reflects the sense-making involved in more 'refined' structure-sensitive dynamic composition of the type studied in semantics and pragmatics (simply because the resulting structured representations serve as retrieval cues to semantic long-term memory). This indirectness does not necessarily diminish the utility of this ERP component for exploring the pragmatics of language interpretation. For example, the findings reviewed in section 2 unequivocally show that various types of extra-sentential context (prior text, speaker knowledge, one's value system) are rapidly assimilated into a rich mental representation of the relevant context, such that they pave the way for retrieving the next word's coded meaning to a systematically different degree. Also, in many cases, a context-sensitive memory retrieval account will make the same predictions as an integration account. However, because the proximal cause of the N400 effect is most likely intensified memory retrieval, not the difficulty of composing a semantic structure or of inferring speaker meaning, experimenters must be careful to exclude other factors that might affect such retrieval, such as word frequency, word repetition, or various forms of simple priming from other words in the context (see Otten & Van Berkum 2007, for an example).

An example serves to make the point. ERP studies on truth value have yielded inconsistent N400 results. In some studies, the N400 has been shown to be highly sensitive to whether statements were true (e.g., *Dutch trains are yellow*) or false (e.g., *Dutch trains are white*; Hagoort *et al.* 2004; Nieuwland & Kuperberg in press). However, in a classic study involving negation (Fischler, Bloom, Childers, Roucos & Perry 1983), critical sentence-final words in true (*A robin is a bird*) and false statements (*A robin is not a bird*) elicited comparable N400 responses (see Kounios & Holcomb, 1992 and Noveck & Posada 2003, for related findings). I suggest that this variability actually comes about because of how simple and complex aspects of the context 'balance out' in cueing and hence facilitate the word-induced retrieval of relevant meaning. In the Hagoort *et al.* study, the concept of *Dutch trains* or – for Dutch listeners – even just *trains* joins forces with the precise compositional meaning of *Dutch trains are...* to suggest a limited set of potentially relevant concepts, which includes *yellow* but not *white*. In the Fischler *et al.* study, however, the concept *robin*, a presumably excellent retrieval cue for *bird*, *competes* with the precise compositional meaning of *A robin is not a....* Also, because of the way the Fischler *et al.* experiment and materials were set up, precise compositional meaning may not have exerted the effect one might expect in ordinary language use (see Nieuwland & Kuperberg in press, for arguments and evidence for the latter). Thus, the absence of truth-value effects on the N400 observed by Fischler and colleagues may well have resulted from weak sentence-level semantic retrieval cues being overruled by very strong local lexical retrieval cues.

4.4 Urgent maintenance required

Much like the Russian space station that bore the same name, the current account is patchy, with most of its components needing an upgrade fast. First, the explanatory power that comes from the wide variety of potentially effective contextual retrieval cues ('context as a mixed bag') has a downside: N400 predictions for a specific experiment now depend on a precise account of how these many factors are weighed, given the materials at hand. Although this is bad news, Nature may simply be this complex, and require us to develop more quantitative models (a development currently also seen in constraint-based models of syntactic parsing). Second, it remains to be seen whether the account can be sensibly extended to accommodate the functionally distinct N400 phenomena revealed by initially presenting information to the left or right hemisphere only (cf. Federmeier 2007), or other recent

suggestions that the N400 is actually a composite effect reflecting a complex network of neural sources (e.g., Halgren, Dhond, Christensen, Van Petten, Marinkovic, Lewine & Dale 2002; Lau, Phillips & Poeppel 2008). Note that a unifying concept like 'intensified memory retrieval' is not necessarily at odds with the N400 being generated by a network of brain areas; what matters is whether what the network is doing fits the bill. But such precise mapping remains to be done.

Third, a core component of the account, intensified retrieval, remains to be specified in detail. One place to look for such details is in general models of long-term memory (computational and neuro-biological), an issue I will briefly return to in section 5. Another avenue – possibly ending up in the same place – is to exploit and further develop ideas about attentional control and depth of semantic analysis currently used to explain shallow processing and 'semantic illusions'. Behavioural research has shown that readers and listeners sometimes overlook severe semantic anomalies in language, even when asked to look for them (see Sanford & Sturt 2002, for a review). For example, after having been told about a plane crash right on the border between France and Italy, many people overlook the severe anomaly in *The authorities were trying to decide where to bury the survivors* (Barton & Sanford 1993). What seems critical here is that (a) the context activates a strong scenario, (b) the impostor word – *survivors* – fits the scenario, (c) the impostor word is semantically related to the acceptable word – *victims* – it replaces, and (d) the impostor word is not marked as particularly noteworthy by linguistic focus, such as prosodic stress, italics, or cleft-constructions (e.g., *It was the survivors that...*; Sanford, Sanford, Molle, & Emmott 2006). To account for these phenomena, it has been suggested (Sanford & Garrod 1998, 2005) that comprehenders can adapt the depth (precision, level of specificity, 'grain size'; Hobbs 1985) to which they analyse the meaning of a word, and that for deeper-analysed words, more semantic detail is *retrieved from semantic memory*. Such partly focus-controlled modulations of 'retrieval grain size' could well be part of what it means to intensify retrieval.

Although it has its own name, I see the MIR account as a variant of the well-established memory retrieval account (e.g., Kutas & Federmeier 2000; Kutas, van Petten & Kluender 2006), an idea that has been around for a long time. The current proposal differs primarily in that it makes a number of things that were left open in earlier accounts more explicit, notably that (a) incrementally computed *complex* sentence and speaker meanings can drive simple pattern-matching/completion mechanisms involved in long-term memory retrieval, and (b) cues to relevance

can – in some as yet to be determined way – tune up or down the same retrieval processes. As such, the account allows us to formulate a specific hypothesis on how *pragmatic* modulations of the N400 might come about.

4.5 The Nref effect

So what about the frontally sustained *Nref effect*? Several indications could be taken to suggest that, in contrast to the N400, the Nref effect is a direct reflection of context-dependent 'pragmatic' inferencing, in this case presumably engaged in to determine the most suitable referent. First, readers with high verbal working-memory capacity or 'reading span', who are known to engage in more inferential activity (Calvo 2001; Linderholm, 2002; St. George, Mannes & Hoffman 1997), generate larger Nref effects than readers with more limited capacity (Nieuwland & Van Berkum, 2006b). Second, in our fMRI study, referential ambiguity selectively engaged medial frontal regions often related to inferential activity (see Nieuwland, Petersson & Van Berkum 2007, for details). Third, the timing seems to be right. Whereas N400 effects begin to emerge somewhere between 150–300 ms, the Nref effects observed so far typically begin to develop around 300–400 ms (sometimes much later), and often last to at least 1200 ms. Fourth, as might be expected from an ERP effect reflecting sophisticated inference-making, the Nref effect seems to be elicited only in cases where there is deep ambiguity at the level of the situation model – what matters is not whether two discourse entities have merely been mentioned, but whether both of them qualify as referents given the details of the situation model and of the unfolding current utterance (Nieuwland, Otten & Van Berkum 2007). All this fits with the idea that whereas N400 effects index the early, and in terms of memory mechanisms fairly 'dumb', resonance-based retrieval of coded word meanings, Nref effects reflect the fairly sophisticated inferential activity needed to sort out subsequent problems.

Of course, at this point, all this is just circumstantial evidence, and the issue requires much more careful examination. I have provisionally labelled the referentially induced sustained frontal negativities 'Nref effects' because of their negative polarity and eliciting condition. However, that does not mean that the processes directly responsible for the negativity here must be *uniquely* tied to resolving referential ambiguity. One possibility is that the critical ingredient is computationally intensive inferencing, and/or the additional load on frontal working memory systems imposed by it (see Van Berkum *et al.* 2007, for a

discussion, and Baggio, Van Lambalgen & Hagoort 2008, for a similar sustained anterior negativity in situations that require a non-monotonic adjustment of the discourse model). Another possibility we cannot as yet rule out is that the Nref ERP effect is the unique signature of making inferences *about other people's minds* (cf. Pylkkänen in press, for a theory-of-mind interpretation of comparable shifts in MEG), which would link it to Gricean mechanisms involved in computing implicatures and possibly also pragmatic enrichment. It is far too early to resolve these issues, which require dedicated critical experiments as well as careful comparison to, and reasoning about, other, similar ERP effects in the literature.[12]

In all, I have argued that whereas the reported Nref effect may well index some aspects of the complex processing involved in constructing precise representations of sentence and speaker meaning, context-dependent N400 effects presumably index some aspects of the operation of a more primitive semantic memory-retrieval (i.e. pattern-recognition) system, cued by pragmatic representations as well as much simpler stuff. Of course, as alluded to before, these two ERP effects won't be the only ones in town – given the complexity and multi-faceted nature of interpretation, it is not realistic to expect that its neural reflections will be limited to less than a handful of ERP effects. Also, we need to remind ourselves that the very concept of relatively invariant 'coded' meaning is not universally accepted (e.g., Kempson 2001); if word sense retrieval turns out to be as much an act of construction as the composition of sentence or speaker meaning, the current proposal may need to be adjusted.

5 The anticipating language user

Taking a design perspective, Levinson (2000) has noted that, because normal speech has a rather low data transfer rate (under 0.1 kbit/s, i.e., ~50,000 times as slow as the average ADSL download rate), it makes sense to offload the communication channel by rapid thinking. The general idea is that what can be reliably inferred need not be expressed, allowing us to get away with, say, *he* instead of *the fraudulous lecturer that I just talked about before*, or with *Some of the guests left* instead of *Some of the guests, but not all of them, left the party*. Of course, if the inferencing required to recover speaker meaning from coded meaning needs to take into account all the tiny little details of the specific current context, it might be slow (so the argument goes), and as such of little help in solving the communicative bottleneck problem. Against this background,

Levinson proposes a set of pragmatic heuristics, shared by speakers and listeners, that can very rapidly deliver plausible 'default' enrichments, without the need to carefully peruse the current context and engage in situation-specific, customized 'nonce' inferencing (as hypothesized in Relevance Theory, Wilson & Sperber 2004).

5.1 Readiness is all — anticipating potentially relevant meaning

However, although Levinson's argument from design is compelling with respect to the need for quick inferencing, the associated case against exclusively relying on situation-specific, customized inferences may not be as strong as it seems. Note that such customized inferences may work a lot better if, next to what is said, the information needed to enrich the coded meaning and derive speaker meaning happens to be sufficiently available at the right time. And if the required information is ready, who knows how long a context-sensitive, customized inference really takes?

A central idea in the so-called memory-based text-processing tradition (e.g., Gerrig & McKoon 1998; Gerrig & O'Brien 2005) is *readiness*, the timely availability of plausibly relevant information. Firmly based in general models of human memory (e.g., Ratcliff & McKoon 1988; Anderson 1990), research in this tradition has shown that as we read though a text, potentially relevant additional information waxes and wanes without cost, as a function of how our content-addressable long-term memory passively 'resonates' to currently active representations (Myers & O'Brien 1998). Specifically, active representations in working memory simply act as memory cues for information in long-term memory, and associated information – from general world knowledge as well as inactive portions of discourse memory – is made available for further processing automatically.

Importantly, although active representations that serve as retrieval cues can be simple (e.g., a single word), they can also be highly complex and involve the combination of many different bits of information ('compound cues'). Of particular relevance here, many inferences that seem to rely on sophisticated active processing, including anaphoric, bridging, causal and predictive inferences, can actually come for free as a function of convergent memory retrieval cues (see Gerrig & O'Brien 2005, for a review). Even something as complex as current common ground has been argued to come virtually for free in this framework, as the information that is automatically rendered more available by combining the linguistic and other currently active retrieval cues *with the current interlocutor as a retrieval cue* (Gerrig & McKoon 1998).

Although the cues can be complex, the resonance process itself is sometimes referred to as 'dumb', because the information made 'ready' may not be what is needed – after all, the system essentially does automatic pattern recognition and pattern completion, not reasoning over structured representations. Models of text processing therefore usually postulate resonance-based memory retrieval as a first step only, with its cost-free suggestions being taken up or pruned away by more sophisticated compositional and inferential sense-making processes (see, e.g., Kintsch 1998). Translated to distinctions used here, the more precise computations involved in compositional semantics, pragmatic enrichment and implicature derivation rely on (and incrementally drive) resonance-based dumb memory retrieval, but by no means *reduce* to them.

I think it is exactly this readiness function of our content-addressable long-term memory that is behind the contextual expectations discussed in the MIR and other memory-retrieval accounts of context-based N400 effects (Kutas & Federmeier 2000; Federmeier 2007). When combined with by *I have a big*, a stereotypically 'upper-class' accent simply increases the availability of things that people with posh accents tend to have (expensive cars, cigars, an attitude), at the expense of things they do not tend to have (a Fiat Uno, or a tattoo). Similarly for classic N400-inducing sentences such as *He buttered the bread with...* or *He ate the...*, which increase the readiness of specific or generally edible items respectively. And likewise for *The dean told the lecturer that there was ample reason to...*, which in a story about a swindling lecturer will increase the readiness of concepts involving grave consequences (being reprimanded or fired), at the expense of happier concepts (e.g., being praised or promoted).[13]

One can of course debate whether the passive, dumb pattern-recognition and pattern-completion functionality afforded by our content-addressable long-term memories should be called 'prediction' or 'anticipation' proper – some may want to reserve those terms for a more active, 'intentional' mode of operation. However, it qualifies as anticipation in several ways. First, meaning is essentially about being able to predict (cf. Altmann 1997), so to the extent that our content-addressable memory automatically increases the availability (readiness) of conceptually associated information in response to what we read or hear in a given context, we are essentially anticipating. Second, rational analyses of long-term memory (e.g., Anderson, 1990; Schooler & Anderson, 1997) suggest that long-term memory processes are optimized to generate information that is needed in the immediate future.

The idea that our long-term memory is fundamentally geared to anticipating future information needs also resonates with recent neuroscience thinking about the role of memory in predicting the future, rather than ruminating over the past (e.g., Schacter & Addis 2007; Schacter, Addis & Buckner 2007).

Whether this should or should not be called anticipation is perhaps a terminological issue. But the point here is this: to the extent that our brains are great at having relevant enriching information ready at just the right time (possibly even in terms of what is in common ground and what is not), context-sensitive customized inferences about what the speaker intends to convey may not be so hard to draw. In fact, some of the inferences may actually be achieved *via richly cued long-term memory retrieval*, in which case they come cheap and fast. What then remains of Levinson's systems-design argument for hard-coded general heuristics, contra customized inferencing, remains to be seen. These default heuristics may well be necessary for other reasons – I lack the expertise needed to assess this. What I can say, though, is that there is more than one way to at least partly bypass the transmission bottleneck in human communication. Context-insensitive heuristics that rapidly deliver default interpretations can help. But a conceptual long-term memory that voluntarily offers enriching information on the fly, at just the right time, can be a big help too.

5.2 Anticipating upcoming communication

Beyond the conceptual anticipation reflected in N400 effects, there is also strong ERP evidence that interlocutors anticipate upcoming *communication*. First, as we saw before, an unfolding utterance such as *David praised Linda because* raises strong expectations as to who will be talked about next, a prediction so strong that a perfectly legal subsequent *he* is briefly taken as a syntactic error (Van Berkum *et al.* 2007). Second, other ERP experiments convincingly show that people go beyond this, to routinely anticipate specific upcoming words. In one of these experiments (Van Berkum, Brown, Zwitserlood, Kooijman, & Hagoort 2005), participants listened to (Dutch) mini-stories such as (10a), which in a paper-and-pencil cloze test were predominantly completed with one particular critical noun (in this case, *painting*, the Dutch translation of which is a neuter-gender word). To test whether such discourse-based lexical prediction would also occur 'online' as part of real-time language comprehension, the EEG participants would at this point first hear a gender-inflected adjective whose syntactic gender either agreed with the

anticipated noun, as in (10b) or did not agree with this expected noun, as in (10c):

(10) a. The burglar had no trouble locating the secret family safe. Of course, it was situated behind a...
b. ... big_{NEU} but rather unobtrusive $\text{painting}_{\text{NEU}}$
c. ... $\textit{big}_{\text{COM}}$ but rather unobtrusive $\text{bookcase}_{\text{COM}}$.

Relative to the gender-congruent prenominal adjective in (10b), the gender-incongruent adjective in (10c) elicited a small but reliable ERP effect right at the inflection, illustrated in figure 16.5. Because this prediction effect hinged on the idiosyncratic (hence memorized) syntactic gender of an expected but not yet presented noun, it suggested that discourse-level information can indeed lead people to anticipate specific upcoming words 'online', as a local sentence unfolds. In addition, the fact that such prediction could be probed via syntactic gender agreement suggested that the syntactic properties of those anticipated 'ghost' words can immediately begin to interact with locally unfolding syntactic constraints, such as the gender inflection on a prenominal adjective.

In follow-up research (Otten & Van Berkum 2008; Otten, Nieuwland & Van Berkum 2007), we examined whether these discourse-based predictions were being driven by a true message-level representation of the

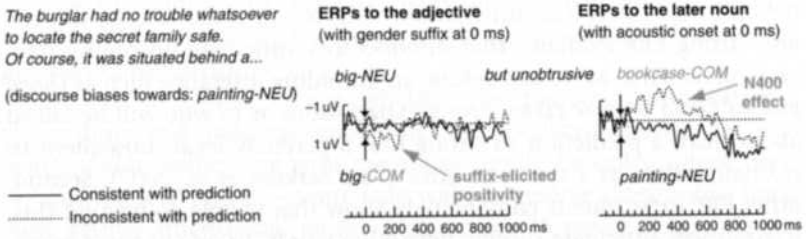

Figure 16.5 ERP effects of discourse-based prediction of upcoming words. Left: The ERP effect to spoken adjectives whose morphosyntactic gender suffix did not match discourse-based expectations for specific upcoming nouns (e.g. the neuter Dutch equivalent of *painting*, preceded by a prenominal adjective with common gender suffix). Right: The N400 effect elicited by the actual spoken nouns presented later in the sentence, with a coherent but less expected noun (e.g., *bookcase*) eliciting a much larger N400 than the discourse-predictable noun (*painting*). Acoustic onset of the critical suffix (left) or later noun (right) is at 0 ms.

discourse (as had been assumed by Van Berkum *et al.* 2005), or whether they could be reduced to some simpler mechanism involving scenario-based or convergent lexical priming. The ERP results actually suggest that in the agreement-sensitive paradigms used here, which only test for predictions that percolate down to structured sentence-level representations, the precise message of the discourse up to that point helps people anticipate specific upcoming words.

Together with other evidence from ERPs (DeLong, Urbach, & Kutas 2005; Nieuwland & Van Berkum 2006a; Wicha, Moreno & Kutas 2004) and behavioural methods (Trueswell & Tanenhaus 2005; De Ruiter, Mitterer & Enfield 2006), these experiments show that readers and listeners don't just passively sit back and enjoy the show, but actively anticipate what their interlocutor is going to say next. This may seem odd, for the generativity of language allows interlocutors to say lots of things (a line of reasoning that has been used to argue against prediction, see Jackendoff 2002). But in ordinary rich context, and illustrated by the fact that we can successfully finish other people's sentences, interlocutors are in fact not entirely unpredictable. Furthermore, although the mechanisms underneath this type of prediction are currently debated (see e.g., Pickering & Garrod 2007), much of it may again come for free as a function of how human memory works (Gerrig & McKoon 1998; Gerrig & O'Brien 2005; Schacter, Addis & Buckner 2007).

5.3 So what?

Theories in pragmatics usually focus on making sense of what is said, not on what *will* be said. However, the speed with which language users successfully make sense of rather under specified utterances suggests that they are in fact doing some preparatory thinking. In line with behavioural studies, the ERP evidence discussed here demonstates that readers and listeners routinely look ahead. They anticipate relevant meaning as well as upcoming communication. Moreover, the basis for such anticipation far exceeds simple word–word priming of the doctor–nurse type. As suggested by behavioural research in the memory-based text-processing tradition, as well as by more recent neurocognitive work on memory, it may well be that human long-term memory functions do most of the work here, cleverly, for free, and fast. Such considerations directly bear on central arguments in pragmatic theory, such as whether language users need a limited set of special fast-acting heuristics to compute speaker meaning (Levinson 2000) or can instead make do

with more idiosyncratic context-sensitive inferencing (Wilson & Sperber 2004). Furthermore, if we're lucky, understanding how memory works can help solve a related problem, which is to understand which subset of the vast knowledge people have about the world, their own past, their goals, the current situation, and their interlocutor, is part of the effective interpretive background as words come in, and why.

6 Conclusion

The psycholinguistic ERP studies reviewed here address a central topic of pragmatics: the use of context in language processing. One might argue that the real-time aspects and neural signatures of such context-dependent processing are irrelevant to pragmatics as a linguistic discipline, but, fortunately, such a classic competence view on linguistics is rapidly losing ground (cf. Jackendoff 2002, 2007b). Linguistics, psychology, and neuroscience all study the same system in the end – albeit at different levels – and matters are too complex to disregard potentially relevant evidence from whatever neighbouring discipline. Furthermore, when pragmatic theories become partly grounded in analyses of what the human brain can and cannot do (cf. Levinson 2000), one might as well have a closer look at the extant cognitive and cognitive neuroscience data anyway.

This interdisciplinary flow of information should go both ways, of course, and I think that – even if all of what I propose here is wrong – the N400 analysis in this chapter actually makes the point. It is not just about how ERPs can inform pragmatic theory, but emphatically also the other way around: theoretical distinctions used in pragmatics (and semantics) may help us understand the brain signals we pick up. Over the past few years, it slowly dawned upon me that, for all its high-tech tools and its ability to 'look under the hood', the cognitive neuroscience of language interpretation by and large wasn't making as much progress and impact as it might have (see Geurts in press, and Pylkänen in press, for comparable observations). Apart from being bogged down by historically determined perennial questions (e.g., modularity) and relatively accidental research traditions – something any decent research programme can get stuck in – I think a major cause for this delay in progress and impact is its relative detachment from research in linguistics and classic experimental psychology. If my analysis is correct, then the emerging interdisciplinary field of experimental pragmatics should benefit us all.

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1. In the psycholinguistic ERP literature, interpretation is often referred to as 'semantic processing'. However, this is not to be confused with the specific denotation of 'semantic processing' in linguistics; psycholinguistic ERP research on semantic processing is usually agnostic on whether the phenomena being studied involve linguistic semantics (coded meaning) or pragmatics (the rest).
2. In cases where people quote or act out other speakers, things get more complicated. Whether the current N400 effect can be effectively neutralized in, say, *And then my wife said: 'I am pregnant because I feel sick'* spoken in a deep male voice is an entirely empirical issue. Because the N400 is also sensitive to more shallow 'primes' in the context (see section 4), I suspect that such layering will attenuate but not necessarily entirely eliminate the N400 effect.
3. With something like euthanasia valued very differently by different people, this admits a degree of subjectivity in meaning that semanticists might not feel very comfortable with. Note, however, that speaker meaning also involves subjective factors (e.g., given what I know about so-and-so, our common ground and goals, what might he or she have meant?). More generally, it seems clear that although mental representations of meaning need to have sufficient commonality across speakers to make communication work, they will all in the end be 'subjective' anyway.
4. Because this is sometimes overlooked, let me re-emphasize: in spite of its label, an N400 effect can begin to emerge around *150 ms* after word onset. Also, although Nref effects may last for over a second, their typical onset is around *300–400 ms*. So, on the time-scale of rapid incremental language processing observations, these are not late effects.
5. One might argue that the attenuation of the N400 effect observed in Experiment 1 of Nieuwland & Van Berkum (2006a) reflects an extremely rapid referential modulation of how coded word meaning fits the context. In this experiment, we presented cartoon-like stories in which critical words with an inanimate semantic feature (e.g. *yacht*) repeatedly occurred in animacy-requiring postverbal positions (e.g. *The psychotherapist advised the yacht to be honest not only with her, but especially with himself.*) We found a large N400 effect on the first critical occurrence of *yacht* (relative to a suitable control, here *sailor*), but no N400 effect on the second and third critical occurrence. One interesting possibility is that knowing the particular referent of *yacht*

here changes the locally relevant coded meaning, and as such eliminates the N400 effect downstream in the story. In this particular study, however, we also cannot rule out that at least some of the attenuation comes about because *yacht* is repeated (cf. section 4).

6. The fruits of all this computation should lead to adjustments of the discourse representation, the common ground, and the 'private' ground (i.e., other beliefs of the listener). However, whether such (possibly highly incremental) model updating should be seen as a separate step or an *intrinsic part* of the above computations remains to be established.
7. N400 effects elicited by *words* in non-linguistic prime contexts, such as the word *keys* presented after the sound of a dripping faucet versus that of rattling keys (Van Petten & Rheinfelder 1995), or the word *basement* after a high versus a low tone (Koelsch, Kasper, Sammler, Schulze, Gunter & Friederici 2004), do in principle lend themselves to a speaker meaning interpretation. And so does the rebus-like presentation of a picture as part of an unfolding sentence.
8. The semantic long-term memory discussed here is conceptual memory in the broadest sense, i.e., memory of meaningful entities, situations, events, etc., and their various relations as they occur in the real world (including any fictitious worlds made part of it) known to a person. This includes semantic memory narrowly defined (say, a basic network of concepts, or a set of feature lists), but also far more richly structured knowledge, including such things as how to behave at a thesis defence ceremony and why, the turbulent history of Cuba, typical steps in replacing a hard disk, and, say, the narrative conventions respected in most cartoons.
9. In linguistics, these phenomena are usually analysed in very different ways. However, the proposal is that in terms of the impact on the comprehension processes indexed by the N400, their processing consequences may be identical.
10. In the current proposal, unexpected conceptual features may thus lead to intensified retrieval in two ways: (a) most basically, because divergent or even conflicting cues make such features more difficult to retrieve, and (b) as a second-order effect, because the unexpectedness itself may signal the need for deeper, more detailed memory sampling.
11. In fact, this intimate link between sense-making and memory retrieval is probably why proponents of a retrieval perspective, such as Kutas, Federmeier, and Van Petten, sometimes do refer to the N400 as reflecting integration.
12. For example, we sometimes *but not invariably* see a comparable late negative shift in standard semantic anomaly paradigms eliciting an N400 (e.g., Van Berkum *et al.* 2003: figure 6; Van Berkum *et al.* 2008: figures 1 and 2); if these effects share their functional and neural source with the Nref effect, one will need to explain why the putative process – say, inferencing – occurs on some semantic anomaly occasions, but not on others.
13. I prefer the terms 'resonance' and 'readiness' over 'priming' because, following early models of semantic memory, the latter is usually associated with links between simple units, like doctor–nurse. However, in modern models of memory, highly complex structured combinations of cues can also retrieve or 'prime' stored information. To recognize the need for this, just think about

the fact that a particular *sequence* of events, or a complexly structured scene, can bring something to mind. Furthermore, what is brought to mind need not be simple either. Rich structure can retrieve more rich structure from memory (see also Gerrig & O'Brien 2005).

References

Altmann, G. T. M. (1997). *The Ascent of Babel: An Exploration of Language, Mind, and Understanding*. Oxford: Oxford University Press.

Altmann, G. T. M. & M. Steedman (1988). Interaction with context during human sentence processing. *Cognition, 30*: 191–238.

Anderson, J. R. (1990). *The Adaptive Character of Thought*. Hillsdale, NJ: Erlbaum.

Bach, K. (2006). The top 10 misconceptions about implicature. In B. Birner & G. Ward (eds.), *A Festschrift for Larry Horn*. Amsterdam: John Benjamins.

Baggio, G., M. van Lambalgen & P. Hagoort (2008). Computing and re-computing discourse models: an ERP study. *Journal of Memory and Language*.

Barton, S. B. & A. J. Sanford (1993). A case study of anomaly detection: shallow semantic processing and cohesion establishment. *Memory & Cognition, 21*: 477–87.

Bernat, E., S. Bunce, & H. Shevrin (2001). Event-related brain potentials differentiate positive and negative mood adjectives during both supraliminal and subliminal visual processing. *International Journal of Psychophysiology*, 42(1): 11–34.

Blasko, D. G. & V. A. Kazmerski (2006). ERP correlates of individual differences in the comprehension of nonliteral language. *Metaphor and Symbol*, 21: 267–84.

Bohan, J. (2008). Depth of Processing and Semantic Anomalies. Unpublished dissertation.

Cacioppo, J. T., S. L. Crites, G. G. Berntson & M. G. H. Coles (1993). If attitudes affect how stimuli are processed, should they not affect the event-related brain potential? *Psychological Science*, 4: 108–12.

Cacioppo, J. T., J. T. Larsen, N. K. Smith, & G. G. Berntson (2004). The affect system: What lurks below the surface of feelings? In A. S. R. Manstead, N. H. Frijda, & A. H. Fischer (eds.), *Feelings and Emotions: The Amsterdam Conference*. New York: Cambridge, University Press, pp. 223–42.

Calvo, M. G. (2001). Working memory and inferences: evidence from eye fixations during reading. *Memory*, 9: 365–81.

Camblin, C. C., P. C. Gordon, T. Y. Swaab, (2007). The interplay of discourse congruence and lexical association during sentence processing: evidence from ERPs and eye tracking. *Journal of Memory & Language*, 56: 103–28.

Carston, R. (2002). *Thoughts and Utterances: The Pragmatics of Explicit Communication*. Oxford: Blackwell.

Clark, H. H. (1996). *Using Language*. Cambridge: Cambridge University Press.

Clark, H. H. (1997). Dogmas of understanding. *Discourse Processes*, 23: 567–98.

Corley, M., L. J. MacGregor, & D. I. Donaldson, (2007). It's the way that you, er, say it: hesitations in speech affect language comprehension. *Cognition*, 105: 658–68.

Coulson, S. (2004). Electrophysiology and pragmatic language comprehension. In I. A. Noveck and D. Sperber (eds.), *Experimental Pragmatics*. Basingstoke and New York: Palgrave Macmillan, pp. 187–206.

Coulson, S. & K. D. Federmeier (in press). Words in context: ERPs and the lexical/postlexical distinction. *Journal of Psycholinguistic Research*.

Damasio, A. R. (2004). Emotions and feelings: A neurobiological perspective. In A. S. R. Manstead, N. H. Frijda & A. H. Fischer (eds.), *Feelings and Emotions: The Amsterdam Conference*. New York: Cambridge University Press, pp. 49–57.

DeLong K. A., T. P. Urbach & M. Kutas (2005). Probabilistic word pre-activation during language comprehension inferred from electrical brain activity. *Nature Neuroscience*, 8(8): 1117–21.

De Ruiter, J. P., H. Mitterer & N. J. Enfield (2006). Projecting the end of a speaker's turn: a cognitive cornerstone of conversation. *Language Journal*, 82: 515–35.

Federmeier, K. D. (2007). Thinking ahead: the role and roots of prediction in language comprehension. *Psychophysiology*, 44: 491–505.

Federmeier, K. D. & M. Kutas (1999). A rose by any other name: long-term memory structure and sentence processing. *Journal of Memory and Language*, 41: 469–95.

Fischler, I., P. A. Bloom, D. G. Childers, A. A. Arroyo, & N. W. Perry (1984). Brain potentials during sentence verification: late negativity and long-term memory strength. *Neuropsychologia*, 22: 559–68.

Fischler, I., P. A. Bloom, D. G. Childers, S. Roucos, & N. W. Perry (1983). Brain potentials related to stages of sentence verification. *Psychophysiology*, 20(4): 400–9.

Friederici, A. 2002. Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences*, 6 (2): 78–84.

Garrett, M. & R. M. Harnish (2007). Experimental pragmatics: testing for implicature. *Pragmatics and Cognition*, 15(1): 65–90.

Gerrig, R. J., & G. McKoon (1998). The readiness is all: the functionality of memory-based text processing. *Discourse Processes*, 26: 67–86.

Gerrig, R. J., & E. J. O'Brien (2005). The scope of memory-based processing. *Discourse Processes*, 39: 225–42.

Geurts, B. (1999). *Presuppositions and Pronouns*. Oxford: Elsevier.

Geurts, B. (in press). Neurocognition of language: good, bad, and bogus. *Language and Cognitive Processes*.

Geurts, B. & D. Beaver (2007). Discourse representation theory. In *Stanford Encyclopedia of Philosophy*.

Hagoort, P., L. Hald, M. Bastiaansen & K. M. Petersson (2004). Integration of word meaning and world knowledge in language comprehension. *Science*, 304: 438–41.

Hald, L. A., E. G. Steenbeek-Planting & P. Hagoort (2007). The interaction of discourse context and world knowledge in online sentence comprehension. Evidence from the N400. *Brain Research*, 1146: 210–18.

Halgren, E., R. P. Dhond, N. Christensen, C. Van Petten, K. Marinkovic, J. D. Lewine, & A. M. Dale (2002). N400-like MEG responses modulated by semantic context, word frequency, and lexical class in sentences. *NeuroImage*, 17(3): 1101–16.

Hobbs, J. R., (1985). Granularity. In *Proceedings of the Ninth International Joint Conference on Artificial Intelligence*, Los Angeles, California, pp. 432–5.

Holcomb, P. J., J. Grainger & T. O'Rourke (2002). An electrophysiological study of the effects of orthographic neighborhood size on printed word perception. *Journal of Cognitive Neuroscience*, 14: 938–50.

Holt, D. J., S. Lynn & G. R. Kuperberg, (in press). Comprehending the emotional meaning of sentences: an ERP study. *Journal of Cognitive Neuroscience*.

Jackendoff, R. (2002). *Foundations of Language: Brain, Meaning, Grammar, Evolution*. Oxford: Oxford University Press.

Jackendoff, R. (2007a). *Language, Consciousness, Culture: Essays on Mental Structure*, Cambridge, MA: MIT Press.

Jackendoff, R. (2007b). A Parallel Architecture perspective on language processing. *Brain Research*, 1146: 2–22.

Kamp, H., & U. Reyle (1993). *From Discourse to Logic*. Dordrecht: Kluwer.

Kempson, R. (2001). Pragmatics: language and communication. In M. Aronoff & J. Rees-Miller (eds.), *Handbook of Linguistics*. Malden, MA: Blackwell.

Kim, A. & L. Osterhout (2005). The independence of combinatory semantic processing: evidence from event-related potentials. *Journal of Memory and Language*, 52: 205–25.

Kintsch, W., (1998). *Comprehension: A Paradigm for Cognition*. New York: Cambridge University Press.

Koelsch, S., E. Kasper, D. Sammler, K. Schulze, T. Gunter, & A. D. Friederici (2004). Music, language and meaning: brain signatures of semantic processing. *Nature Neuroscience*, 7(3): 302–7.

Kounios, J., & P. J. Holcomb (1992). Structure and process in semantic memory: evidence from event-related brain potentials and reaction times. *Journal of Experimental Psychology: General*, 121: 459–79.

Kuperberg, G. R. (2007). Neural mechanisms of language comprehension: challenges to syntax. *Brain Research*, 1146: 23–49.

Kutas, M. & K. D. Federmeier (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Sciences*, 4: 463–70.

Kutas, M., & S. A. Hillyard (1980). Reading senseless sentences: brain potentials reflect semantic incongruity. *Science*, 207: 203–5.

Kutas, M., C. Van Petten & R. Kluender (2006). Psycholinguistics electrified II: 1994–2005. In M. Traxler & M.A.Gernsbacher (eds.), *Handbook of Psycholinguistics*, 2nd edn New York: Elsevier, pp. 659–724.

Lau, E., C. Phillips & D. Poeppel (2008). A cortical network for semantics: (de)constructing the N400. *Nature*, 9: 920–33.

Levinson, S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.

Levinson, S. C. (2000). *Presumptive Meanings: The Theory of Generalized Conversational Implicature*. Cambridge, MA: The MIT Press.

Li, X., P. Hagoort, & Y. Yang (2008). Event-related potential evidence on the influence of accentuation in spoken discourse comprehension in Chinese. *Journal of Cognitive Neuroscience*, 20: 906–15.

Linderholm, T. (2002). Predictive inference generation as a function of working memory capacity and causal text constraints. *Discourse Procesess*, 34: 259–80.

Morris, J. P., N. K. Squires, C. S. Taber & M. Lodge (2003). Activation of political attitudes: a psychophysiological examination of the hot cognition hypothesis. *Political Psychology*, 24: 727–45.

Myers, J. L. & E. J. O'Brien (1998). Accessing the discourse representation during reading. *Discourse Processes*, 26: 131–57.

Newell, A. (1990). *Unified Theories of Cognition*. Cambridge, MA: Harvard University Press.

Nieuwland, M. S. & G. R. Kuperberg (in press). When the truth isn't too hard to handle: an Event-Related Potential study on the pragmatics of negation. *Psychological Science*.

Nieuwland, M. S., M. Otten & J. J. A. Van Berkum (2007). Who are you talking about? Tracking discourse-level referential processing with ERPs. *Journal of Cognitive Neuroscience*, 19: 228–36.

Nieuwland, M. S., K. M. Petersson & J. J. A. Van Berkum (2007). On sense and reference: examining the functional neuroanatomy of referential processing. *Neuro Image*, 37: 993–1004.

Nieuwland, M. S., & J. J. A. Van Berkum (2005). Testing the limits of the semantic illusion phenomenon: ERPs reveal temporary semantic change deafness in discourse comprehension.*Cognitive Brain Research*, 24: 691–701.

Nieuwland, M. S., & J. J. A. Van Berkum (2006a). When peanuts fall in love: N400 evidence for the power of discourse. *Journal of Cognitive Neuroscience*, 18: 1098–111.

Nieuwland, M. S, & J. J. A. Van Berkum (2008). Individual differences and contextual bias in pronoun resolution: evidence from ERPs. *Brain Research*, 1118: 155–67.

Nieuwland, M. S, & J. J. A. Van Berkum (in press). The interplay between semantic and referential aspects of anaphoric noun phrase resolution: evidence from ERPs. *Brain and Language*, 106: 119–31.

Noveck, I. A. & A. Posada (2003). Characterizing the time course of an implicature: an evoked potentials study. *Brain and Language*, 85: 203–10.

Osterhout, L., A. Kim, & G. Kuperberg (in press). The neurobiology of sentence comprehension. To appear in M. Spivey, M. Joanaisse & K. McRae (eds.), *The Cambridge Handbook of Psycholinguistics*. Cambridge: Cambridge University Press.

Osterhout, L. & L. A. Mobley (1995). Event-related brain potentials elicited by failure to agree. *Journal of Memory and Language*, 34: 739–73.

Otten, M., M. S. Nieuwland, & J. J. A. Van Berkum (2007). Great expectations: specific lexical anticipation influences the processing of spoken language. *BMC Neuroscience*, 8 (89).

Otten, M. & J. J. A. Van Berkum (2007). What makes a discourse constraining? Comparing the effects of discourse message and scenario fit on the discourse-dependent N400 effect. *Brain Research*, 1153: 166–77.

Otten, M. & J. J. A. Van Berkum (2008). Discourse-based anticipation during language processing: prediction or priming? *Discourse Processes*, 45: 464–96.

Pickering, M. J., & S. Garrod (2007). Do people use language production to make predictions during comprehension? *Trends in Cognitive Sciences*, 11: 105–10.

Pylkkänen, L. (in press), Mismatching meanings in brain and behavior. *Language and Linguistic Compass*.

Ratcliff, R., & G. McKoon (1988). A retrieval theory of priming in memory. *Psychological Review*, 95: 285–408.

Roberts, C. (2004). Context in dynamic interpretation. In L. R. Horn & G. Ward (eds.), *The Handbook of Pragmatics*. Maldon, MA: Blackwell, pp. 197–220.

Sanford, A. J., & S. C. Garrod (1998). The role of scenario mapping in text comprehension. *Discourse Processes*, 26: 159–90.

Sanford, A. J. & S. C. Garrod (2005). Memory-based approaches and beyond. *Discourse Processes*, (39): 205–34.

Sanford, A. J. S., A. J. Sanford, J., Molle & C. Emmott (2006). Shallow processing and attention capture in written and spoken discourse. *Discourse Processes*, 42 (2): 109–30.

Sanford, A. J. & P. Sturt (2002). Depth of processing in language comprehension: not noticing the evidence. *Trends in Cognitive Sciences*, 6: 382–6.

Schacter, D. L. & D. R. Addis (2007). The cognitive neuroscience of constructive memory: remembering the past and imagining the future. *Philosophical Transactions of the Royal Society (B)*, 362: 773–86.

Schacter, D. L., D. R. Addis, & R. L. Buckner (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience*, 8: 657–61.

Schooler, L. J. & J. R. Anderson (1997). The role of process in the rational analysis of memory. *Cognitive Psychology*, 32(3): 219–50.

Sitnikova, T., G. R. Kuperberg & P. J. Holcomb (2003). Semantic integration in videos of real-world events: an electrophysiological investigation. *Psychophysiology*, 40: 160–4.

Sperber, D. & I. A. Noveck (2004) Introduction. In I. A. Noveck & D. Sperber (eds.), *Experimental Pragmatics*. Basingstoke: Palgrave Macmillan.

Stenberg, G., M. Lindgren, M. Johansson, A. Olsson & I. Rosen (2000). Semantic processing without conscious identification-evidence from event-related potentials. *Journal of Experimental Psychology; Learning, Memory and Cognition*, 26: 973–1004.

St. George, M., S. Mannes, & J. E. Hoffman (1994). Global semantic expectancy and language comprehension. *Journal of Cognitive Neuroscience*, 6(1): 70–83.

St. George, M., S. Mannes, & J. E. Hoffman (1997). Individual differences in inference generation: an ERP analysis. *Journal of Cognitive Neuroscience*, 9: 776–87.

Trueswell, J., & M. Tanenhaus (2005) (eds.), *Approaches to Studying World-situated Language Use: Bridging the Language-as-product and Language-action Traditions*. Cambridge, MA: MIT Press.

Van Alphen, P. & J. J. A. Van Berkum (in press). Is there pain in champagne? Semantic involvement of words within words during sense-making. *Journal of Cognitive Neuroscience*.

Van Berkum, J. J. A. (2004). Sentence comprehension in a wider discourse: Can we use ERPs to keep track of things? In M. Carreiras & C. Clifton Jr. (eds.), *The On-line Study of Sentence Comprehension: Eye tracking, ERPs and Beyond*. New York: Psychology Press, pp. 229–70.

Van Berkum, J. J. A., C. M. Brown & P. Hagoort (1999a). Early referential context effects in sentence processing: evidence from event-related brain potentials. *Journal of Memory and Language*, 41: 147–82.

Van Berkum, J. J. A., C. M. Brown & P. Hagoort (1999b). When does gender constrain parsing? Evidence from ERPs. *Journal of Psycholinguistic Research*, 28(5): 555–71.

Van Berkum, J. J. A., C. M. Brown, P. Zwitserlood, V. Kooijman & P. Hagoort (2005). Anticipating upcoming words in discourse: evidence from ERPs and reading times. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 31: 443–67.

Van Berkum, J. J. A., P. Hagoort, & C. M. Brown (1999). Semantic integration in sentences and discourse: evidence from the N400. *Journal of Cognitive Neuroscience*, 11(6): 657–71.

Van Berkum, J. J. A., B. Holleman, M. S. Nieuwland, M. Otten & J. Murre (in press). Right or Wrong? The brain's fast response to morally objectionable statements. *Psychological Science*.

Van Berkum, J. J. A., A. W. Koornneef, M. Otten & M. S. Nieuwland (2007). Establishing reference in language comprehension: an electrophysiological perspective. *Brain Research*, 1146: 158–71.

Van Berkum, J. J. A., D. Van den Brink, C. M. J. Y. Tesink, M. Kos & P. Hagoort (2008). The neural integration of speaker and message. *Journal of Cognitive Neuroscience*, 20(4): 580–91.

Van Berkum, J. J. A., P. Zwitserlood, M. C. M. Bastiaansen, C. M. Brown & P. Hagoort (2004). So who's " he" anyway? Differential ERP and ERSP effects of referential success, ambiguity and failure during spoken language comprehension. Annual meeting of the Cognitive Neuroscience Society (CNS-2004), San Francisco, April 18–20.

Van Berkum, J. J. A., P. Zwitserlood, C. M. Brown & P. Hagoort (2003b). When and how do listeners relate a sentence to the wider discourse? Evidence from the N400 effect. *Cognitive Brain Research*, 17: 701–18.

Van den Brink, D., C. M. Brown, and P. Hagoort (2006). The cascaded nature of lexical selection and integration in auditory sentence processing. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 32: 364–72.

Van Petten, C., S. Coulson, S. Rubin, E. Plante & M. Parks (1999). Time course of word identification and semantic integration in spoken language. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 25: 394–417.

Van Petten, C., & M. Kutas (1990). Interactions between sentence context and word frequency in event-related brain potentials. *Memory and Cognition*, 18: 380–93.

Van Petten, C., M. Kutas, R. Kluender, M. Mitchiner & H. McIsaac (1991). Fractionating the word repetition effect with event-related potentials. *Journal of Cognitive Neuroscience*, 3: 131–50.

Van Petten C, & H. Rheinfelder (1995). Conceptual relationships between spoken words and environmental sounds: event-related brain potential measures. *Neuropsychologia*, 33: 485–508.

West, W. C., & P. J. Holcomb (2002). Event-related potentials during discourse-level semantic integration of complex pictures. *Cognitive Brain Research*, 13: 363–75.

Wicha, N. Y. Y., E. M. Moreno & M. Kutas (2004). Anticipating words and their gender: an event-related brain potential study of semantic integration, gender expectancy, and gender agreement in Spanish sentence reading. *Journal of Cognitive Neuroscience*, 16: 1272–88.

Wilson, D., & Sperber, D. (2004). Relevance Theory. In G. Ward & L. Horn (eds.), *Handbook of Pragmatics*. Oxford: Blackwell, pp. 607–32.

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