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Content and context in incremental processing: "the ham sandwich" revisited

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Abstract The interplay of content and context is observable in a moment to moment manner as propositional content unfolds. The current contribution illustrates this through data from real-time language comprehension indicating that propositional content is not computed in isolation but relies in important ways on context during every step of the computation of meaning. The relevant notion of context that we have to adopt includes all aspects of possible worlds and draws on a variety of knowledge representations, which in a first processing phase serve to generate expectations for upcoming words. In a second phase, the discourse representation is assessed and if necessary updated by means of inferential reasoning and enrichment to reflect the speaker's intended meaning.

Keywords Pragmatics · Meaning shift · Context · Speaker meaning · Inference

1 Introduction

Truth-conditional content is intimately intertwined with aspects of the context that go beyond pure lexical meaning. Utterances that appear to be ill-formed based on grammatical restrictions on compositionality ("The ham sandwich wants to pay.") may render a statement true when uttered under certain circumstances in a restaurant setting. Likewise, utterances that are true on the basis of lexical and grammatical information ("The peanut is salted.") yield false propositional content when referring to a cartoon character with human properties. In this contribution, I

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approach the interplay of linguistic meaning, context and truth-conditional content from a language processing perspective that seeks to disentangle the time-course of utterance comprehension as it unfolds in a moment to moment manner. From the point of view of temporal dynamics, there does not seem to be a clear-cut distinction between "what is said" and "what is implicated". Rather we observe two temporally distinct mechanisms. The first mechanism is modulated by expectations built up by prior discourse, including common ground and other aspects of context, and incrementally computes predictions for upcoming words. The second mechanism engages inferential reasoning in order to arrive at a meaningful interpretation.

Content is highly dependent on context and crucially at a very early moment in time, rendering any strict sequentiality of semantics-before-pragmatics in the sense of content-before-context inaccurate. To account for the data in a proper way, a broad notion of context must be adopted, including sentential context, co-text, situational context, world knowledge, common ground, etc. In cases in which expectations are not met (again, a very broad notion including expectations of the grammatical system such as type selection), the processing system attempts to compute a felicitous interpretation by drawing inferences and enriching composition based on a cooperative speaker-hearer interaction. This reasoning is also guided by context, and speaker intentions are taken into consideration to construct a meaningful interpretation. The role of speaker intention as part of context has led to many controversies (cf. e.g., Bosco et al. 2004; Stalnaker 1999 for an affirmative view and Bach 2005 for a negative view). Yet, a hearer's meaningful interpretation is not necessarily the intended meaning of the speaker, so inferences based on presumed speaker intention can form a part of this reasoning step, but they represent the hearer's assumptions about the speaker's intentions, which may well diverge from the actual intended meaning. Take for instance an advertisement for the Cologne-based beer brand "Früh" (German for "early", "soon"): Next to an emptied glass of Früh-beer, you find the slogan "Bevor es Alt wird." ("Before it turns dark/old.") The slogan exploits the homophony between the adjective "old" and the noun—encoded by capitalization—referring to a variety of beer ("top-fermented dark beer"). Without the necessary socio-cultural information, there is a nice opposition between the local speciality beer that is brewed in Cologne, a clear beer ("Früh" is a variety of the traditional local "Kölsch"), and the dark beer brewed only 50 km away in the city of Düsseldorf that is subjected to a longer fermentation process ("Altbier", meaning "old beer", is a top-fermented dark variety). On the surface, the advertisement thus plays with the contrast between the fresh and young "Früh" variety and the longer fermented (old) type of beer. However, the slogan also alludes to the local rivalry between the two cities of Cologne and Düsseldorf. The menace therefore is not merely of a young beer turning old, but of the fine beer of Cologne turning into the Düsseldorf variety. The reader can find this witty and amusing on both readings, but within the socio-cultural context, it is the association of Früh/Cologne and Alt/Düsseldorf that evokes the strongest effect.

In the next section, I review relevant empirical findings from the recording of time-sensitive electrophysiological measures that corroborate a two-step architecture of utterance processing with the former being driven by contextually derived

predictions and the latter reflecting inferential effort yielding enriched interpretation. Then the architecture is tested against a presumably strong case of context-dependence: contextual licensing has been determined as a prerequisite for meaning shift in the "ham sandwich" cases, but the novel data indicate that reference transfer takes place irrespective of contextual endorsement lending support to an independent pragmatic operation.

2 Content and context in language comprehension

The term context has been used quite loosely not only in the theoretical literature but also in the psycho- and neurolinguistic literature. In the majority of investigations, context is confined to the surrounding text, mostly spanning across a single sentence, but sometimes also including multi-sentence passages. Research on ambiguity resolution has demonstrated that the (textual) context is used to select the most consistent interpretation from a set of alternatives and to suppress implausible meaning aspects (cf. e.g., Altmann and Steedman 1988; Swinney 1979). Combinations of visual images with auditory sentence presentation have further revealed that the non-linguistic visual context serves to disambiguate utterance interpretation guided by world knowledge (Kamide et al. 2003; Sedivy et al. 1999). Bransford and Johnson (1972) have shown that the comprehension of text passages improves when they are presented with a headline or a supporting visual scene; both cues enhance the global coherence of the text passage.

Context also figures prominently in the processing of polysemous expressions ("reading Goethe" versus "meeting Goethe"; "protesting during Vietnam" versus "hitchhiking around Vietnam"; cf. Frisson and Pickering 1999). The fact that polysemous expressions do not demonstrate a processing disadvantage relative to non-polysemous words was taken as evidence for underspecified representations for which the intended meaning is derived based on context information (e.g., Copestake and Briscoe 1995; Frazier and Rayner 1990; Frisson and Pickering 1999). A similar approach even considers underspecified representations to be "good enough" (Ferreira et al. 2002) unless context requires a more specified reading. See Frisson (2009) for an overview of arguments for and against the underspecification view.

In the following I turn to electrophysiological measures to sketch an extensive notion of context that draws from diverse aspects of context and affects temporally distinct mechanisms. Event-related brain potentials (ERPs) have the benefit of a high temporal resolution, which allows us to investigate the time-course dynamics of language processing in a moment to moment manner. This is particularly relevant for current purposes since it enables us to assess distinct aspects of content and context as they unfold over time. To this end, I provide a review of electrophysiological findings that help us understand the concurrence of content and context and I sketch a model of language processing that can serve as a framework for developing novel research questions about the contribution of context to incremental processing. This limited scope is necessary to initiate systematic research into the composition of meaning.

What are electrophysiological measures? Based on the electroencephalogram (EEG), they represent changes in the neural activity of the human brain that arise in response to a cognitive, sensory or motor event. The EEG is recorded non-invasively via electrodes placed at the surface of a person's scalp. ERPs represent electrical activity that is time-locked to an event and therefore provide information about the brain's response to this particular event (e.g., a critical word in a sentence or discourse). They are relative measures between two events that differ minimally from each other and provide a multidimensional signal including information about time (onset latency in millisecond resolution), polarity (negative- or positive-going potential change), magnitude (amplitude of the response), and topography (maximum activity relative to position of scalp electrode).

Turning to the ERP literature on content and context, I propose a two-phase architecture of the processing system. In the first phase, a multiplicity of effects arising from the parser's predictive power are observable. Previous research indicates that the textual context, the situational context, the interlocutors' individual knowledge, among other context features supply the parser with cues to generate expectations for upcoming words. In the second phase, a final representation is constructed during which processing demands from inferential reasoning and enrichment emerge. The driving force of this latter operation is cooperation and communicative effectiveness. Accordingly, the hearer's assumptions about the speaker's intention play a pivotal role in this phase. This phase is further viewed as representational in nature and reflects the construction and reorganization of discourse structure. As far as event-related potentials are concerned these two phases surface as distinct ERP signatures depicted in the schematic illustration in Fig. 1. Demands arising in relation to the predictive power of context are reflected by a negative-going potential peaking around 400 ms after a stimulus is encountered (N400). Demands arising due to inferencing and discourse representational considerations surface in a positive-going potential around 600 ms after the onset of a critical stimulus (Late Positivity). In previous research on referential processing, I have labeled the underlying mechanisms corresponding to the N400 and Late Positivity "Discourse Linking" and "Discourse Updating" respectively (cf. the Syntax-Discourse Model; Schumacher and Hung 2012). Schumacher (2012) provides a comprehensive overview on the contribution of context to these two phases. In the following, I highlight the core findings that support the argument before presenting novel data on the role of context during transfer of meaning.

3 Predictive power

The meaning of an utterance is constructed as the sentence unfolds. The parser computes predictions for upcoming words in an incremental manner on the basis of what has already been encountered. It draws on information provided by the surrounding text and the associated network of semantic links and feature specifications, mutual knowledge including information about the world, and individual knowledge such as expertise or ethical beliefs. The less expected an upcoming word is on the basis of these context-dependent predictors, the more

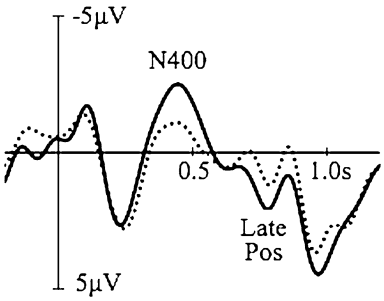


Fig. 1 Schematic illustration of N400 and Late Positivity effects for condition A (*solid line*) compared to condition B (*dotted line*). ERP effects are visible as relative differences between responses to condition A and B. The *horizontal bar* represents time relative to the onset of a critical word (at 0 s). The *vertical bar* depicts the magnitude of the signal in microvolts; negativity is plotted upwards

pronounced is the amplitude of the N400 signature. This indicates that computational demands are exerted whenever an expectation for an upcoming word is not met. In addition, the more severe the deviation from the expected is, the more pronounced is the effect.

In their seminal work, Kutas and Hillyard (1980) showed that unexpected words like "socks" (which also generate a semantic anomaly) in "He spread the warm bread with *socks*"[1] produced a more enhanced N400 compared to an expected sentence completion. Similar effects were observed in response to locally well-formed utterances ("Jane told the brother that he was exceptionally *slow*.") that violated general knowledge derived from the broader co-text (e.g., a situation in which Jane's brother was exceptionally quick) (van Berkum et al. 1999). Immediate consequences of textual relations have also been observed for cohesive devices and transitional states between utterances. An expected anaphoric expression is one that reflects an identity relation with a previously introduced referent, but indirectly related entities (as in "Tim visited a lecture. He said that the *speaker* …" where "the speaker" is accommodated) are preferred over new entities mentioned out of the blue, yielding a three-way gradation of the amplitude of the N400 (given via identity < indirectly related < new; Burkhardt 2006). Similarly, topic continuity is more expected than topic shift, the latter thus evoking a more pronounced N400 amplitude (Hung and Schumacher 2012). Moreover, predictions are not merely formed on the basis of lexical associations and considerations of coherence, but are also influenced by various prominence cues reflecting the degree of a referent's accessibility (cf. e.g., Streb et al. 1999; Schumacher and Baumann 2010).

Apart from co-textual relations, mutual knowledge shared by interlocutors also plays an important role in forming expectations for upcoming expressions. Take for instance world knowledge. If a hearer knows that Dutch trains are yellow but encounters an utterance such as "Dutch trains are *white* and very crowded", the unexpected color adjective engenders a pronounced N400 amplitude relative to the expected continuation (Hagoort et al. 2004). Stereotypes also contribute to the

[1] Time-locking points to which ERPs were measured are indicated by italics in the following examples.

generation of expectations as shown by mismatches between propositional content and acoustically encoded demographic information about the speaker (i.e. age, gender, socio-economic status). An utterance such as "Every evening I drink some *wine* before I go to sleep." represents a possible statement made by an adult but not by a child (again, yielding a pronounced N400) (van Berkum et al. 2008).

Knowledge about genres and the creative use of words also affects the parser's predictive force. Nieuwland and van Berkum (2006) for instance illustrated that once the term "peanut" is understood as a cartoon-like character in the passage below, the context-independent meaning of "peanut" referring to a type of bean interferes with utterance interpretation (reflected in a more pronounced N400 for the context-inappropriate "The peanut was salted" relative to the context-appropriate "The peanut was in love"):

> A woman saw a dancing peanut who had a big smile on his face. The peanut was singing about a girl he had just met. And judging from the song, the peanut was totally crazy about her. The woman thought it was really cute to see the peanut singing and dancing like that. The peanut was *salted/in love*, and by the sound of it, this was definitely mutual. He was seeing a little almond.

Interestingly, meaning shift from a salient property to a person associated with it that is contextually embedded in an appropriate scenario evokes no enhanced N400 amplitude relative to a non-shifted control. ("The barkeeper told the waitress that *the ham sandwich/the mailman* wanted to pay.") I return to the role of context for utterances including such reference transfer in Sect. 5.

Individual knowledge is also decisive in the generation of predictions. Expert-based knowledge is used, showing a processing disadvantage for unknown linguistic concepts when read by students of chemistry versus students of linguistics (Schumacher and Meibauer 2013). And hearer-specific moral beliefs narrow down the set of expected potential continuations (e.g., the hearer's attitude towards euthanasia affects the processing of "I think that euthanasia is an *acceptable* course of action"; from van Berkum et al. 2009). Value-inconsistent content evokes a more enhanced N400 compared to content consistent with the hearer's beliefs.

In sum, the processing correlates strongly suggest that as a sentence unfolds and partial interpretation of the utterance has already been formed, the space of alternative continuations is narrowed down based not only on linguistic knowledge, but also on world knowledge and common ground among other things. This supports models that assume an early influence of context on propositional content and suggests that the initial interpretation step is not merely confined to locutionary content (Grice's original conception of "what is said") but relies on context-dependent (pragmatic) information as well (as for instance suggested by Relevance Theory or truth-conditional pragmatics).

4 Discourse construction and updating

Whereas the operations in the first phase are highly automatic, the subsequent process appears to be more controlled and driven by reasoning, plausibility and

coherence considerations. In this phase, the discourse representation structure is assessed and updated if necessary, employing inferential reasoning to add for instance unarticulated meaning constituents and to create a coherent representation. Critically, context is a decisive ingredient to this phase as well because the inferential system attempts to establish the most plausible interpretation on the basis of all available information. Processing demands associated with the maintenance and reorganization of discourse representation structure are reflected by a positive-going potential. This Late Positivity emerges when new discourse units must be created, as is the case for any kind of non-coreferential expression (cf. e.g., Schumacher 2009), or when information in previously established discourse representation must be corrected, as is required for contrastive readings (cf. e.g., Wang and Schumacher 2013) or for topic shift (Hung and Schumacher 2012). Accordingly it has also been associated with information packaging (Chafe 1976; Vallduví 1992) because it reflects the encoding of instructions for the construction and updating of the mental model/discourse representation (Schumacher and Hung 2012).

A crucial impetus to this operation is the attempt to maximize discourse coherence (cf. Asher and Lascarides 1983). To date there are no ERP studies on the priority of certain coherence relations over others, but a study on different inferential relations induced by an instrument expression indicates that stronger coherence relations are less computationally demanding. When encountering "the pistol" in one of the following passages "Yesterday, a Ph.D. student was shot/killed/found dead downtown. The press reported that *the pistol* was probably from army stocks", the relation between the instrument "the pistol" and the contextually given shooting event is strongest, while the establishment of a coherent relation following the killing or finding-dead event requires more inferential work. This extra effort is reflected in a Late Positive deflection and indicates that cost is exerted when previous discourse structure must be enriched towards a more specific (shooting) event (Burkhardt 2007).

Further support for discourse updating costs has been observed in response to creative language use that requires meaning shift or meaning adjustment of some sort, which here is viewed in terms of updating and enrichment of discourse representation structure. Metaphorically used expressions engender a Late Positivity relative to a literal control ("Power is a strong *intoxicant*"; cf. e.g., Coulson and van Petten 2002) and so do metonymically used expressions such as "*the ham sandwich* wants to pay" (in Schumacher 2011). In these cases, the emerging discourse representation is based on assumptions about what the speaker meant to say, which serve to fill in unarticulated meaning constituents and induce an adjustment of meaning. Context thus represents "a series of factors that contribute to reconstructing the meaning intended by a speaker in a communicative exchange" (Bosco et al. 2004, p. 467).

The two-phase processing model outlined here thus proposes that propositional content is first evaluated against a set of contextually derived predictions and is then integrated into the discourse representation where additional inferences are drawn. Whether these two processes are interrelated will be addressed in the next section.

5 Context in meaning shift

In this section, I want to take a closer look at a particular type of meaning shift that has been described as being highly context-dependent—the "ham sandwich" cases—to determine whether absence of contextual support is capable of blocking discourse updating mechanisms. This also allows us to test the fundamental dissociation within the processing architecture between context-based effects arising from expectations generated by previously conveyed information on the one hand and inferential processes yielding enrichment on the other hand. To this end, I introduce the theoretical rationale, discuss a precursor study that tested contextually licensed meaning shift, and then present a novel study with materials lacking rich contextual support for meaning shift.

In "The ham sandwich is sitting at table 20" (from Nunberg 1979) a salient property is used to refer to an individual. When uttered in a restaurant by a waiter, "the ham sandwich" can be interpreted as "a person contextually associated with the ham sandwich" (Nunberg 1979; Jackendoff 1997). Contextual support (i.e. the restaurant setting) seems to facilitate this kind of meaning shift; as a matter of fact it has been argued that contextual licensing is essential for it. The following prerequisites have been formulated for this kind of meaning shift from a property to an individual: (i) the salience/noteworthiness of the property used to identify an individual, (ii) a functional correspondence between the property and the intended referent, and (iii) context support (cf. Jackendoff 1997; Nunberg 1995; Ward 2004). Context-dependence is also featured as core criterion for meaning shift in truth-conditional pragmatics (Recanati 2010). The use of this rhetorical tool has been associated with the communicative intent to be brief yet maximally informative (Egg 2004; Recanati 2010).

5.1 Previous ERP findings from meaning shift (supporting context)

The precursor to the present investigation is a study that investigated the online comprehension of this type of metonymic shift embedded in an appropriate context, which reported a Late Positivity only illustrated in the right panel of Fig. 2 (Schumacher 2011). The meaning shift from an expression such as "the hepatitis" to "person contextually associated with hepatitis" engendered a positive deflection in comparison to a control condition that did not require meaning shift (referring to "the therapist"). The prerequisites listed above are met in this study: (i) a noteworthy property (hepatitis) is used to refer to an individual (a patient); (ii) the property and the individual stand in a functional relation with each other (i.e. an ailment of a person); (iii) the context provides an appropriate scene by invoking a clinical setting (the doctor, his assistant). The Late Positivity was considered to reflect enrichment of the discourse representation structure, resulting in a shift from a property to a person denoting entity.

5.2 Current study on meaning shift (neutral context)

The present research sought to investigate the role of context during the implementation of meaning shift. To this end, the materials from Schumacher

(2011) were deprived of supporting context information by substituting the rich occupational terms with content-neutral proper names (see left panel of Fig. 2) and the following two predictions were tested. First, in the absence of sustaining contextual support, a more pronounced N400 was hypothesized to emerge for the meaning shift relative to the control condition because the type mismatching expression is more surprising than encountering an expression referring to a person. Second, if transfer of meaning relies heavily on contextual support (as suggested in the literature), enriched composition should be impeded (hence no Late Positivity

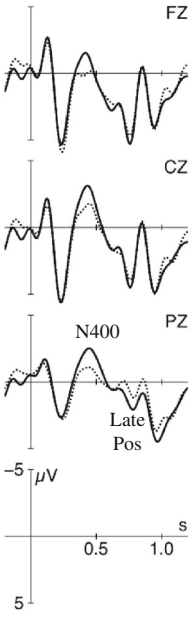
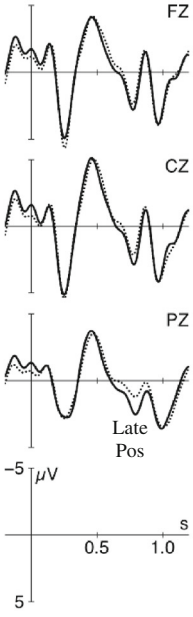
Neutral context (current study)	Supporting context (Schumacher 2011)
Thomas asks Claudia again who had called that early. Claudia responds that *the hepatitis/the therapist* had called that early.	The doctor asks his assistant again who had called that early. The assistant responds that *the hepatitis/the therapist* had called that early.
	
N400 - Late Positivity	Late Positivity

Fig. 2 Context-effect. Comparison of meaning shift with neutral context (current study, *left panel*) and with supporting context (Schumacher 2011, *right panel*). Reference transfer condition is plotted in *solid*, control condition in *dotted line*

for the meaning shift). By contrast, if meaning shift is more generally driven by the desire to reach a meaningful interpretation, speaker meaning should be inferred no matter how weak the contextual license is. In its most extreme case, this suggests that even in cases of (apparent) incoherence between utterances, the hearer draws inferences to construct interpropositional relations and enriches the interpretation to warrant a globally coherent discourse representation.

5.2.1 Methods and materials

EEGs were recorded from 24 monolingual native speakers of German (14 women; 21–32 years of age). The materials from Schumacher (2011) were modified in order to remove contextual cues. To this end, the scene-setting expressions from the context sentence—all of which represented occupational titles—were replaced by proper names. This way, context sentences were kept as neutral as possible and void of additional supporting clues for the meaning shift (criterion (iii) above). Forty pairs of two-sentence passages were created. Each context sentence introduced two characters by their proper names and presented a question that explicitly asked for an individual performing a particular action (e.g. "Thomas asks Claudia who had called that early."). In that way, an expectation was built up for an expression denoting an individual in the subsequent target sentence (answering to "who"), which might suffice to facilitate the meaning transfer from a salient property to an individual. The subsequent target sentence was the answer to the question and consisted of a lead-in phrase (e.g. "Claudia responds that…") that served as an additional boost for the expectation of an individual denoting expression, and an embedded sentence containing the answer (e.g. "the hepatitis had called that early"). There were two versions of the target sentence for each passage, one with a noun phrase denoting a salient property of an individual and requiring reference transfer (e.g. "the hepatitis") and one as a control that included a noun phrase that unambiguously referred to an individual (e.g. "the therapist"). This yielded a total of 80 critical passages (40 requiring reference transfer and 40 control passages). The critical expressions in the two conditions were matched for syllable length and frequency of occurrence on the basis of the *Wortschatz Universität Leipzig* database (http://wortschatz.uni-leipzig.de), as well as for morphological complexity. They were related to various scenarios, e.g. hospital ("Hepatitis–Therapeutin", "hepatitis–therapist"), restaurant ("Schwarzbier–Stammgast", "black lager–regular guest"), or music ("Gitarre–Sängerin", "guitar–singer"). The experimental passages were interspersed with 100 additional two-sentence passages and verification questions were constructed for each passage to assess participants' attention to the stimuli.

Materials were presented visually in segments in rapid serial presentation; target expressions were presented for a duration of 550 ms with a 150 ms interstimulus interval. Participants were asked to read the passages and respond to a comprehension question after each trial. All procedures were identical to those reported in Schumacher (2011).

5.2.2 Data recording, preprocessing and analysis

The EEG was recorded from 24 Ag/AgCl scalp electrodes fixed in an elastic cap (ground: AFz). Recordings were referenced to the left mastoid (with subsequent offline rereferencing to linked mastoids). Electrode impedances were kept below 5 kΩ. The EEG was amplified using a *Twente Medical Systems DC amplifier* and digitized with a 250 Hz sampling rate. To exclude slow signal drifts, raw EEG data were filtered offline with a 0.3–20 Hz bandpass filter. Ocular artifacts were removed automatically and manually. Trials for which the comprehension question was answered incorrectly were also excluded from further analysis.

For the ERPs, averages were computed per participant, electrode and condition. Grand-averaged ERPs, time-locked to the onset of the critical expression (marked in italics in Fig. 2), were analyzed in two time windows—300–500 ms (N400) and 650–800 ms (Late Positivity), corresponding to the analyses reported in Schumacher (2011). Repeated measures analyses of variance (ANOVAs) based on the mean amplitude values within the predetermined time windows were performed with the factors NP TYPE (2 levels: meaning shift and control condition) and topographical region of interest [ROI] (3 levels: anterior (F3/F4/F7/F8/FZ/FCZ), central (CP1/CP2/CP5/CP6/CZ/CPZ), posterior (P3/P3/P7/P8/PZ/POZ)).

5.2.3 Results

The grand-average ERPs for the two critical conditions (meaning shift vs. control) are depicted in Fig. 2 (left panel) and reveal a biphasic pattern for the meaning shift condition with an enhanced negativity peaking around 400 ms after the onset of the critical NP followed by a positive deflection between 650 and 800 ms. This pattern was confirmed by statistical analyses. In the time window between 300 and 500 ms, the ANOVA registered a main effect of NP TYPE [$F(1,23) = 16.51$, $p < .001$]. In the time window between 650 and 800 ms after the onset of the critical word, statistical analysis revealed an interaction of NP TYPE x ROI [$F(2, 46) = 4.32$, $p < .05$]. The resolution of this interaction revealed a main effect of NP TYPE over posterior channels [$F(1,23) = 4.81$, $p < .05$].

5.2.4 Discussion

The present experiment sought to assess the influence of context on the online comprehension of expressions that require meaning shift. This was guided by the theoretical assumption that meaning shift in "ham sandwich" utterances is highly contingent on rich contextual support. The predictions were two-fold. First, in the absence of facilitating context information, an enhanced N400 was predicted to emerge. This was confirmed by the data that registered a more pronounced, broadly distributed negativity between 300 and 500 ms for the metonymically used expressions (e.g., "the hepatitis") in contrast to the control expressions that did not require any meaning shift (e.g., "the therapist"). This N400-modulation is particularly interesting given that both conditions lack supporting context information. Nevertheless, the control expression engenders a less pronounced negativity,

suggesting that it is easier to process than the metonymic expression. This effect is not generated by differences arising from inherent properties of the nouns as evidenced by independent comparisons with a filler condition that used the critical expressions in an unshifted environment. ("Thorsten asks Nadine again what it is that concerns so many people. Nadine responds that *the hepatitis* concerns so many people.") Rather the pronounced N400 indicates that a more severe breach of the expectation for the upcoming word is detected in the metonymic continuation than in the control condition; this is the context sentence generates an expectation for an expression that carries a specific feature bundle including the semantic type.

Second, this study wanted to investigate whether enriched composition and the updating of discourse structure—reflected in a Late Positivity—would be blocked in the absence of sustaining contextual support. This was not the case since the ERP data revealed a statistically reliable Late Positivity with a maximum over posterior sites between 650 and 800 ms after the onset of the metonymic expressions relative to the control expressions. This is taken to reflect discourse updating costs due to the need to enrich the representation for "the hepatitis" in order to satisfy the type requirements and reflect the speaker's assumed intended meaning.[2]

These data complement the findings from Schumacher (2011) in interesting ways. First, compared to the results reported therein, where N400-differences were absent, a clear context effect emerges for meaning shift in the present investigation, such that missing contextual support evokes a negativity relative to the control condition. These data are consistent with earlier findings that report an enhanced N400 for context-dependent expectation-based parsing as outlined in Sect. 3 above. And they advance them in showing that it is not a lexical representation per se that is expected ("the therapist" is also not predictable from a context that elicits a response to "Thomas asks Claudia who had called that early.") but the parser generates an expectation for a particular type induced by the combination of the predicate and the *wh*-word. When this type expectation is not met, the amplitude of the N400 is more pronounced than when a person-denoting expression is encountered.

Crucially, the data pattern indicates that in spite of the absence of contextual licensing, an additional operation is taking place reflected by the Late Positivity for the shift-inducing expression. This implies first of all that contextual influence on expectation-based parsing must be dissociated from processes of enrichment. Thus while the parser detects an incongruity on the basis of contextual prediction (reflected in the N400), further operations can still be activated that bring about a felicitous interpretation. Second, the additional Late Positivity suggests that enrichment takes place even in cases where context does not reinforce it (contra accounts that consider contextual facilitation one of the guiding principles during proper assignment of a transfer of meaning in "ham sandwich" cases). Accordingly, it is not just a matter of connecting incoming information with the wider discourse

[2] This does not imply that the type mismatch is a necessary trigger for meaning shift. As Recanati (citing an example by Dan Sperber) points out in truth-conditional pragmatics, meaning shift may be required in grammatically congruent compositions as in the context-dependent interpretation of "The ham sandwich stinks" (Recanati 2010, p. 167).

that yields a meaningful interpretation, but enriched composition is an operation that mediates between different uses of an expression. This shows that comprehenders immediately attempt to construct a meaningful interpretation and are capable of using pragmatic mechanisms subserving meaning shift to reach this goal. Hence processes of enriched composition are more independent of contextual support than has traditionally been assumed in discussions of this particular phenomenon. This is not to say that these operations do not require context—the adjustment of meaning takes place against a particular background and even within a minimal co-text in which the hearer generates inferences—but it demonstrates that absence of licensing context cannot prevent enrichment.

Whether the observed pattern is generalizable to other instances of meaning shift ought to be investigated in future research. The "ham sandwich" cases are in numerous ways distinct from more routinized instances of meaning shift ("Henriette read Dickens", "They protested during Vietnam"), which rely on more standard cognitive routines to select the intended meaning (such as producer-for-product, place-for-event) whereby the different meanings stand in a closer relationship with each other at the level of lexical representation, possibly inducing a qualitatively different meaning shift. Eye-tracking measures suggest no processing costs for these routinized meaning shifts—supporting the underspecification view—but report processing difficulties when novel shifts are enforced as in "reading Needham" or "protesting during Finland" (cf. Frisson and Pickering 1999). Importantly, when context provides a cue for the type of metonymic relation, it can again rescue the interpretation of novel metonymic expressions as suggested by the disappearance of the processing disadvantage (e.g., "My great-grandmother has all the novels written by Needham in her library. I heard that she often read Needham when she had the time."; from Frisson and Pickering 2007). Furthermore, while a theory that considers logical types—such as Asher's (2011) type composition logic—can elegantly account for the current findings, pragmatic enrichment is not necessarily contingent on a type mismatch and can occur freely.

6 Conclusion

Real-time data from language comprehension support the claim that context plays an important role during incremental processing and demonstrate that propositional content is not computed in isolation but relies in important ways on context during every step of meaning computation. The relevant notion of context is a very broad one, comprising all aspects of possible worlds, including information about the speaker and the hearer, the communicative situation and dependencies on time and space; previous utterances and numerous knowledge sources serve as a funnel that narrows down the expectations for upcoming information. What is implicated is computed on the basis of cooperativeness and an utterance implicates by relevance that for instance a certain property refers to an individual irrespective of contextual licensing. Cooperativeness is hence built into the system as a mechanism to extract potential speaker meaning. While traditional truth conditional approaches target utterance meaning in isolation, meaning in context represents the natural

communicative situation that needs to be accounted for. Composition of meaning in context is contingent (i) on expectation generated by prior information exchange and on what we know about possible worlds and (ii) on a commitment to what has been uttered that culminates in the aim of reaching a meaningful and cooperative interpretation. Hearers typically do not dismiss an utterance as anomalous, but attempt to rescue the interpretation through enrichment of unarticulated meaning components, transfer of meaning or modification of prior assumptions built into the discourse representation structure. Content and context are thus intimately intertwined as interpretation unfolds.

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