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## Verb aspect, event structure, and coreferential processing

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### Abstract

We used an off-line story continuation task and an online ERP reading task to investigate coreferential processing following sentences that portrayed transfer-of-possession events as either ongoing or completed, using imperfective and perfective verb aspect (e.g., Amanda was shifting/shifted some poker chips to Scott). The story continuation task demonstrated that people were more likely to begin continuations with references to the Goal than to the Source, but that perfective aspect strengthened this bias. In the ERP task we probed expectations for Source and Goal referents by employing pronouns that matched one of the referents in gender. The ERP results were consistent with the biases revealed in the story continuation task and demonstrate that the difference in Goal bias for the two forms of aspect was manifested differently in the brain. These results provide novel behavioral and neurocognitive evidence that verb aspect influences the construction of situation models during language comprehension.

### Keywords

Verb aspect; Thematic roles; Coreferential processing; Pronouns; ERP

### Introduction

It is well known that the process of understanding language involves the construction of a mental model of the situations being described (Johnson-Laird, 1983; Kintsch, 1988; Morrow, Greenspan, & Bower, 1987; Sanford & Garrod, 1981; Van Dijk & Kintsch, 1983; Zwaan, Langston, & Graesser, 1995; for a review see Zwaan & Radvansky, 1998). This mental model is a reflection of dynamic processes that underlie the combination of different types of linguistic (e.g., phonetic, morphosyntactic, semantic), and non-linguistic (world knowledge, situational environment) representations. One of the crucial facts about successful mental model construction, and thus successful language understanding, is that comprehenders must identify which situations, people, objects, and locations are being referred to in their models from the linguistic cues provided by language. In this regard, the lexical and semantic properties of verbs play a key role in constraining people's expectations regarding who and what the continuing discourse is likely to be about (e.g., Altmann &

Kamide, 1999, 2007; Arnold, 2001; Ferretti, Kutas, & McRae, 2007; Hare, McRae, & Elman, 2003; Kamide, Altmann, & Haywood, 2003; Stevenson, Crawley, & Kleinman, 1994; Van Berkum, Koorneef, Otten, & Nieuwland, 2007). In the present research we examine how describing situations as ongoing versus completed, achieved by varying verb aspect, influences people's expectations about who will be mentioned next as the discourse continues and, importantly, how these expectations influence the degree of difficulty people exhibit during coreferential processing. Relatively little is known about how temporally describing situations as ongoing or as completed influences referential processing, despite the fact that psycholinguistic studies of verb aspect have demonstrated that this linguistic cue profiles participants, objects, and locations differently in the temporal and causal structure of situations (Ferretti, Kutas, & McRae, 2007; Madden & Zwaan, 2003; Morrow, 1985; Truitt & Zwaan, 1997).

### Verb aspect and language processing

The grammatical category of verb aspect functions as a morphosyntactic cue that signals to comprehenders how to view the temporal unfolding of situations mentioned in linguistic environments. In the present research, we examine two different forms of aspect, specifically the imperfective (*was giving*) and perfective (*gave*). Imperfective aspect encodes a temporal focus on the ongoing development of situations, whereas the perfective aspect describes the entire situation as completed (Comrie, 1976; Moens & Steedman, 1988).

Previous psycholinguistic investigations have shown that verb aspect constrains situation model construction in different ways (for a review see Madden and Ferretti (2009)). First, aspect contributes to the determination of how information in a text is partitioned with respect to foreground and background (Carreiras, Carriedo, Alonso, & Fernández, 1997; Madden & Zwaan, 2003; Magliano & Schleich, 2000; Morrow, 1985). For example, Magliano and Schleich had participants read narratives in which a critical situation was described either as ongoing with imperfective aspect (*was delivering*) or as completed with perfective aspect (*delivered*). These sentences were always followed by three additional sentences describing events that were consistent with being concurrent or subsequent to the critical situation. Activation of the critical situation in participants' mental models of the text was probed by measuring the time it took them to verify whether or not a situation denoted by a verb phrase had appeared earlier in the text (e.g., *deliver baby*). The verb phrases were presented either immediately after the critical sentence or after the three subsequent sentences. Their results demonstrated that at the end of the critical sentence and after three subsequent sentences, people were faster to identify the verb phrases that had appeared earlier in the text when they originally appeared in imperfective versus perfective form. Magliano and Schleich interpreted this as evidence that imperfective aspect serves to foreground an action more strongly than perfective aspect.

A second way that verb aspect influences the construction of situation models is by modulating the activation of participants, instruments, and locations of situations (Carreiras et al., 1997; Ferretti et al., 2007; Morrow, 1985; Truitt & Zwaan, 1997). For example, Morrow (1985) had people first memorize a layout of a house and then read sentences describing the movement of a person from one room (Source room) to another room in the house (Goal room). These sentences always involved verbs of motion and were inflected with either imperfective or perfective aspect (e.g., John was walking/walked from the kitchen to the bedroom). Morrow found that following imperfective sentences, people located the figure (i.e., John) somewhere on the path between the Source room and Goal locations, whereas following perfective aspect participants consistently located the figure in the Goal room. More recently, Ferretti et al. (2007) have extended these findings by showing that verb aspect also plays a role in the activation of world knowledge about the common

locations of situations. Specifically, they demonstrated in a semantic priming task and in on-line sentence comprehension that knowledge about common locations of situations is more activated following verbs marked with imperfective than perfective aspect.

These results suggest that the ongoing versus completed status of situations signaled by different verb aspects has important implications for the way in which salient people, objects, and locations are situated in the mental models that people construct during language processing. However, to date there has been relatively little research examining how modulation of the activation of the different properties of situations by verb aspect influences coreferential processing, despite the fact that such consequences would be expected to exist. For example, identifying the referent for a pronoun may be less difficult when the referent has been made more accessible as a result of the temporal focusing properties of verb aspect.

A recent off-line study by Rohde, Kehler, and Elman (2006) provides evidence for how verb aspect influences participant's coreferential processing. Participants in this study read context sentences that included verbs of transfer presented in either perfective or imperfective form, followed by an ambiguous pronoun that could be used to refer to either the Source or Goal referent (see Example 1). Participants were asked to generate natural sentence continuations using the pronoun prompt provided.

- (1) John<sub>SOURCE</sub> handed/was handing a book to Bob<sub>GOAL</sub>. He \_\_\_\_\_.

Judges annotated the elicited continuations, assessing whether the continuation was consistent with a Goal interpretation of the pronoun (Goal continuation) or a Source interpretation (Source continuation). The results demonstrated that people were significantly more likely to generate a Goal continuation following a context sentence with perfective aspect than one with imperfective aspect.

The effect of verb aspect on coreference was confirmed in a second study by Rohde and Kehler (2008) that manipulated both verb aspect and prompt type (see Examples 2 and 3) in order to show that patterns of coreferential processing fit within a more general model of people's expectations regarding who will be mentioned next as a discourse continues. The second study replicated the original coreferential processing results in a pronoun-prompt condition, and it also showed that verb aspect influences people's choice of next mention in a bare-prompt condition.

- (2) [pronoun prompt] John<sub>SOURCE</sub> handed/was handing a book to Bob<sub>GOAL</sub>. He \_\_\_\_\_.
- (3) [bare prompt] John<sub>SOURCE</sub> handed/was handing a book to Bob<sub>GOAL</sub>. \_\_\_\_\_.

Verb aspect had the same effect in both prompt conditions (more Goal continuations following perfective context sentences than following imperfective context sentences), though there were more Goal continuations overall in the bare-prompt condition than in the pronoun-prompt condition. This difference was due to the prevalence of bare-prompt continuations that contained proper name references to the Goal. Following previous researchers (Arnold, 2001; Stevenson et al., 1994) Rohde and Kehler suggest that the pronoun-prompt data exhibit the results of two interacting biases: a bias regarding choice of next mention, which favors the Goal and is influenced by aspectual form, and a bias regarding choice of referring expression, which reflects a general tendency to use pronouns to corefer with grammatical subjects (i.e., the Source referent in contexts like (1–3)). Taken together, these two biases account for both the reduced number of Goal continuations in the

pronoun-prompt condition and the consistent increase in the number of Goal continuations following context sentences with perfective aspect in both prompt types.

### The present study

Although Rohde et al.'s research demonstrates that verb aspect can bias how participants will assign ambiguous pronouns in an off-line completion task, it provides no evidence that such biases influence comprehenders' incremental online processing. The present study addresses this question by utilizing an online reading task to examine how the temporal structure of transfer-of-possession events affects people's expectations about which individual will be mentioned next. In order to examine whether the coreferential processes identified by Rohde et al. are also found when people simply read for comprehension, we used event-related brain potential methodology (ERP). The use of ERP allows us to examine people's brain potentials when interpreting pronouns that unambiguously refer to either the Source or Goal when the pronoun is more versus less consistent with their expectations about which entity is likely to be mentioned next. This methodology is also particularly well-suited to investigating referential processing in the brain because of its fine temporal resolution and because people can simply read for comprehension without a secondary task. Furthermore, past research has used ERP methodology to examine how people interpret pronouns during language processing, and thus provides a foundation for interpreting the results of the present experiments (we discuss this past ERP research in the introduction to Experiment 2).

In order to establish the extent to which references to Sources and Goals are expected at the point in which pronouns were presented in the online ERP reading task, we conducted an off-line story continuation experiment. In this experiment, people read transfer-of-possession context sentences and then generated follow-ons that naturally continued the story. However, unlike Rohde et al. (2006) and Rohde and Kehler (2008), we used a context sentence containing two opposite-gendered entities. This allowed us to index people's expectations regarding which entity was likely to be mentioned next, as well as to analyze the types of referring expressions people choose in a context in which a pronominal reference would be unambiguous.

Our main predictions for the following experiments are as follows. Under the plausible assumption that Goals are more salient than Sources within the end state of transfer-of-possession events, we expect to find more story continuations that mention the Goal in the perfective case than in the imperfective case. We likewise predict that brain potentials during coreferential processing in such passages should also reflect this aspect-modulated Goal bias.

### Experiment 1

We conducted a story continuation experiment to test how the representation of the temporal structure of an event affects comprehenders' expectations about which individual will be mentioned next. Event structure was manipulated by changing the aspect of the verb in the context sentence. We evaluated next-mention biases in participants' elicited story continuations and tested for an effect of verb aspect.

### Participants

Fifty four undergraduate psychology students (43 females) from Wilfrid Laurier University participated in the experiment for course credit. All participants were monolingual native English speakers.

## Materials

The stimuli consisted of 72 target items and 72 fillers. Target items contained a context sentence with a Source-Goal transfer-of-possession verb. The Source and Goal referents were both proper names that differed in gender.

(2) Perfective: John<sub>SOURCE</sub> handed a book to Mary<sub>GOAL</sub>. \_\_\_\_\_.

(3) Imperfective: John<sub>SOURCE</sub> was handing a book to Mary<sub>GOAL</sub>. \_\_\_\_\_.

The gender of the Source and Goal referents was balanced across stimuli. Each participant saw half the verbs with perfective aspect and half with imperfective, and no participant saw any verb more than once. The 72 target items were randomly mixed with the 72 fillers. The fillers described non-transfer-of-possession events involving one or two individuals. Half of the filler verbs were perfective and half were imperfective. The majority of perfective verbs in the fillers used active voice and a small minority used passive voice. As in the target items, the individuals were mentioned using proper names. There were 10 randomly ordered lists.

## Task

Story continuations were collected via a web-based interface that participants could access from their own computer. Each item was presented on a page by itself with a text box in which participants were instructed to write their continuation. The entire experiment took roughly 45 min, but participants were encouraged to have an hour available so that the experiment could be completed in one session.

Participants were instructed to imagine a natural story continuation for each prompt, writing the first continuation that came to mind and avoiding humor. In this task, participants create a mental model of the event in the matrix clause and then write a continuation that reflects their expectations about where the story is going. As such, the task involves both interpretation and production (Arnold, 2001).

## Evaluation and analysis

The elicited story continuations were coded for several factors: choice of first mention (Source or Goal), referring expression of first mention (name or pronoun), and position of first mention (first word or not).

Analyses of variance were conducted on the first-mention choices to test for an effect of aspect. One-sample *t*-tests were used to compare the percentages of first mentions to a hypothetical mean of 50%. Because the assessed first-mention choices represent two binary outcomes, the results are treated as proportions. Therefore, an arcsine transformation was first applied to the percentages of first mentions before carrying out analyses of variance and *t*-tests. For clarity of presentation, we present means in the form of raw proportions.

## Results

The continuations from 14 participants were eliminated because the participants misunderstood the task (writing only sentence fragments or questions) or did not complete the entire experiment. From the remaining 40 participants' continuations, 13% were excluded because the continuation did not contain any reference to either the Source or the Goal (or else referred to the Source and Goal together as "they"), along with 3.6% that consisted only of a sentence fragment (e.g., a prepositional phrase or a relative clause), 3.4% that referred to the Source or Goal only with a possessive ("his" or "hers"), and less than 1% that were non-sensical or contained mistakes concerning the interpreted gender of the male/female names.

Our analysis considers two sets of elicited continuations, one in which the Source or Goal was mentioned as the first word of the continuation, and the subset of those in which the reference to the Source or Goal was pronominalized. As Fig. 1 shows, for both sets of continuations, both the perfective and imperfective conditions yielded a bias to the Goal, but the strength of the Goal bias differed by verb aspect.

Considering the first set of continuations, we excluded two participants who had fewer than four continuations in either the perfective or imperfective condition. The resulting dataset consisted of 1847 continuations from 38 participants. Participants exhibited a Goal bias following both perfective context sentences (85.3%;  $t_1(37) = 12.71$ ,  $p < .001$ ;  $t_2(71) = 17.65$ ,  $p < .001$ ) and imperfective context sentences (77.3%;  $t_1(37) = 9.22$ ,  $p < .001$ ;  $t_2(71) = 11.81$ ,  $p < .001$ ). However, Goal references were significantly more common following perfective than imperfective verbs ( $F_1(1, 37) = 17.50$ ,  $p < .001$ ;  $F_2(1, 71) = 8.70$ ,  $p < .005$ ;  $\min F'(1, 108) = 5.81$ ,  $p < .02$ ; mean difference between conditions = 8.0%; 95% Confidence Interval =  $\pm 1.8\%$ ).

The results were similar for the set of continuations in which the Source or Goal was mentioned as the first word of the continuation with a pronoun. We excluded 14 participants who had fewer than four continuations in either the perfective or imperfective condition. The resulting dataset consisted of 858 continuations from 26 participants. As before, the Goal bias was stronger following perfective sentences (74.8%;  $t_1(25) = 4.66$ ,  $p < .001$ ;  $t_2(71) = 7.84$ ,  $p < .001$ ) than imperfective sentences (62.7%;  $t_1(25) = 2.48$ ,  $p < .03$ ;  $t_2(71) = 5.03$ ,  $p < .001$ ). This difference is significant ( $F_1(1, 25) = 10.11$ ,  $p < .004$ ;  $F_2(1, 71) = 4.56$ ,  $p < .04$ ;  $\min F'(1, 95) = 3.14$ ,  $p < .08$ ; mean difference between conditions = 12.1%; 95% Confidence Interval =  $\pm 3.4\%$ ). (Note that we report the analysis for the first word of the continuations because that is the critical point of interest in the ERP study reported in Experiment 2. However, the results were similar for the pattern of first-mention preferences regardless of position of mention (2056 continuations, 39 participants): the Goal bias was stronger following perfective sentences (83.8%;  $t_1(38) = 11.71$ ,  $p < .001$ ;  $t_2(71) = 16.28$ ,  $p < .001$ ) than imperfective sentences (76.8%;  $t_1(38) = 9.07$ ,  $p < .001$ ;  $t_2(71) = 11.85$ ,  $p < .001$ ). This difference is significant ( $F_1(1, 38) = 17.06$ ,  $p < .001$ ;  $F_2(1, 71) = 8.00$ ,  $p < .007$ ;  $\min F'(1, 109) = 5.45$ ,  $p < .03$ ; mean difference between conditions = 7.0%; 95% Confidence Interval =  $\pm 1.6\%$ ).

## Discussion

The results of Experiment 1 demonstrated that across both verb aspects, participants were more likely to write continuations that began with a reference to the Goal entity, but that the Goal bias was stronger in the perfective condition. This result is consistent with findings in previous off-line studies showing that verb aspect influences coreferential processing (Rohde & Kehler, 2008; Rohde et al., 2006). It also fits earlier claims based on perfective-only materials that the Goal bias is driven by a preference to focus on the end state of a transfer-of-possession event under the assumption that the Goal is more salient than the Source with respect to the end state (Arnold, 2001; Stevenson et al., 1994). As would be expected on this view, the salience of the Goal is comparatively reduced in the imperfective condition, in which the context sentence event is portrayed as ongoing.

Like Rohde et al. (2006), we find that the effect of verb aspect is also apparent when we consider only the subset of the data in which the Source or Goal was referred to with a pronoun. The results we present here differ from Rohde et al.'s results in one respect however: the Goal continuations in the pronoun-only data reported here represent more than half the continuations elicited following context sentences in both the perfective and imperfective conditions, whereas the Goal continuations in the pronoun-only data in Rohde et al.'s work made up less than half of the continuations following context sentences in both

aspect conditions. This difference was anticipated, however, in light of the fact that pronouns in our stimuli (unlike Rohde et al.) were unambiguous. Participants in Experiment 1 who produced a pronoun in their response were able to signal the identity of their intended referent as unambiguously as if they had used a proper name. In previous work, the Goal bias has been shown to be similarly strong when proper names are considered: as with studies before them (Arnold, 2001; Stevenson et al., 1994), Rohde and Kehler (2008) found a large bias toward the Goal when all referring expressions were cataloged in a bare-prompt condition like the one used here; the effect of providing a pronoun prompt in an ambiguous context diminished this bias. In the current experiment, providing an *unambiguous* context brought the Goal bias for pronouns closer to what has been previously witnessed for referring expressions in bare-prompt conditions. Indeed, pronominal references to both the Source and Goal were quite common in both conditions in the story continuation experiment, which was important in confirming the naturalness of the stimuli used in the experiment described in the next section.

Finally, it is worth noting that our results support previous claims that referring expression production conforms to the predictions of the *repeated name penalty* of Gordon, Grosz, and Gilliom (1993). Gordon et al. demonstrated that repeated names used to refer to the entity occupying the subject position in the previous sentence are more difficult to process than pronouns, even when the pronoun, unlike the name, is ambiguous. Crucially, this phenomenon did not extend to referents occupying other grammatical positions later in the sentence. Gordon et al. explain this by appealing to a purely information-structural constraint requiring the pronominalization of *backward-looking centers* in Centering theory (Grosz, Joshi, & Weinstein, 1995) that is independent of the sorts of semantically-driven next-mention biases we address here (which could be seen as influencing the ranking of *forward-looking centers* in Centering). This constraint immediately yields three predictions for our data: (i) that a large majority of the references to the (subject) Source should be pronominalized, (ii) a large majority of named references should be to the (non-subject) Goal, and (iii) both of these percentages should not differ significantly across the aspect manipulation (since this manipulation only influences next-mention biases, and not grammatical role positioning nor the relevant centering constructs). These predictions were all borne out in our data. In their choice of referring expression, the large majority of participants' references to the Source were pronominalized (perfective: 77.2%; imperfective 78.7%), and this bias did not differ significantly across the two verb aspects ( $F_1(1, 66) = 0.3226, p < .58$ ;  $F_2(1, 39) = 0.0028, p < .96$ ). Likewise, when participants used a name, they were overwhelmingly more likely to be referring to the Goal than the Source (perfective: 94.7%; imperfective: 92.2%); again this bias did not differ significantly across the two verb aspects ( $F_1(1, 22) = 3.3667, p < .09$ ;  $F_2(1, 71) = 2.492, p < .12$ ). An interesting ramification of this constraint is that a pronominal reference to the previous subject is *always* predicted to be felicitous, regardless of the operative next-mention biases. The remaining, and somewhat independent, question regards the extent to which next-mention biases make pronominal reference to *non-subject* antecedents easier to process, which is the central question addressed in this paper.

## Experiment 2

Experiment 2 used ERP methodology to investigate how verb aspect interacts with the lexical semantic structure of transfer-of-possession verbs to constrain expectations about who is likely to be mentioned next during online language comprehension. Participants read sentences describing either ongoing or completed transfer-of-possession events followed by sentences that always described a plausible subsequent event. Importantly, the second sentences always began with a pronoun that unambiguously referred to either the Source or Goal entity in the prior sentences. Using unambiguous pronouns enabled us to probe the

event entity that is most expected by examining the electrophysiological response when the references are more versus less consistent with these expectations.

- (4) Sue(SOURCE) handed/was handing a timecard to Fred(GOAL). She/He asked about the upcoming meeting.

The two brain wave components that have figured most prominently in research examining coreferential processing of pronouns include the left anterior negativity (LAN), and the P600 (sometimes also called syntactic positive shift). The left anterior negativity (or LAN) typically appears between 300 and 500 ms following the onset of eliciting stimuli (Kluender & Kutas, 1993; Munte, Heinze, & Mangun, 1993; Osterhout & Holcomb, 1992), although the LAN has also been observed with onsets as early as 100–200 ms (e.g., Friederici, Pfeifer, & Hahne, 1993). The LAN has been found to be elicited to morphosyntactic violations (e.g., gender, case marking, number, and verb agreement), word category violations (Coulson, King, & Kutas, 1998; Friederici et al., 1993; Hagoort & Brown, 1994; Munte et al., 1993; Osterhout & Holcomb, 1992; Osterhout & Mobley, 1995), and increased working memory load (King & Kutas, 1995; Kluender & Kutas, 1993).

The P600 is a positive brain potential that peaks at approximately 600 ms following the onset of a word and can begin as early as 200 ms (Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992). This component is known for being sensitive to syntactic violations (Coulson et al., 1998; Friederici, Hahne, & Saddy, 2002; Hagoort et al., 1993; Osterhout & Holcomb, 1992), syntactic complexity (Kaan, Harris, Gibson, & Holcomb, 2000; Osterhout & Holcomb, 1992), and syntactic reanalysis (Friederici et al., 2002; Schmitt, Lamers, & Munte, 2002). The P600 usually is maximal at central and posterior head locations when elicited to syntactic violations (e.g., Coulson et al., 1998; Osterhout & Mobley, 1995) and syntactic complexity (Kaan & Swaab, 2003; Kaan et al., 2000).

Previous ERP research has demonstrated that the P600 effect is also elicited as a consequence of people's expectations for upcoming discourse to refer to a participant having a particular gender (and as a result, their expectations for encountering a pronoun having a particular gender) under conditions in which there are no formal morphosyntactic violations (e.g., Osterhout & Mobley, 1995; Van Berkum et al., 2007). For example, Osterhout and Mobley (1995) examined gender agreement mismatches between personal pronouns and potential subject antecedents that were inherently male or female (e.g., *The aunt heard that she/he had won the lottery*). In these sentences participants could take the mismatching pronoun as referring to some unmentioned entity rather than the subject of the sentence and thus there is no syntactic violation per se. Their results demonstrated an enhanced P600 for pronouns with a gender that mismatched the subject antecedents relative to when they matched. These results have been taken to suggest that people's expectations for the sentence to continue to refer to the subject influenced their likelihood of interpreting the pronouns to be co-referential with the subject, and that this in turn led to an electrophysiological response that was consistent with the typical response following a morphosyntactic violation.

A recent study that is more similar to the present research has been conducted by Van Berkum et al. (2007). Van Berkum et al. examined how implicit causality verbs influence the foregrounding of entities and the subsequent coreferential processing with respect to those entities. Prior research with this class of verbs has demonstrated that people typically expect a discourse to continue with references to entities that are implicated in the causes of such events (e.g., Au, 1986; Brown & Fish, 1983; Garvey & Caramazza, 1974; McKoon, Greene, & Ratcliff, 1993). In Van Berkum et al. (2007), participants read passages in Dutch such as (5) (note these examples are rough English translations), which included verbs with a strong bias for either the first noun phrase or second noun phrase to be associated with the

cause of the event, followed by pronouns that unambiguously referred to entities that were either consistent (5a) or inconsistent (5b) with this bias. Note that Van Berkum et al.'s passages also did not involve a morphosyntactic violation, as their passages always contained an available gender matching antecedent.

- (5a) David and Linda were both driving pretty fast. At a busy intersection they crashed hard into each other. David apologized to Linda because he according to the witnesses was the one to blame.
- (5b) David and Linda were both driving pretty fast. At a busy intersection they crashed hard into each other. Linda apologized to David because he according to the witnesses was not the one to blame.

Van Berkum et al.'s results demonstrated that relative to bias consistent pronouns, bias inconsistent pronouns elicited a P600 effect that was maximal between 400 and 700 ms following their onset. The authors suggest that this occurred as a result of people proactively predicting that the remainder of the sentence will be about the entity that is consistent with the implicit bias of the verb, and as such the P600 effect occurs when they encounter a pronoun that has a gender that does not match this prediction.

The present study is similar to Van Berkum et al. (2007) in utilizing contexts that contain two antecedents with different genders, a verb that biases the reader toward interpreting a subsequent referring expression to be coreferential with one of the two antecedents, and a subsequent (gender marked) pronoun. The crucial difference is that whereas Van Berkum et al. showed the effect of varying verbs and hence entire events, we are showing the effect of varying a more subtle grammatical feature, the aspectual marking on the verb, which in turn affects the way that the structure of the event is construed. Based on these differences and similarities, our clearest prediction for the present study is that pronouns coreferential with less expected antecedents (in our case, Source pronouns) should elicit an enhanced P600 relative to more expected antecedents (Goal pronouns), and, importantly, that the P600 effect should be greater following perfective than imperfective sentences.

Our predictions for the LAN component are less clear. On one hand, this component has been shown to be elicited to morphosyntactic violations involving case (Coulson et al., 1998), gender (e.g., Munte et al., 1993), and subject–verb agreement (Osterhout & Mobley, 1995; Rossi, Gugler, Hahne, & Friederici, 2005). On the other hand, the (more similar) Van Berkum et al. (2007) study did not find anterior negativity elicited to pronouns with gender that mismatch expectations of readers and in the absence of a formal morphosyntactic violation. For these reasons, it is not clear whether anterior negativity will be elicited to the less expected pronouns (i.e., Source pronouns) following imperfective and perfective verbs.

## Method

### Participants

Fifty-two undergraduate psychology students (30 females) from Wilfrid Laurier University participated for course credit. All participants were native English speaking, had normal or corrected-to normal visual acuity, and all were right-handed. None of the students participated in Experiment 1.

### Materials

Two-sentence passages were constructed such that the first sentence was taken directly from the items in Experiment 1. The second sentence in each item described an event that could plausibly occur subsequent to (or in some cases simultaneously with) the transfer event described in the first sentence. The stimuli were designed so that the event described in the

second sentence was compatible with either a Source-referring subject or a Goal-referring subject (see the sample item in Example 4). The region of interest was the first word of the second sentence; the remaining material ensured that the passages sounded natural. The filler items were constructed the same way, and were balanced for the number of male/female names, the number of times the 1st-mentioned/2nd-mentioned individual from the first sentence was re-mentioned in the second sentence, and the aspect of the verb in the first sentence. The 72 target passages were placed across four lists; each list contained 18 passages from each of the four experimental conditions (perfective verb/Source pronoun, perfective verb/Goal pronoun, imperfective verb/Source pronoun, imperfective verb/Goal pronoun). The same 72 filler passages appeared in each list. No participant saw any verb more than once, and across the four lists each verb was paired with each of the four experimental conditions.

## Procedure

Participants sat in a chair in front of a computer monitor located in an electrically-shielded chamber. They were instructed to read the words one at a time for comprehension and to answer periodic comprehension questions by pressing buttons labeled “Yes” and “No”. These questions were simple queries about facts in the passages. The 72 experimental passages and 72 filler passages were presented one word at a time in the center of a computer screen. All words were presented for a duration of 300 ms and were followed by 200 ms of blank screen. The interval between the offset of the last word of the first sentence and the onset of the first word of the second sentence (i.e., the target pronouns) was 1000 ms.

## EEG recording and analysis

The electroencephalogram (EEG) was recorded from 64 electrodes distributed evenly over the scalp (see Fig. 2 for a schematic diagram of the electrode array). Eye movements and blinks were monitored via additional electrodes placed on the outer canthus and infraorbital ridge of each eye. Electrode impedances were kept below 5 K $\Omega$ . EEG was processed through a Neuroscan Synamps2 amplifier set at a bandpass of 0.05–100 Hz, and was digitized at 250 Hz.

## Results

Data was re-referenced off-line to the average of the left and right mastoids. High frequency noise was removed by applying a low-pass filter set at 30 Hz. ERPs were then computed in epochs that extended 100 ms before the pronouns to 1000 ms after their onset. Trials contaminated by blinks, eye-movements, and excessive muscle activity were rejected off-line before averaging; a total of 12% of trials were lost due to such artifacts. Note that all participants had at least five artifact free trials per condition, and on average they had approximately 16 trials per condition.

Fig. 3 illustrates the results following perfective sentences. Pronouns with Source referents elicited brain potentials that were more negative at left anterior locations than pronouns with Goal referents, a difference that began early – approximately 100–300 ms following the onset of the pronoun, and was sustained throughout much of the 1000 ms epoch. Source co-referential pronouns also elicited greater positivity than Goal-referring pronouns at central and posterior head locations; this difference was maximal between 500 and 800 ms post-stimulus onset. Fig. 4 shows the results following imperfective sentences. As in the perfective condition, Source pronouns also elicited greater anterior negativity than Goal pronouns, but this effect had a broader distribution and a later onset (approximately 300 ms post-stimulus onset) than in the perfective condition. Over central and posterior locations,

Source- and Goal-referring pronouns did not vary in amplitude, unlike their perfective sentence counterparts.

In order to capture these differences at anterior versus central and posterior head locations, we conducted one three-way ANOVA on the mean amplitudes for anterior electrodes and a second ANOVA on central and posterior electrodes (see Fig. 2). These two analyses were conducted on three temporal regions of interest: 100–300 ms, 300–500 ms, and 500–800 ms. In all analyses, the primary factors of interest were aspect (imperfective versus perfective), reference (Goal versus Source) and electrode site, all of which were within-participants variables. List was used as a between participant factor to stabilize variance caused by rotating participants across different lists. We followed up all significant three-way interactions found between aspect, reference, and electrodes at anterior locations by conducting an additional topographic distribution analysis with all electrodes down the midline removed, and with left hemisphere versus right hemisphere electrodes (see Fig. 2) added as a within-participant variable. Table 1 summarizes the main results of the two ANOVAs. All *p*-values are reported after epsilon correction (Huynh-Feldt) for repeated measures with greater than one degree of freedom. The 95% Confidence Intervals of the mean difference between conditions are reported for all significant comparisons.

### 100–300 ms

**Anterior**—The main effects of aspect and reference were non-significant, and the two-way interaction between aspect and reference also did not reach significance. However, planned comparisons revealed that mean amplitudes for Source-referring pronouns ( $M = -0.67 \mu\text{V}$ ) were more negative than for Goal-referring pronouns ( $M = -0.04 \mu\text{V}$ ) following perfective sentences ( $F(1, 48) = 4.13, p < .05$ ; mean difference between conditions =  $0.63 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.63 \mu\text{V}$ ). Alternatively, Source- and Goal-referring pronouns did not vary in amplitude following imperfective sentences (Source,  $M = -0.54 \mu\text{V}$ ; Goal,  $M = -0.52 \mu\text{V}$ ,  $F < 1$ ).

There was a three-way interaction between aspect, reference, and electrode site. We followed up this interaction by conducting the aforementioned analysis with hemisphere added as an independent variable. The three-way interaction between aspect, reference, and hemisphere was marginally significant. Following perfective sentences, mean amplitudes for Source pronouns ( $M = -0.92 \mu\text{V}$ ) were more negative than Goal pronouns ( $M = 0.05 \mu\text{V}$ ) over left hemisphere electrodes ( $F(1, 48) = 15.72, p < .001$ ; mean difference between conditions =  $0.97 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.49 \mu\text{V}$ ), whereas the difference between the Source and Goal pronouns over right hemisphere electrodes was non-significant (Source,  $M = -0.40 \mu\text{V}$ ; Goal,  $M = -0.04 \mu\text{V}$ ),  $F < 1$ . Alternatively, the reference of the pronouns following imperfective sentences had no influence on amplitudes over the left (Source,  $M = -0.47 \mu\text{V}$ ; Goal,  $M = -0.61 \mu\text{V}$ ) or right hemisphere locations (Source,  $M = -0.60 \mu\text{V}$ ; Goal,  $M = -0.41 \mu\text{V}$ ), both  $F$ s  $< 1$ .

**Central + posterior**—All effects were non-significant.

### 300–500 ms

**Anterior**—In this region, there was a marginal effect of reference which occurred because Source-referring pronouns had amplitudes that were more negative than Goal-referring pronouns (Source,  $M = -2.73 \mu\text{V}$ ; Goal,  $M = -2.14 \mu\text{V}$ ). The two-way interaction between aspect and reference was not significant. The difference in amplitudes between Source and Goal pronouns was marginally significant following imperfective sentences (Source,  $M = -2.72 \mu\text{V}$ ; Goal,  $M = -2.01 \mu\text{V}$ ),  $F(1, 48) = 3.20, p < .08$ , but did not approach significance following perfective sentences (Source,  $M = -2.75 \mu\text{V}$ ; Goal,  $M = -2.26 \mu\text{V}$ ),  $F < 1.54$ .

Similar to the 100–300 ms region, there was a three-way interaction between aspect, reference, and electrode site. The results of the distribution analysis demonstrated a significant three-way interaction between aspect, reference, and hemisphere. Following perfective sentences, mean amplitudes for Source pronouns ( $M = -3.08 \mu\text{V}$ ) were more negative than Goal pronouns ( $M = -2.15 \mu\text{V}$ ) over left hemisphere electrodes ( $F(1, 48) = 9.00, p < .01$ , mean difference between conditions =  $0.93 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.62 \mu\text{V}$ ), whereas there was no difference between the pronouns over right hemisphere electrodes (Source,  $M = -2.23 \mu\text{V}$ ; Goal,  $M = -2.18 \mu\text{V}$ ),  $F < 1$ . In contrast, following imperfective sentences, mean amplitudes for Source pronouns ( $M = -2.63 \mu\text{V}$ ) were significantly more negative than Goal pronouns ( $M = -1.73 \mu\text{V}$ ) over right hemisphere electrodes ( $F(1, 48) = 8.53, p < .01$ , mean difference between conditions =  $0.90 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.62 \mu\text{V}$ ), and marginally different over left hemisphere electrodes (Source,  $M = -2.61 \mu\text{V}$ ; Goal,  $M = -2.08 \mu\text{V}$ ),  $F(1, 48) = 2.82, p < .10$ . Thus, greater anterior negativity for Source than Goal pronouns was found following both imperfective and perfective sentences, although this difference was more localized to the left hemisphere following perfective sentences.

**Central + posterior**—At these electrode sites there was a marginal crossover interaction between aspect and reference. At central and posterior sites, mean amplitudes for Source pronouns were more positive than Goal pronouns following perfective sentences (Source,  $M = 1.69 \mu\text{V}$ ; Goal,  $M = 1.18 \mu\text{V}$ ), whereas following imperfective sentences, Source pronouns were less positive than Goal pronouns (Source,  $M = 1.24 \mu\text{V}$ ; Goal,  $M = 1.67 \mu\text{V}$ ). Although these differences in amplitudes between pronouns for the two types of aspect led to the marginal interaction between aspect and reference, the differences in amplitudes did not reach significance following imperfective sentences,  $F < 1.51$ , or perfective sentences,  $F(1, 48) = 2.07, p = .16$ . The three-way interaction between aspect, reference, and electrode site was non-significant.

### 500–800 ms

**Anterior**—Reference continued to have an influence in this later time region as mean amplitudes for Source pronouns were more negative than for Goal pronouns (Source,  $M = -1.24 \mu\text{V}$ ; Goal,  $M = -0.42 \mu\text{V}$ ). The difference in amplitude between the two pronouns was significant following imperfective sentences (Source,  $M = -1.24 \mu\text{V}$ ; Goal,  $M = -0.16 \mu\text{V}$ ;  $F(1, 48) = 5.60, p < .03$ ; mean difference between conditions =  $1.08 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.92 \mu\text{V}$ ), but did not approach significance when they followed perfective sentences (Source,  $M = -1.24 \mu\text{V}$ ; Goal,  $M = -0.69 \mu\text{V}$ ),  $F < 1.46$ . The two-way interaction between aspect and reference was not significant. However, there was once again a significant three-way interaction between aspect, reference, and electrode site. The distribution analysis demonstrated a marginal three-way interaction between aspect, reference, and hemisphere. This interaction occurred because mean amplitudes were more negative for Source pronouns ( $M = -1.07 \mu\text{V}$ ) than for Goal pronouns ( $M = -0.09 \mu\text{V}$ ) following imperfective sentences at left hemisphere electrodes ( $F(1, 48) = 13.52, p < .001$ , mean difference between conditions =  $0.98 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.53 \mu\text{V}$ ), and right hemisphere locations (Source,  $M = -1.25 \mu\text{V}$ ; Goal,  $M = -0.08 \mu\text{V}$ ;  $F(1, 48) = 19.36, p < .001$ , mean difference between conditions =  $1.17 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.53$ ). Alternatively, amplitudes for Source pronouns ( $M = -1.54 \mu\text{V}$ ) were more negative than for Goal pronouns ( $M = -0.58 \mu\text{V}$ ) following perfective sentences over left hemisphere electrodes ( $F(1, 48) = 13.17, p < .001$ , mean difference between conditions =  $0.96 \mu\text{V}$ ; 95% Confidence Interval =  $\pm 0.53$ ), but not over right hemisphere electrodes (Source,  $M = -0.81 \mu\text{V}$ ; Goal,  $M = -0.69 \mu\text{V}$ ),  $F < 1$ .

**Central + posterior**—There were no significant main effects of aspect or reference at central and posterior electrodes. However, there was a significant two-way interaction between aspect and reference. This interaction occurred because mean amplitudes were significantly more positive for Source ( $M = 0.91 \mu\text{V}$ ) than Goal pronouns ( $M = 0.06 \mu\text{V}$ ) following perfective sentences ( $F(1, 48) = 6.39, p < .02$ ; mean difference between conditions  $= 0.85 \mu\text{V}$ ; 95% Confidence Interval  $= \pm 0.68$ ), whereas the difference between Source and Goal pronouns following imperfective sentences was non-significant (Source,  $M = 0.38 \mu\text{V}$ ; Goal,  $M = 0.67 \mu\text{V}$ ),  $F < 1$ . The three-way interaction between aspect, reference, and electrode site was non-significant.

## Discussion

The results of Experiment 2 demonstrated that people had more difficulty integrating the pronouns when they referred to Source referents as opposed to Goal referents, following both imperfective and perfective verbs of transfer. Specifically, greater anterior negativity was observed to Source than Goal pronouns for both forms of aspect. However, the distribution of this negativity was different for the two forms of verb aspect – following perfective sentences, the negativity had an earlier onset (100–300 ms) and was focal over the left hemisphere, whereas following imperfective sentences the negativity had a later onset (300–500 ms) and a broader distribution. Furthermore, following perfective verbs only, the left anterior negativity was followed by an enhanced P600 to Source co-referential pronouns at central and posterior locations. This effect began at approximately 300 ms and was maximal between 500 and 800 ms.

The finding of an enhanced P600 elicited to Source pronouns following perfective verbs is consistent with previous research investigating mismatches between gender expectations and pronouns when there are no formal morphosyntactic violations (Osterhout & Mobley, 1995; Van Berkum et al., 2007). For instance, under Van Berkum et al.'s (2007) referential attractor proposal, strong biases from context (e.g., implicit biases of verbs, gender specific names, gender role stereotypes) can lead people to proactively predict that upcoming discourse is likely to refer to a specific referent. These strong preferences (or attractors) for referents can lead to P600 effects when the morphosyntactic features of an encountered pronoun mismatch the gender of the entity that is foregrounded in a comprehender's situation model, even when there are alternative entities in the context that are gender consistent. Applied to the present research, this approach would suggest that the strong Goal bias found following perfective verbs foregrounds the Goal entity in a comprehender's situation model, whereas the Source entity is backgrounded and less available for coreferential processing. Thus, when people encountered a pronoun with morphosyntactic features that were inconsistent with this strong Goal bias, they treated the mismatch as a morphosyntactic problem (or anomaly). The referential attractor approach also provides an explanation for the lack of a P600 difference between Source and Goal pronouns following imperfective verbs. Whereas the perfective condition patterned after Van Berkum et al.'s materials in creating a strong attractor (74.8% Goal continuations in Experiment 1), the weaker bias associated with the imperfective condition did not (62.7% Goal continuations). This suggests that the P600 effect failed to emerge in the imperfective condition in Experiment 2 because readers did not have strong expectations for a Goal entity to follow sentences with imperfective verbs (i.e., a weaker referential attractor for the Goal referent), at least not to the degree that readers viewed Source-referring pronouns as constituting a morphosyntactic anomaly. We discuss this point further below.

The referential attractor approach does not specifically predict the pattern of anterior negativity observed here. However, the LAN elicited to Source pronouns following perfective verbs is consistent with research that has demonstrated the presence of a LAN in

conjunction with P600 effects to morphosyntactic violations (e.g., Coulson et al., 1998; Rossi et al., 2005). This similarity suggests to us that the brain may treat the gender mismatch in the perfective condition in a manner similar to morphosyntactic violations. On the other hand, we note that Van Berkum et al. (2007) did not find a LAN elicited to pronouns with gender that mismatched their participants' expectations. Without further research, it is difficult to know why Van Berkum et al. (2007) did not find a similar effect. However, as discussed above, whereas Van Berkum et al. showed the effect of varying verbs and hence entire events, we show the effect of varying a more subtle grammatical feature, the aspectual marking on the verb, which in turn affects the way that the structure of the event is construed. In this regard, we examine how a morphosyntactic manipulation (verb aspect) influences expectations for morphosyntactic information (gender), whereas Van Berkum et al.'s manipulation involved constraining expectations for morphosyntactic information (gender), but these expectations were not driven by the morphosyntactic properties of their verbs.

An anonymous reviewer worries that the anterior negativity observed in the present study for the Source referents in the perfective and imperfective conditions could be caused by increased processing difficulty for antecedents that are further from the referring expression, with the presence of the P600 possibly influencing the shape of this negativity in the perfective condition. (In this respect, our experiment differed from Van Berkum et al. (2007), in which referential distance was counterbalanced by including verbs with a strong bias for either the first noun phrase or second noun phrase.) We believe that it is unlikely that a distance effect could be responsible for such difficulty in our data, however. Whereas it is known that there is a recency advantage with respect to the position of the sentence containing the antecedent in the prior discourse (Clark & Sengul, 1979), the overwhelming evidence suggests that the contribution of grammatical position to the salience of a referent actually diminishes as one moves from left-to-right in the immediately previous sentence (i.e., from less-to-more recent), with the subject position possibly even holding a unique status (Crawley, Stevenson, & Kleinman, 1990; Gernsbacher & Hargreaves, 1988; Matthews & Chodorow, 1988; Stevenson et al., 1994; Grosz et al., 1995, a.m.o.). It is precisely this fact that makes the prominence of the Goal identified for Source–Goal transfer-of-possession sentences in completion studies, and the negativities found to Source subjects in our study, particularly interesting.

Recall that Stevenson et al. (1994), for instance, found a near-even distribution for Source and Goal referents (51%/49%) for ambiguous pronouns in transfer-of-possession sentence frames. This result can be compared to that for a superficially similar condition that they ran using Agent-Goal sentence frames, e.g., “Sam ran toward Richard. He...”. Although an analogous discrepancy with respect to distance exists between the subject and Goal in these frames, Stevenson et al. found that more than 84% of the pronoun references went to the (more distant) entity in subject position. This bias is more in accordance with previous work that provides evidence for a subject preference, and thus if anything, this body of work would predict that non-subject referents would be the ones that yield greater processing difficulty.

With respect to our ERP results, we note that the two negativities are different not only in topography but timing as well, which is crucial in that the P600 effect does not appear as significant until after the left anterior negativity in the perfective condition. This means that there is no P600 effect to counteract the anterior negativity at right anterior conditions in this time region. Whereas we cannot entirely rule out the possibility of an influence of the P600 on the anterior negativity in the later regions, it seems to us to be unlikely, given that at posterior locations in those time regions (including when and where the P600 effect is maximal; i.e., 500–800 ms) there is no statistical evidence that the effect is right lateralized

(or, at least, certainly not to the degree required). It stands to reason that it is therefore unlikely to be right lateralized at anterior locations as well.

We believe that other recent research by Van Berkum and colleagues provides additional insight into the anterior negativity elicited to Source pronouns that followed imperfective verbs (Nieuwland, Otten, & Van Berkum, 2007; Nieuwland & Van Berkum, 2006). Of particular interest is their research demonstrating a broadly distributed anterior negativity that is elicited to pronouns and nouns that are consistent with multiple antecedents with the same gender. This referentially induced sustained negativity, dubbed the Nref effect, begins approximately 300 ms post-stimulus onset and does not appear in conjunction with P600 effects. Importantly for the present research, the size of the Nref effect is modulated by the implicit biases of verbs to be followed by particular participants mentioned in sentences (Nieuwland & Van Berkum, 2006). For example, Nieuwland and Van Berkum (2006) conducted a referential cloze task in which they noted how often people complete sentence fragments by using the ambiguous pronouns to refer to either the first entity or second entity mentioned in the fragments (e.g., Linda invited Anna when her...). They then examined their observed Nref effect as a function of verbs that were moderately biased toward a specific entity versus those that had more similar biases for both entities. This analysis demonstrated that the Nref effect for ambiguous pronouns was much larger when the verbs exhibited similar biases toward both entities as opposed to a high bias toward one entity. Moreover, they also demonstrated that this effect was more pronounced for participants with larger reading spans (i.e., larger working memory capacity). These results suggest the Nref effect may be most apparent under conditions in which the lexical semantic properties of the verbs do not lead to large differences in the foregrounding of multiple referential candidates in a comprehender's situation model. They also suggest that readers that have higher reading spans are more likely to detect and resolve formally ambiguous pronouns. Finally, the results also demonstrate that the brain does not treat such referential ambiguity in the same manner as a morphosyntactic problem (or anomaly) as no P600 effect is elicited.

In the present experiment we examined unambiguous pronouns, so one might wonder how our results relate to these findings in light of the fact that the Nref effect resembles our anterior negativity following imperfective verbs in both timing and topography. As discussed above, perfective verbs had a significantly stronger bias to be followed by first mentions to the Goal entity than did imperfective verbs. Thus the focus on the ongoing development of transfer-of-possession events by imperfective aspect functions to make the Source entity foregrounded to a greater degree in a comprehender's situation model than when the events are described as completed. One possibility is that the anterior negativity in the imperfective condition reflects difficulty in referential processing due to the fact that both Source and Goal entities are simultaneously active in the developing situation model. When people receive a pronoun that is consistent with the less preferred but still referentially available Source entity, it creates referential processing difficulty leading to the observed anterior negativity and the absence of a P600 effect.

Although it may at first seem counterintuitive that competition among referents that differ in gender would create pronoun processing difficulty (especially in light of evidence that gender information is used rapidly during pronoun interpretation; see Arnold, Eisenband, Brown-Schmidt, and Trueswell (2000) and references therein), recent evidence from a production study renders it less surprising. Arnold and Griffin (2007) asked participants to produce passage continuations in two contexts: one that contained a single main character, and another that also included a less-salient, secondary character of the opposite gender. In each case, only the items in which the participant's continuation referred to the main character from the grammatical subject position were analyzed. Despite the fact that pronominal reference is completely unambiguous in both contexts, participants used a

pronoun far less often in the two-character condition than in the single-character condition. The latencies in production of the referring expressions were also significantly greater in the two-character context.

Arnold and Griffin suggest that multiple characters mentioned in a discourse will share the speaker's available attentional resources, such that the introduction of a second character will result in decreased activation of the main character as compared to the level it would have had if appearing alone. Although their experiments and discussion mainly pertain to production, their results are consistent with research on the interpretation side that suggests that pronoun resolution is not a primarily 'bottom-up' search process, i.e., in which the majority of processing work occurs when the pronoun is encountered, but is instead largely influenced by the comprehender's prior 'top-down' expectations about who will be mentioned next (Arnold, 2001; Kehler, Kertz, Rohde, & Elman, 2008; Koorneef & Van Berkum, 2006; Stevenson et al., 1994). This view predicts greater processing difficulty for a hearer when multiple characters are in the discourse even when the pronoun is unambiguous, since the lower the level of activation of the intended referent, the greater the processing work that will be required at the time the pronoun is encountered.

In summary, the timing and topographical differences between the anterior negativities for the two forms of aspect, in conjunction with the absence of the P600 effect in only the imperfective condition, show that the brain construes the gender mismatch differently for the two forms of verb aspect. For the perfective condition it appears as though a morphosyntactic anomaly has occurred, whereas the imperfect condition seems to show referential integration difficulty without construing the difficulty as morphosyntactic in nature.

## General discussion

The present research shows that verb aspect interacts with the lexical semantic properties of verbs of transfer to influence a comprehender's online incremental expectations for who is likely to be mentioned next as a discourse proceeds. This finding adds to a growing body of literature that shows that describing situations as ongoing or completed with verb aspect influences the foregrounding and backgrounding of information (people, places, and objects) about those situations (Carreiras et al., 1997; Ferretti et al., 2007; Madden & Zwaan, 2003; Magliano & Schleich, 2000; Morrow, 1985; Rohde et al., 2006). Importantly, our ERP results extend this research by showing how the foregrounding and backgrounding of entities with verb aspect influences coreferential processing when people simply read sentences for comprehension. In addition, our off-line story continuation results provided an independent index for how likely pronouns were to refer to one entity or another in a comprehender's mental model, and the first-mention biases revealed in that study were consistent with the pattern of results observed in the online ERP experiment.

Our findings also have implications for our understanding of the constraints that modulate the implicit biases of verbs with respect to the expectations they engender about which entities are likely to be mentioned next (Arnold, 2001; Stevenson et al., 1994; Rohde et al., 2006; Van Berkum et al., 2007). The results are consistent with previous research by Stevenson et al., 1994, Arnold (2001), and Rohde et al. (2006) in demonstrating that the Goal bias following verbs of transfer is an epiphenomenon of a bias toward focusing on the end state of the previously described event. Both the story continuation data and ERP data demonstrated that focusing on the ongoing development of these situations reduced the bias toward the Goal entity in favor of the Source entity. Our results extend previous research by providing evidence that this event-level bias is also present during online language comprehension.

Our results also have implications for our understanding of how the brain deals with difficulty in coreferential processing that arises from these factors (e.g., Nieuwland & Van Berkum, 2006; Van Berkum et al., 2007). The present research demonstrates that the implicit biases associated with transfer-of-possession verbs also influences the ease with which people resolve the referents for pronouns and, crucially, that these biases are influenced by the temporal focus afforded by verb aspect. Our P600 results for the perfective condition are consistent with recent research showing that the brain construes mismatches between strong gender expectations and pronouns as a morphosyntactic anomaly, even when the discourse contexts contain potential antecedents with matching gender (Osterhout & Mobley, 1995; Van Berkum et al., 2007). Furthermore, the LAN elicited to Source pronouns in conjunction with the enhanced P600 is consistent with the electrophysiological response found to formal morphosyntactic violations (Coulson et al., 1998; Osterhout & Mobley, 1995; Rossi et al., 2005). The lack of a P600 effect and the timing and topographic distribution of the anterior negativity observed for Source pronouns in the imperfective condition show that the brain does not treat the gender mismatch (which is associated with a much smaller bias than in the perfective condition) as a morphosyntactic anomaly or violation, but rather as referential integration difficulty.

Finally, our results are most consistent with constraint-based models (Garnsey, Pearlmutter, Meyers, & Lotocky, 1997; MacDonald, Pearlmutter, & Seidenberg, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) and other recent expectation-based approaches to sentence processing (e.g., Hale, 2001; Van Berkum et al., 2007; Levy, 2008). These models suggest that comprehenders simultaneously integrate information about how words combine to form the syntactic structure of a sentence along with semantic, pragmatic, and real-world knowledge about the structure of events previously described in the discourse when interpreting discourse-dependent linguistic forms such as pronouns. The results reported here extend previous approaches by showing that verb aspect influences coreferential processing and, therefore, that models of coreference (and models of sentence processing in general) need to incorporate information about the temporal and causal structure of (and real-world knowledge associated with) events to properly account for the data.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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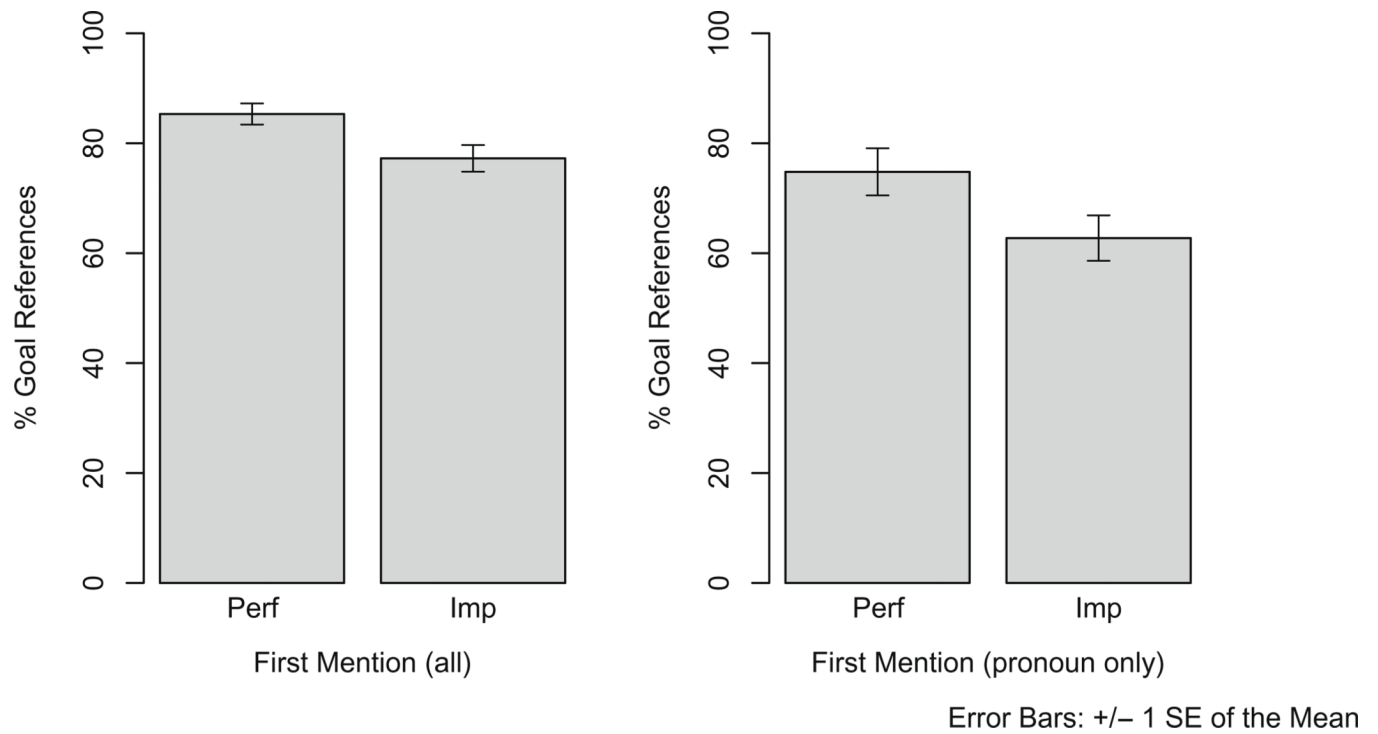
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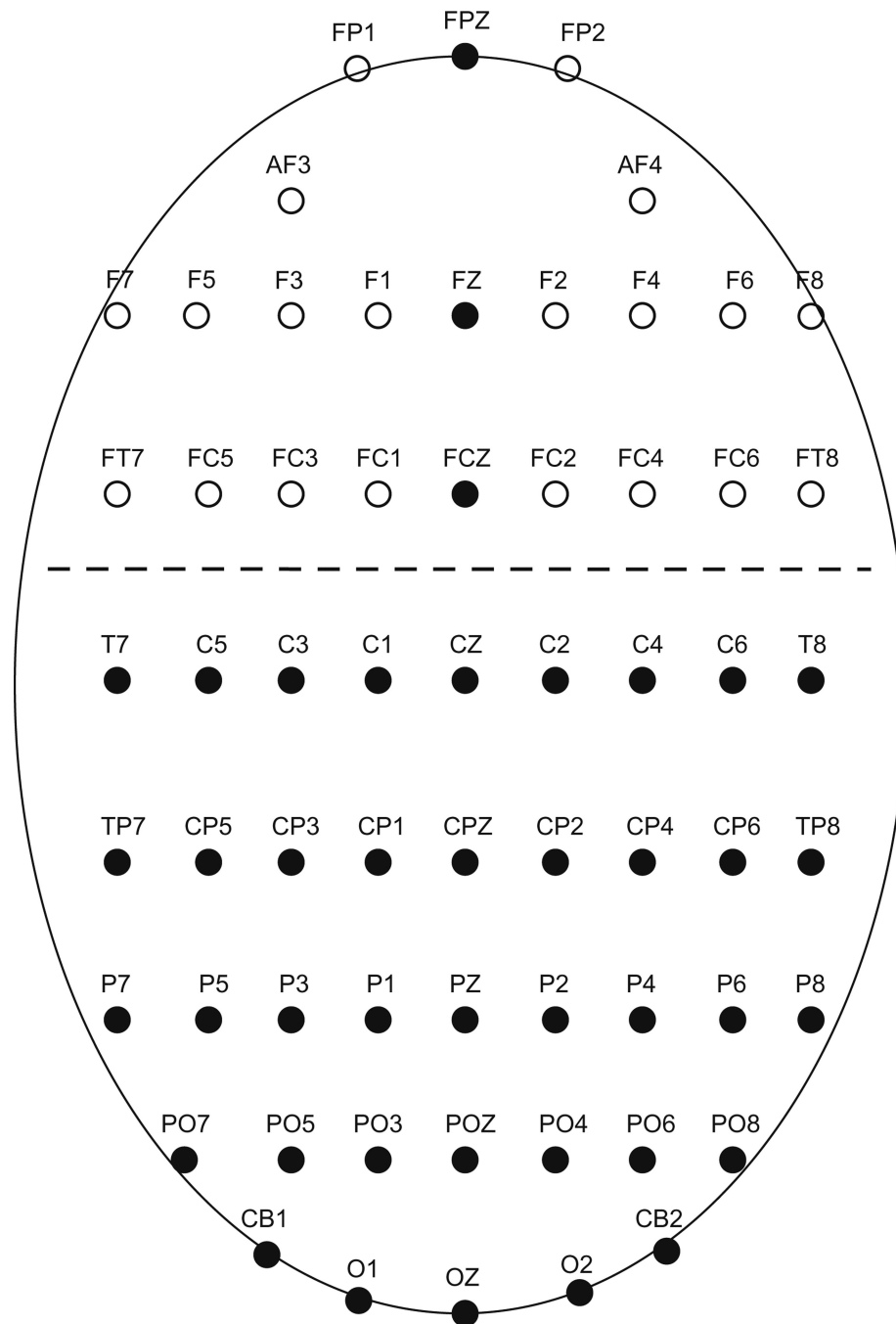
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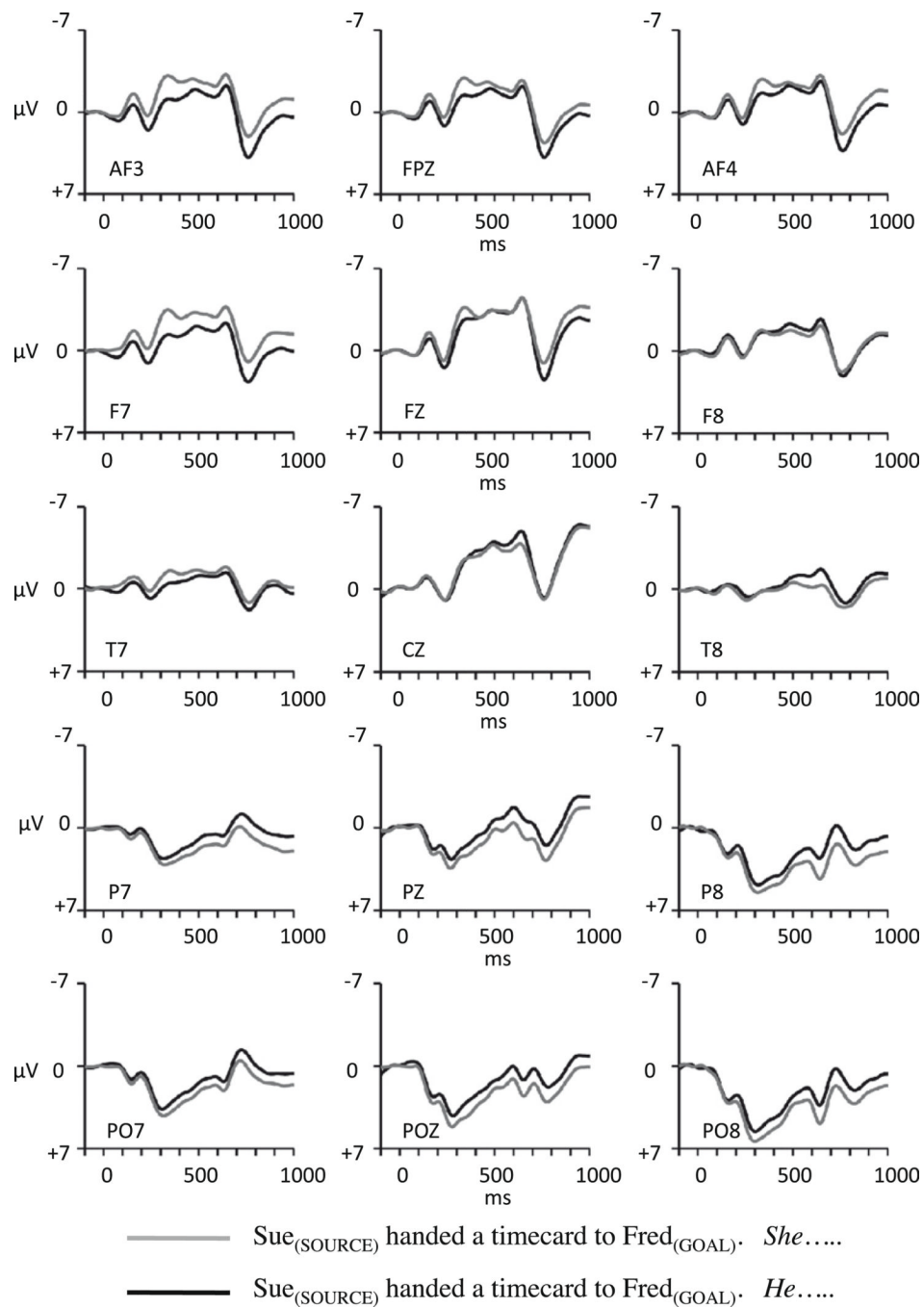
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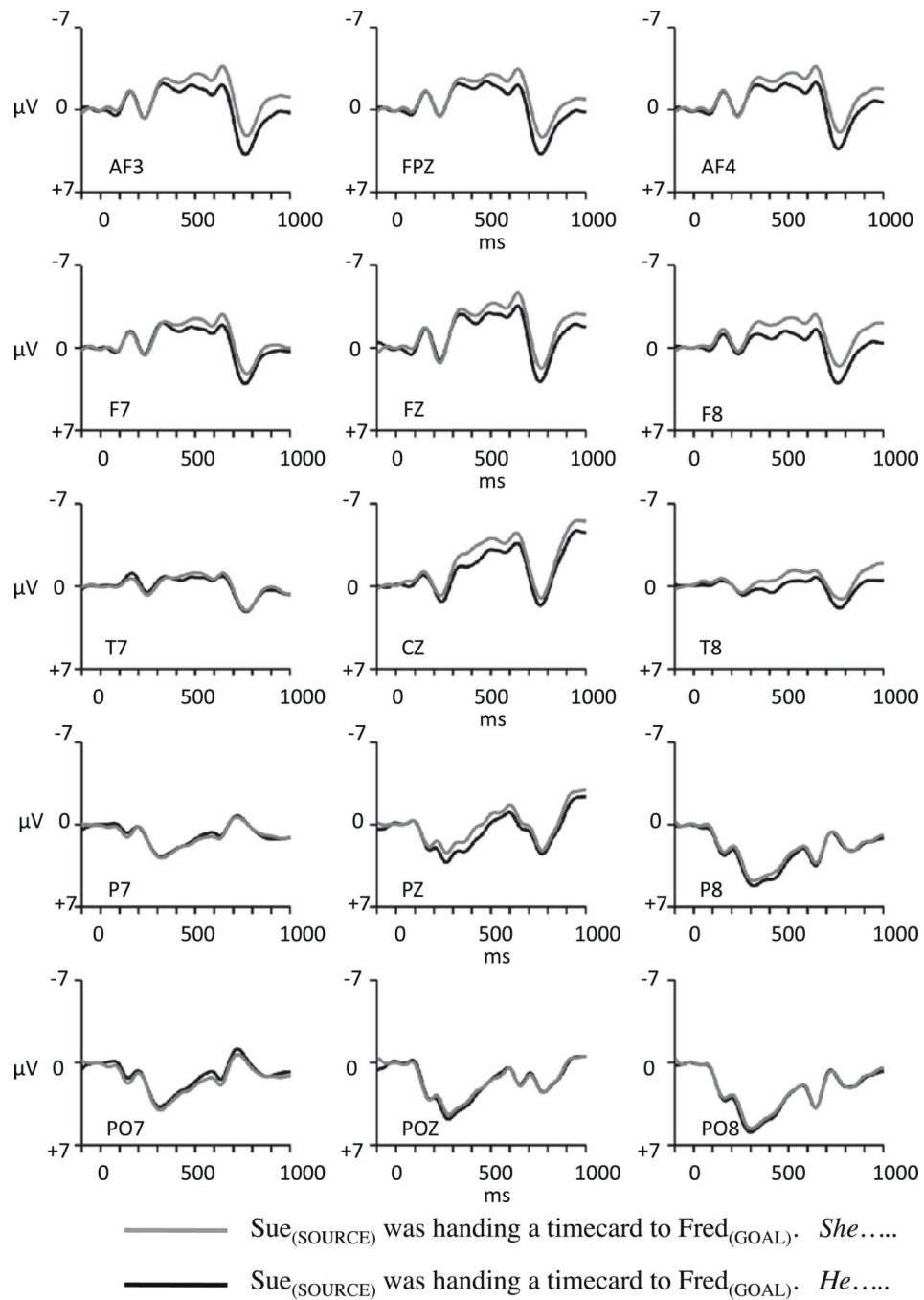
**Fig. 1.**  
Next-mention biases by verbal aspect (with standard errors).



**Fig. 2.** Schematic diagram showing the electrode labels and sites for the electrodes used in the Experiment 2 analyses. Note that the two mastoid electrodes are not shown in the diagram. The dashed line separates the electrodes used in the analyses of anterior (top) and central and posterior (bottom) electrode sites. The non-shaded electrodes were used in the topographical analyses examining left versus right hemisphere electrodes.



**Fig. 3.** Grand average ( $n = 52$ ) results for Source-referring pronouns (gray lines) and Goal-referring pronouns (black lines) following perfective sentences at selected electrode sites.



**Fig. 4.** Grand average ( $n = 52$ ) results for Source-referring pronouns (gray lines) and Goal-referring pronouns (black lines) following imperfective sentences at selected electrode sites.

**Table 1**

Summary of the ANOVA results for the mean ERP amplitudes in the time regions of interest in Experiment 2.

	Anterior electrodes	Posterior electrodes
<i>100–300 ms</i>		
Aspect	$F < 1$	$F < 1$
Reference	$F < 1.28$	$F < 1$
Aspect $\times$ reference	$F(1, 48) = 1.90$	$F(1, 48) = 1.92$
Aspect $\times$ reference $\times$ electrode	$F(22, 1056) = 3.02, p < .05$	$F(38, 1824) = 1.95$
Aspect $\times$ reference $\times$ hemisphere	$F(1, 48) = 3.61, p < .07$	–
<i>300–500 ms</i>		
Aspect	$F < 1$	$F < 1$
Reference	$F(1, 48) = 3.63, p < .07$	$F < 1$
Aspect $\times$ reference	$F < 1$	$F(1, 48) = 3.55, p < .07$
Aspect $\times$ reference $\times$ electrode	$F(22, 1056) = 3.48, p < .05$	$F < 1.28$
Aspect $\times$ reference $\times$ hemisphere	$F(1, 48) = 4.15, p < .05$	–
<i>500–800 ms</i>		
Aspect	$F < 1$	$F < 1$
Reference	$F(1, 48) = 5.35, p < .03$	$F < 1.32$
Aspect $\times$ reference	$F < 1$	$F(1, 48) = 5.66, p < .03$
Aspect $\times$ reference $\times$ electrode	$F(22, 1056) = 2.57, p < .03$	$F < 1.37$
Aspect $\times$ reference $\times$ hemisphere	$F(1, 48) = 3.81, p < .06$	–