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Event Syntax and Event Semantics as Constraints on Availability of Discourse

Raymond B. Becker
Wilfrid Laurier University

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Event syntax and event semantics as constraints on availability of discourse

by

Raymond B. Becker

(Bachelor of Science, the University of Wisconsin, Whitewater, 1999)

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Abstract

The understanding of how temporal information constrains situation models is far from complete. In these two experiments participants read short stories, where the antecedent sentence was manipulated with respect to varying tense, grammatical and lexical verb aspect (Experiment 1), and then by varying grammatical and lexical verb aspect in conjunction with long and short duration events (Experiment 2). We used electrophysiological measures time-locked to the anaphoric referent to investigate how the brain responds to these temporal constraints. The purpose was to investigate the possibility that these variables have an influence on the availability of discourse concepts in situation models. In Experiment 1, the anaphoric referent elicited a larger N400 when it was presented previously in a perfective antecedent sentence than an imperfective sentence. This N400 difference for grammatical aspect was limited to antecedent sentences with accomplishments as there was no statistical evidence for activities. Tense did not influence availability regardless of lexical aspect. In Experiment 2, N400 amplitudes were again modulated by grammatical aspect and this effect was also found to be limited to when antecedent sentences contained accomplishments. Furthermore, the results demonstrated that the imperfective advantage observed for accomplishments is not present after an intervening event with a long time shift. The implications of these findings are discussed in terms of theories of situation models.

Keywords: Event-related brain potentials, situation models, mental simulation, co-referential processing, grammatical aspect, lexical aspect

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Table of Contents

Introduction

Fermenting grape juice into wine takes time. The background knowledge of wine-makers provides them with the experience of how much time must pass for grape juice to turn into wine. The taste, color, and smells all contribute to the wine-maker's experience of past episodes or situations. But experience is not enough to understand the winemaking process. What is necessary is a way to organize the experience so as to make sense of the process. This structure helps the winemaker understand *what* needs to happen *when* in the process of making wine. Psycholinguistics has attempted to understand how these structures, commonly referred to as situation models, work as they are expressed in language. Although much has been learned about the structure of events, the role of time in the unfolding of events remains underexplored. The research presented in this thesis extends current work on situation models by investigating the permutations of event syntax (grammatical aspect and tense) with event semantics (lexical aspect and time shifts).

It is sometimes thought that language processes are studied separately from other cognitive processes such as time duration estimation/discrimination, and sequential learning (e.g., musical rhythms). And language researchers might, as might researchers in either of the other cognitive domains mentioned above, be faulted for becoming too narrowly focused, and not seeing the big picture. However, the notion of modularity proposed by Fodor (1983), which assumes that language and other processes function independently, has lost favor due to an enormous amount of evidence supporting interactive theories of cognition, such as embodied cognition. Further, the theories of language processing discussed in this thesis also apply to other areas of cognition. For example, the processes of mapping and shifting as described by

Gernsbacher (1990) in her model of the Structure Building Framework (discussed in more detail in the section to come) are meant as *general* cognitive principles, not specific to language processing.

Situational availability

Mental models (Craik, 1943; Johnson-Laird, 1980; 1983) are cognitive structures built from experience. At the same time, mental models help to make sense of new experiences, because the initial structures set the stage for new information. According to some accounts, these structures are composed of verbal codes and image codes as described by Paivio's (1986, 1991) Dual Coding Theory (DCT). DCT proposed that verbal and linguistic codes were represented in parallel levels (Sadoski & Paivio, 2007), which retained the relationship of words and propositions paired with their sensory experience (i.e., sensory modality).

Instead of separate codes, embodied cognition theorists (Glenberg, 1997; Barsalou, 1999) have argued for the grounding of word/concepts in the action and perception systems. Thus, the meaning of the words are not stored as separate codes from the perceptual reality that they index to; such as the word/concept BIRD indexes to the visual image of the bird, hearing a bird singing. The meaning is derived from the perception and action systems and cannot be derived from the linguistic system in itself. While this argument works well for concrete concepts, grounding abstract concepts such as TIME is more controversial.

One approach to grounding abstract concepts in perceptual systems is the Situational Availability approach (Barsalou & Wiemer-Hastings, 2005). Situational Availability is the notion that the meaning of abstract concepts relies on memories of specific situations, or episodes, that easily come to mind when a person thinks about the word/concept. For example, in a study by Barsalou and Wiemer-Hastings they investigated the differences in associated-word recall

between abstract and concrete concepts using a protocol list task. Participants were asked to produce as many words as came to mind related to the target word (e.g., TRUE). They found that for abstract concepts like TRUE participants produced situational words such as *ultimacy* or *significance*. In contrast, for concrete words like BIRD, participants produced concrete features such as *tiny* or *fragile*. Barsalou and Weimer-Hastings refer to this finding as a difference in the situational availability for abstract concepts compared to the availability of taxonomic features of concrete concepts.

The situational availability account is not only relevant to word-concepts but can also be extended to situation model research by looking at how different temporal cues make information available. While it is likely that just the word/concept time elicits a situation itself rather than activating a semantic network of associated nodes (e.g., IS UP, FLIES, BANDITS, WOUNDS ALL HEALS, ROSEMARY AND THYME, etc), a person's understanding of temporal properties such as duration, natural beginnings, and endpoints of events also contribute to the availability of information associated with those events in a situation. More generally speaking, they shape a person's experience of TIME and what TIME means. By extending the notion of situational availability to the overall experience of temporal properties, such as the experiences guided by event syntax and event semantics, it may possible to go beyond the situations evoked by only the word-concept TIME to also include experiential properties of TIME important to grounding the concept in bodily and perceptual systems.

Mental models and situation models

Surface code. The surface code is the most basic level of a mental model. It is the mental representation of the words, phrases, and sentences verbatim. Discourse processing research in the late 1960s-1970s focused on how memorable the surface code was. What has become

apparent from this early research is that the memory of the surface code of a text is fleeting. Participants, who have just read the sentence *He sent a letter to Galileo, the great Italian scientist.* will have a high rate of correctly rejecting a different sentence such as *A letter about it was sent to Galileo, the great Italian scientist.,* if asked immediately after reading it (Gernsbacher, 1990). However, after processing about 80 syllables, participants cannot discriminate between sentences with subtle differences in paraphrasing than the sentence that they actually read (Sachs, 1967; as cited by Gernsbacher, 1990).

This demonstration of how the text itself is forgotten so quickly led researchers to study how language is reconstructed into a model that allows for the recall of specific pieces of information not only in a semantic memory, based on associations among facts, but also a representation of the episodes themselves. This is the most basic level of how incoming text gets processed into a mental model, but can affect what is available in memory and what is not.

Textbase. The textbase is made up of propositional nodes. Consider the following story from *Einstein's Dreams* by Alan Lightman (1993, p. 102, as cited by Graesser, Millis, & Zwaan, 1997, p168) which has figured prominently in the discourse processing literature:

> A mushy, brown peach is lifted from the garbage and placed on the table to pinken. It pinkens, it turns hard, it is carried in a shopping sack to the grocer's, put on a shelf, removed and crated, returned to the tree with pink blossoms. In this world, time flows backward.

The first sentence of this text could be represented in the textbase as the following proposition set:

PROP 1: lift (AGENT = X, OBJECT = peach, SOURCE = from garbage)

PROP 2: brown (OBJECT = peach)

PROP 3: mushy (OBJECT = peach)

PROP 4: place (AGENT = X, OBJECT = peach, LOCATION = on table)

PROP 5: pinken (OBJECT = peach)

PROP 6: [in order] to (PROP 4, PROP 5)

The story is interesting because it will likely take the reader a while to figure out that something is unusual and possibly not figure it out until it is explicitly stated that time is flowing backward. Of note is some of the coding, where in the first sentence there is an "X" to indicate that there is no explicit agent. Coherence at this level is considered to be the amount to which these propositions overlap, such as with 2 and 3 referring to the same object. However, incoherence occurs when propositions do not overlap. The textbase level does have some merit in creating shorthand for texts, and possibly even account for some behavioral findings that arguably could not be explained as being the result of differences at the surface code or situation model level, but that discussion would be outside the scope of this thesis. The important point to note from this example as it relates to this thesis is that there are no codes at this level for tense or verb aspect.

Situation model. The situation model level is arguably the most controversial level of the mental model. It represents the world experiences that the reader or listener brings to bear on the comprehension process. This is a controversial construct because researchers and theoreticians are unsure if this is the level of processing where readers construct the meaning of the words, phrases, and text (Glenberg, 1997) or if it is possible to understand the meaning of language through the textbase via the spread of activation (Collins & Loftus, 1975; Collins & Quillian, 1969). As I discuss later, the current trend is against spreading-activation accounts of meaning. Nevertheless, the situation model level is supposed to involve the reader's real-world experience

when understanding text and that includes the experience of time as change (in the case of tense) and boundedness (in the case of aspect).

Theories of mental models

Many theories have been developed to explain how mental models are constructed, and how all of these levels (i.e., surface structure, text base, situation model) work together. Curiously, theoretical frameworks in discourse processing are often tested by their proponents using empirical methods, but there is usually no juxtaposition of two or more theoretical views, where an experiment was designed in a manner as to tease apart one account versus another, or even falsify another proponent's theoretical view. Instead, the literature on situation models is mostly cordial in this respect and the differences among various theories are subtle. I have chosen to review four of the most prominent theories of discourse processing as they relate to the temporal dimension of discourse processing, as this dimension is the focus of my thesis.

Structure Building Framework (SBF). Gernsbacher (1990) suggests an analogy to a Papier-mâché project for describing how readers and listeners create a foundation to build on as new information becomes available. Specifically, the first few sentences build a base, and as new information is introduced, layers are built onto the base through a general cognitive process called mapping. The foundation contains the memory cells associated to the first pieces of information provided in the story. As the reader progresses and new information is provided, the information is mapped onto the existing mental structure, but only if the new information overlaps with the old information, thereby activating the same memory cells. Thus, whether or not the new information is coherent depends on how much it overlaps with old information.

According to Gernsbacher (1990) there are at least four dimensions of coherence, which are not necessarily independent. These dimensions are spatial, temporal, causal, and referential

coherence. It is outside the scope of this thesis to discuss all of these dimensions, but instead the focus of will be on temporal dimensions. Temporal coherence, according to Gernsbacher, involves events that overlap in the same time frame. She points to the work by Anderson and Garrod (1983) as a demonstration of the effects of temporal coherence. Participants in that research were asked to read sentences such as a description of someone running in a marathon. Most people know that running a marathon can take hours, but not days. Thus, if a time shift in the narrative occurs, such as with the prepositional phrase *After a few days*, etc... participants would see the new event as occurring outside of the previous event's time frame. Anderson and Garrod found that sentences denoting situations that occurred outside of the time frame initially described in the introductory sentences were read slower than sentences that described situation that occurring within the established time frame (e.g., *After a few hours*, etc.).

If mapping does not occur due to a lack in overlap in time between new and old information, then a second cognitive principle called shifting happens. The lack of coherence results from the new information activating non-overlapping memory cells with the old information. A shift causes the reader to use new information as the foundation for a new structure instead of mapping it to the old structure.

Construction-Integration Model. The Construction-Integration Model's focus on text meaning construction is primarily based on the text base, which involves propositional representations of the text. For example, Kintsch (1988) proposes that an event such as "Mary bakes and burns a cake" could be represented with a set of arguments, most of which are propositional (e.g., D and E):

A) MARY

B) CAKE

C) SWEET[CAKE]

D) BAKE[agent:MARY,object:CAKE]

E) CONSEQUENCE

[condition:NOT[WATCH[agent:MARY,object:CAKE],EFFECT[BURN,object:CAKE]]

The meaning of this story is represented in amodal lexical (A, B, and C) and propositional nodes (D and E). An amodal representation is an arrangement of nodes detached from sensory experience that are either closely related or arranged closely together, or unrelated and separated by a greater distance. Amodal refers to the nodes in the network of propositions being detached from sensory experience. According to Kintsch (1988) and other proponents of amodal situation models, these nodes rely on the spread of activation through associative nodes to provide meaning (Collins & Loftus, 1975; Collins & Quillian, 1969).

The Event Indexing Model. The Event Indexing Model (Zwaan, Langston, & Graesser, 1995) is focused on how the situation model layer of discourse is constructed. According to this view there are at least five event indices in situation models: spatiality, temporality, causality, protagonist, and intentionality. Readers construct situation models along each of these five indices. As the reader progresses in the story and new information is added, the situation model is updated, but only if the new information requires a shift along any of the five indices. In such a case the reader will update the specific event index. For example, a change in temporal setting such as *A few hours later* requires the reader to update the situation model to the new time index. Event nodes are turned off when readers encounter a discontinuity along a specific event index, and a new event node is turned on (e.g., a temporal event index). Old nodes can be reactivated, according to Zwaan et al., but the nature of these nodes and what their activations are is unclear in the first incarnation of this framework. For example, it is not clear whether event nodes are

based on amodal or perceptual symbol systems (Barsalou, 1997; Glenberg, 1997). However, Zwaan is currently a proponent of embodied cognition, and has more recently argued for the grounding of event nodes in sensorimotor experience (see also comments by Kelter, Kaup, & Claus, 2004).

The Dynamic Model. The Dynamic Model attempts to explain how temporal information is constrained in situation models (Kelter et al., 2004). According to this model, events in long-term memory are static representations, whereas events in working memory are dynamic. Thus, as readers process a text they construct a situation model through two updating processes: tracking and fresh starts. For example, if a story continues to unfold in temporally continuous manner and the reader can track the narrative within the same time frame then the same situation model continues. However, if the story shifts in time too abruptly, then a fresh start is made and a new model becomes the current model or narrative now. As demonstrated later, the Dynamic Model can lead to differences in empirical predictions as compared to the Event Indexing Model with respect to how readers process durativity and time shifts. The latest evidence is in line with the updating processes of tracking and fresh starts, than with the process of shifting as outlined in the Event Indexing Model (Zwaan et al., 1995).

In summary, these four models provide a basis for several different, though not always mutually exclusive, sets of terminologies. The Structure Building Framework incorporates two processes; mapping and shifting. The Construction-Integration Model discusses shifting as the result of nonoverlapping propositions at the textbase level. The Event Indexing Model claims that shifting is the result of a change in any one of at least five (e.g., spatial, temporal, causal, etc...) indices at the situation model level. The Dynamic Model uses the terms *tracking* and *fresh starts* to refer to the ability of readers to track the continuity of text and if not then they make a

fresh start, which is ostensibly a shifting process. However, the shifting process is dynamic and effects can be gradual according to the Dynamic Model, whereas the other models discussed here claim that the shifting process is static and like flipping a switch either a shift is made or it is not.

Referential and co-referential processing

Listening to a story or reading an article requires updating old information with new information. In order for the new information to build a continuous coherent situation model it must refer back to some part of the old information such as a character, an event, or an object. For example, sentences such as *The man crossed the street. He was nearly hit by a careless driver.* describe situations where the subject in the first sentence is called the antecedent and the second sentence refers back to the antecedent using the masculine pronoun, or anaphor, *He*. Thus, the antecedent sets the stage for further information to be provided and the anaphor refers back to the antecedent. The factors that facilitate or interfere with this process have been studied quite extensively using behavioral measures, such as response times and reading times for the anaphor, or anaphoric sentence. More recently, researchers have used Event-Related Brain Potential (ERP) methodology to investigate the neurological correlates of coreferential processing (see Callahan, 2008 for a review). The present thesis contributes to this literature by using ERP methodology to investigate temporal constraints on co-referential processing.

The following section discusses the main ERP components, and then relevant research on co-referential processing is discussed.

ERP Components of interest. Researchers using ERP methodology typically are interested in how the electroencephalogram (EEG) varies as a function of a specific event (e.g., visual or auditory stimulus). At specific time windows after the onset of a particular event, evoked brain potentials vary in positive and negative fluctuations. These "peaks" and "troughs" in EEG

activity are often called components. A component is simply a name indicated by a letter and number given to the amplitude of a brainwave at a specific time window, and are known to correspond to perceptual and cognitive processes. For example, the N400 component is a negative component, as noted by the N, and typically peaks around 400 ms post-stimulus onset (Kutas & Hillyard, 1980). The N400 is typically measured between 300-500 ms after stimulus onset and is broadly distributed over the scalp, although it tends to be maximal at central and parietal regions. This component reflects how well words fit semantically with preceding contexts, including lexical, sentence, and discourse levels of representation (Brown, Hagoort, & Kutas, 2000). The N400 tends to be more negative for words that are more difficult to integrate with their preceding contexts. For example, N400 amplitudes elicited by the sentence-final noun (sugar) in the sentence *I take my coffee with sugar.* would be less negative at 300-500 ms after the onset of *sugar* than for a semantically incongruent word such as *socks*.

The Late Positive Complex (LPC) sometimes follows the appearance of an N400 and typically occurs between 600-1000 ms post-stimulus onset. This component has been reported over both anterior and posterior scalp regions. The LPC is thought to reflect difficulty in conceptual integration and the updating of situation models. Words that are more difficult to integrate into discourse contexts sometimes produce greater positivity than words that are less difficult (Burkhardt, 2006). Differences in the N400 component have also been shown to extend into the late component region in cases that involve words that are very difficult to integrate into situation models (Ferretti, Singer, & Patterson, 2008). The N400 component and the Late Components are the main components of interest in the present thesis.

Recent research on co-referential processing has shown that grammatical aspect biases the reader's focus on participants in events (Ferretti, Rohde, Kehler, & Crutchley, 2009). For

example, Ferretti et al. used a story-continuation task where people were asked to generate a new sentence that continued sentences such as 1a and 1b.

1a. *Sue handed a timecard to Fred.* _____. (Perfective)

1b. *Sue was handing a timecard to Fred.* _____. (Imperfective)

The transfer-of-possession constructions have a Source (Sue) and a Goal (Fred), and the critical manipulation is grammatical aspect (perfective (completed event) versus imperfective (ongoing event)). Ferretti et al. suggested that for imperfective sentences, the reader's focus should be on both the Source and Goal event participants as they are both associated with an ongoing event, whereas for perfective sentences, the reader's focus should be more on Goal participant as this participant is more associated with resultant states of events (see Figure 1). Ferretti et al. found that people made more continuation sentences with first mentions to the Goal participant following perfective sentences than imperfective sentences.

In a second experiment, Ferretti et al. (2009) used ERP methodology to investigate the brain's response to either a masculine or feminine pronoun that began a subsequent sentence and unambiguously referred to the Source or Goal participant in the first sentence. The first sentences were the same as those used in their first experiment. The second sentence described a plausible continuation of the first sentence:

Sentence 1: Sue $_{(SOURCE)}$ handed/was handing a timecard to Fred $_{(GOAL)}$.

Sentence 2: She/He asked about the upcoming meeting.

ERPs elicited to the pronouns were examined to index reader's focus on event participants. Ferretti et al. (2009) found that when verb aspect indicated that the event was completed with perfective aspect, brainwave amplitudes between 100 to 500 ms post-pronoun onset were more negative for Source than Goal referring pronouns at left anterior head locations (called a Left

Anterior Negativity or LAN). The LAN component was followed by a P600 component that was more positive for Source than Goal referring components at posterior head locations. Both of these brain components are known to be sensitive to morphosyntactic violations. In the present case, the violation occurred from verb aspect setting up expectations for pronouns that had a specific gender and then receiving a pronoun inconsistent with these expectations (i.e., a violation of gender agreement).

Although the discussion of Ferretti et al. (2009) is relevant to present research because it shows how grammatical aspect influences coreferential processing, our main interest in the current work is on how grammatical aspect (and other temporal constraints) influence coreferential processing of repeated noun phrases in larger discourse passages. Recently, researchers have shown that the N400 component is modulated by the repetition of noun phrases during coreferential processing (Anderson & Holcomb, 2005; Burkhardt, 2006; Burkhardt & Roehm, 2007; Ferretti et al., 2008). For example, Burkhardt (2006) contrasted three referential dependencies, identity (i.e. repetition), and inference-based and unrelated antecedent-anaphor dependencies:

(2) a. Tim watched a bride. *The bride* … (Identity)

(2) b. Tim went to a wedding. *The bride* … (Inference-based)

(2) c. Tim met Paul. *The bride* … (Unrelated)

Participants read sentences such as these and their brainwaves were recorded. Burkhardt found a gradient in N400 amplitudes elicited to the critical noun phrase (i.e., The bride), with the smallest N400 found for the identity or repeated noun phrase and the largest N400 to the unrelated noun phrase.

Burkhardt and Roehm (2007) furthered this research by investigating the type of

referential dependency (identity versus inference) in conjunction with the saliency of the antecedent anchors in people's mental models. Anchors were considered more salient if they appeared in a context sentence with a uniquely identifiable antecedent (see example 3a and 3c) versus when they appeared with two potential antecedents (3b and 3d).

(3) a. Dietrich filmed for the first time *a midwife* for PRO7. (Repeated-NP, salient)

(3) b. Eike filmed for the first time *a midwife* and a nun for PRO7. (Repeated-NP, non-salient)

(3) c. Erwin filmed for the first time *a delivery* for Arte. (Inferential-NP, salient)

(3) d. Ludwig filmed for the first time *a delivery* and a funeral for Arte. (Inferential-NP, non-salient)

(3) e. He reported that *the midwife* was extremely friendly. (sentence with target NP)

Burkhardt and Roehm found that noun phrases (e.g., the midwife) in identity relations produced smaller N400 amplitudes than when the same noun phrases were in inference relationships. Importantly, they also found that for identity relations, N400 amplitude was not modulated by the saliency of the anchors, whereas the N400 was smaller for inferential relationships with salient anchors. The findings suggest that repetition and saliency of antecedents are two important constraints on the N400 amplitudes during coreferential processing.

In summary, the ERP literature on referential processing suggests two important findings that are relevant to the present thesis. First, difficulty in anaphor processing or integration is a function of its referential dependencies; anaphors that involve co-referring expressions that completely overlap are easier to resolve than anaphors that involve more elaborate inferencing processes. Second, the saliency of antecedents in mental models also influences the ease of co-referential processing. In this regard, Ferretti et al.'s (2009) research suggests that verb aspect can

influence that saliency of participants in antecedent events, whereas Burkhardt and Roehm (2007) have demonstrated no effect of saliency on N400 amplitudes during coreferential processing involving repeated noun phrases.

The following experiments add to this literature by using ERP methodology to investigate how different temporal properties of linguistic descriptions interact to influence the ease of coreferential processing of noun phrases that are repeated in discourse. The following sections review in more detail the temporal properties of discourse related to event syntax and lexical semantics, as well as the few studies that have looked at some interactions between these properties. Following this, we present two experiments that provide novel insight into how these properties combine to constrain coreferential processing.

Event Syntax

Grammatical Aspect. Grammatical aspect refers to how the morphosyntactic properties of verbs refer to the temporal development of the events that they denote (i.e., ongoing versus completed). In English, there are three categories of aspect and these include the imperfective (ongoing event, "was skating"), perfective (completed event, "skated"), and perfect (completed event, "had skated"). Note these examples all involve past tense, but the different aspect categories can appear with all forms of verb tense. The main difference between the two completed forms of aspect is that perfective aspect references to entire events as completed without any reference to their internal properties, whereas the perfect aspect refers more directly to the result states of events and the continuing relevance of those states.

Recent psycholinguistic research has shown that referencing events as ongoing versus completed with verb aspect can influence the content of event representations that are activated from verb phrases read in isolation as well in larger discourse structures (Ferretti et al., 2007;

Ferretti et al., 2009; Madden & Therriault, 2009; Madden & Zwaan, 2003; Magliano & Schleich, 2000). For example, Ferretti et al. used a verb-location priming task and measured naming latencies for locations that were either related or unrelated to verbs that were presented in imperfective or perfect form (e.g., *was cooking-kitchen* versus *had cooked-kitchen*). They found that naming latencies for related verb-location pairs (e.g., *was cooking-kitchen*) were faster than unrelated verb-location pairs events (e.g., *was worshiping-kitchen*) when the verbs were presented in the imperfective. In contrast, no difference was found between related and unrelated verb-location pairings when the verbs were inflected with perfect aspect.

Ferretti et al. (2007) also investigated the difference in N400 amplitudes elicited to high- and low-expected locations that followed imperfective or perfect verbs. Participants read sentences such as *The diver was snorkeling in the ocean/pond.* versus *The diver had snorkeled in the ocean/pond.* Ferretti et al. found an interaction between verb aspect and location expectancy. For imperfective sentences, low-expected locations elicited larger N400 amplitudes than high-expected locations. In contrast, there was no difference in N400 amplitudes to low and high expected locations following perfect verbs.

A recent study by Madden and Therriault (2009) provides insight into how verb aspect influences mental simulations of events in sentences. In this study, participants read sentences where the direct objects were replaced by pictures of the objects either in use or not in use. For example, in the sentence *John was working/had worked on his laptop at home.* the word *laptop* was replaced with a picture of a laptop that was either open (i.e., in use) or closed (i.e., not in use). The authors predicted that there would be an overall processing advantage of the picture when the objects were shown in use versus not in use, due to the activation of a mental simulation that becomes active when people read. Second, they predicted that sentences with the

imperfective verb aspect (e.g., *was working*) would cue a longer-lasting simulation when objects are shown in use than in perfect aspect (e.g., *had worked*). They measured processing times for the picture, reading times for the first and second word following the picture, and sensibility judgment times (i.e., after the sentence participants were asked, *Does this make sense?*). The results supported their predictions. Participants processed the pictures of objects faster overall when they were shown in use versus not in use. Also, this effect was modulated by verb aspect such that processing times for the first and second words following the picture as well as sensibility judgment times were faster when the object was in use than not in use when the sentence was in the imperfective. However, the advantage of objects shown in use versus not in use were not significantly different for reading times for the first and second words following the picture, nor for sensibility judgment times in sentences with perfect aspect. These results are important for the present research because they suggest event simulations and, thus their contents, are longer-lasting over subsequent text when verbs are inflected with imperfective aspect.

The advantage of imperfective for making the contents of events more available has also been shown with larger discourse contexts (Magliano & Schleich, 2000). For example, Magliano and Schleich probed participants' recall for an event in discourse where they initially presented it as ongoing (e.g., *was changing a tire*) versus completed (e.g., *had changed a tire*). People were presented with verb phrases that probed recognition of the critical target events (i.e., change a tire) after one sentence and after four subsequent sentences. Their results demonstrated that following both probes people recognized target events more quickly when they were initially presented with imperfective than perfective aspect.

In summary, recent research on verb aspect has demonstrated the ongoing versus

completed status of events in text influences the content of event representations and also the availability of those events are over subsequent text.

Tense. Verb tense is another way of grammatically inflecting verbs to refer to the temporal properties of events. Specifically, tense functions to reference the time of event occurrence relative to the time of speaking. That is, relative to the current "now" events can be described as occurring in the past (e.g., skated), present (skate), and future (will skate).

Few studies of online sentence processing have investigated the possibility of processing differences resulting from tense manipulations. Preliminary work by Becker, Gonzalez-Marquez, and Matlock (in prep) used sensibility judgments for sentences that vary by past and future tense. The results of this research showed that participants judged sentences in the past tense (e.g., *I saw the bird land on the branch.*) as sensible faster than sentences in the future tense (e.g., *I will see the bird land on the branch.*). Further this effect of tense was not modulated by differences in the event's sensory experience (i.e., whether it is described as something seen, heard, or felt), nor was it modulated by the temporal distance from the present (an hour, week, or month). The reason that the past tense is processed faster than future tense may be because a simulation of a situation is completed with past tense, whereas the future tense is more ongoing. This is one example where using simple past tense (e.g., *saw*) instead of the past imperfective (e.g., *was seeing*) could conflate tense and grammatical aspect in English, as argued by Yap et al. (2009; note that this issue of combining tense with certain aspect categories is discussed in more detail below). Thus it is unclear in this example whether this is an effect of tense or grammatical aspect though the data from two experiments presented in this thesis may provide a clearer picture.

A study by Carreiras, Carriedo, Alonso, and Fernandez (1997) investigated the role of past and present tense in constraining the availability of information in discourse contexts. In this

research, they found that participants were faster to respond to a word for an occupation (e.g., *economist*) when it was associated with the protagonist in the story and the sentence about the protagonist's occupation occurred in the present (e.g., *Now she is an economist.*) than in the past (e.g., *Sometime in the past she worked as an economist.*). These results support the hypothesis that availability in a situation model is constrained by tense. Note that at this time no study on a manipulation of tense in discourse processing has been published using ERP methods. Thus the electrophysiological correlates of processing language as function of tense are unknown.

Event Semantics

Event syntax plays a role in constraining the availability of information in situation models, but it is not the only way that people can express temporal dimensions, such as durativity and event boundaries in language. Intrinsic properties of the verb that are not morphologically marked, can also affect the availability. The following subsections briefly describe research on two areas of event semantics: lexical aspect and time shifts.

Lexical Aspect. Verbs have intrinsic temporal properties that are not morphologically marked as with grammatical aspect and tense. For instance, "turning on the radio" is relatively instantaneous, reaching its endpoint as soon as it begins. *Drinking a coffee* can take several minutes, and progresses steadily towards a natural endpoint, whereas *listening to music* has no inherent endpoint. Thus it can endure indefinitely, and until one decides to terminate the activity, it never gets any closer to being finished. These examples highlight the differences between classes of lexical aspect, treating the temporal structure of situations in terms of duration and endpoint status. *Drinking a coffee* is an example of an accomplishment, whereas *listening to music* is an activity (Vendler, 1967). We contrast these two types of events in the present thesis.

Recently, Baggio, van Lambalgen, and Hagoort (2008) used ERP methodology to

investigate the influence of lexical aspect on syntactic re-analysis in situation models. Dutch participants were asked to read short stories in Dutch where the researcher manipulated activities or accomplishments that were also either neutral or disabled. Neutral conditions did not bring the activities or accomplishments to a definite endpoint unnaturally (e.g., *She was writing a letter when her friend spilled coffee on the tablecloth.*), whereas the disabling condition did (e.g., *She was writing a letter when her friend spilled coffee on the paper.*). Their results demonstrated a sustained anterior negativity for disabled accomplishments at the sentence-final verb, but not for neutral accomplishments. Furthermore, no differences were found between neutral or disabled activities. Sustained anterior negativities are known to index differences in text integration difficulty as a result of semantic and syntactic reanalysis (King & Kutas, 1995; Münte, Schiltz, & Kutas, 1998). Thus, differences in lexical aspect can constrain the ease of integrating a word/concept back into the reader's situation model.

Time Shifts (or event duration). Time shifts are also an intrinsic property of events. Either a long time shift (e.g., *Rachel weeded the garden.*) or a short time shift (e.g., *Rachel picked a tomato.*) can move along the narrative's timeline and significantly affect the availability of the event preceding them. For example, Kelter et al. (2004) investigated whether a short or long duration time shift in an ongoing situation model would affect the accessibility of objects in the situation model. As a second manipulation they either added the long/short duration time shift to the end of the critical sentence (e.g., *for an hour/six hours)*, or they started the subsequent sentence with the adverbial phrase (*After one hour/six hours*). Whereas the temporal modifiers *After one hour/six hours* announce a time shift but do not lead the reader through an event with a specific duration, temporal modifiers such as *for an hour/six hours* do, and readers process the event's duration. These differences have important implications for accounts of situation models.

The dynamic narrative model (Kelter et al.) predicts that durative statements allow the reader to *track* the narrative and give the reader an experience of an ongoing situation, and thus foregrounding the information in that sentence and making it more accessible. In contrast, the adverbial phrase at the beginning of the sentence, *After an hour/six hours* draws the attention of the reader to another type of time shift (i.e., a fresh start), where the event is beginning anew. Kelter et al. found that, consistent with their own account (a dynamic view), participants had more difficulty accessing information about events that preceded a long duration than a short duration. Although event semantics (intrinsic properties of the verb) affect availability, sentence-initial adverbial phrases had no effect. They contrasted the dynamic narrative approach with the event indexing model (Zwaan et al., 1995). The event indexing model would have predicted that fresh starts would also have an effect due to the time shift, and that the model would create a new instance of the situation model based on the sentence-initial adverbial phrase. However, these data indicate the static representations of situation models may not be accurate.

Electrophysiological evidence also supports the claim that time shifts affect situation models. Ditman, Holcomb, and Kuperberg (2008) measured ERPs when a participant read a target noun phrase (e.g., *the child)* in a sentence following its first mention *Kelly scolded the child.* They used sentence-initial temporal adverbials *After one second/hour/year* to investigate the brain's response to response to a short, medium, and long time shift. Their results indicated that N400 amplitudes were more negative if the target word followed a long duration time shift than a short time shift. Although these results were framed as being consistent with the event indexing model, they do appear to be inconsistent with the data from Kelter et al. (2004) who found no difference in reading times for targets which appeared for the second time in sentences with sentence-initial temporal adverbial phrases (i.e., non-durative time shifts). Thus, the

evidence that time shifts do constrain situation models is consistent, but the type of time shift (i.e., durative versus sentence-initial adverbial) and how it is manipulated can affect the results.

The Syntax-Semantics Interface

Piñango, Zurif, and Jackendoff (1999) proposed the model of the Syntax-Semantics Interface, which focused on the problem of verb aspect coercion. Verb aspect coercion is similar to the manipulation used by Baggio et al. (2008) where some activities were disabled, or brought to an endpoint, where they usually have no definite endpoint. Instead of using the term disabled, Piñango et al. suggested that verb aspect can be *coerced* into an endpoint when it usually goes on indefinitely (in the case of activities) or can be coerced into a feeling of continuation for accomplishments which have definite endpoints. For example, the following two sentences show the difference between what Piñango et al. call either a semantically transparent interpretation or one that is coerced:

(4) a. The girl slept until dawn.

(4) b. The girl jumped until dawn.

Sleeping is an activity that does not have a definite endpoint (4a), but can be modified by the temporal preposition *until dawn*. Modifying the activity in this way does not coerce the activity to terminate prematurely (or disable it, to use Baggio et al.'s term). It is semantically transparent according to Piñango et al. (1999). However, the accomplishment *jump* has a definite endpoint, but has been modified by the prepositional phrase *until dawn* such that it must repeat in the readers mind in order to continue on to the time frame stated in the preposition. Thus, it has been coerced by the prepositional phrase that creates a need for mentally filling in the iterativity of *jumping* in order for it to last until dawn. In the case of coerced accomplishments take the following example:

(5) The man died until dawn.

Clearly dying is an accomplishment, not in the sense of something one would win an award, but in the sense of having a definite endpoint. And in this case the preposition *until dawn* modifies the accomplishment to repeat, but the verb does not allow itself to repeat. Thus, example 5 is different from 4b in that the coercion of *dying* to repeat causes a violation of the iteratibility constraint according to Piñango et al., and is ungrammatical.

Yap et al. (2009) also investigated verb aspect interactions by crossing lexical aspect with grammatical aspect. They hypothesized that lexical and grammatical aspect would interact such that a mismatch between the ongoing/completed grammatical aspect markers and the intrinsic lexical aspect properties of activities and accomplishments would result in processing difficulty compared to matching event properties. In order to test the hypothesis, they designed a sentence-picture-matching experiment where participants heard a sentence that varied by lexical aspect (accomplishments versus activities) and grammatical aspect (perfective versus imperfective). Participants then saw either a picture that matched the event as described in the sentence or mismatched, and had to indicate as quickly as possible whether the pictures matched. For accomplishments, participants judged matching sentence-picture pairs faster when they were presented in the perfective than in the imperfective. Conversely, for activities participants judged matching sentence-picture pairs faster when they were presented in the imperfective than in the perfective. Thus, consistency/inconsistency between grammatical aspect and lexical aspect can influence the ease in interpreting events.

The present study

The present study is the first to investigate the interactions between tense, grammatical aspect, lexical aspect, and time shifts on the availability of discourse concepts in situation

models. Experiment 1 (E1) investigated the interaction between tense, grammatical aspect, and lexical aspect. Experiment 2 (E2) investigated the interaction between grammatical aspect, lexical aspect, and time shifts. Based on the research reviewed above, predictions were generated for the possible interactions among the three variables and these predictions are portrayed in Tables 1a and 1b for E1 and Tables 2a and 2b for E2. The darker circles represent a shift in attention from the event to the resultant state and to the next piece of information in the story, and the event is being moved to the background. Thus, darker circles mean that we predict a larger N400 component would be elicited to anaphors due to reduced availability.

Experiment 1 predictions. Based on the findings of Magliano and Schleich (2000), who also investigated accomplishments, the prediction for grammatical aspect in the past tense was that targets initially presented in a perfective antecedent sentence would elicit a larger N400 than targets initially presented in an imperfective sentence (as shown in the left column of Table 1a). As a result of the findings of Carreiras et al. (1997), we expect target availability to be greatest when it is initially presented in the present tense. However, the combination of present tense and grammatical aspect has not been investigated and it is thus not certain what can be predicted with respect to the present tense. One possibility is that the present tense may not result in any additional benefit than what is found with imperfective aspect. In this case, we expect the present tense results to mirror the past tense results whereby imperfective aspect (e.g., *is calculating*) makes the target more available for later integration than perfective aspect (e.g., *calculates*). Alternatively, if there is an additive effect of tense and grammatical aspect, then it is possible that N400 amplitudes elicited to targets may be the smallest for all conditions when they initially appear in present tense sentences with imperfective aspect.

The prediction for activities was similar to accomplishments (see Table 1b). However, we

expect that the intrinsic property of activities of not having natural endpoints may decrease the impact of tense and grammatical aspect.

Experiment 1

In E1, we investigated the brain's response to variations in grammatical aspect, tense, and lexical aspect in discourse. We measured evoked potentials that were time-locked to the onset of a target word that was reintroduced two sentences later after it had originally appeared in the antecedent sentence.

Method

Participants

Fifty-two participants (19 male; median age 19) from Wilfrid Laurier University took part for partial fulfillment of course credit or monetary compensation. In both experiments reported below, all participants were native English speakers, had normal or corrected vision, and were right-handed.

Materials

In total, 124 stories (104 critical stories and 20 fillers) were used in E1. After a few brief introductory sentences where the main character was introduced by a proper name and some context was in place, a critical sentence followed where an event (an activity or accomplishment) was described in the imperfective or perfect aspect and in present or past tense. This was the sentence containing the antecedent; a target which was referred to later. Then two filler sentences followed the antecedent sentence. Care was taken as to not shift the narrative timeline with the filler sentences. The next sentence contained the target word that previously appeared in the critical antecedent sentence. This target appeared at the same sentence location for each story - the 5th word. This sentence was followed by a wrap-up sentence (See Tables 3 and 4 for

examples of passages with accomplishments and activities). At the end of each passage, participants answered basic comprehension questions that were designed to make sure they were paying attention to the text. The stories were equally counterbalanced over four lists. In order to control or ordering and fatigue-related effects, four randomly ordered lists were created for all of the stories and then reversed-orders of those lists were also created to make 8 lists in total.

Procedure

Participants sat in a darkened and electronically-shielded chamber. They sat approximately 60 centimeters away from an IBM monitor, and read stories where the words were presented in white Courier New font on a black background. The introductory sentences were presented in the center of the screen in full, and participants pressed a button on the button box in front of them to advance to the next sentence. After the participants read the critical verb aspect sentence, sentence presentation changed to fixed serial presentation format and they no longer were required to press a button to advance to the next sentence. Each word was presented with a 500 ms stimulus-onset asynchrony (i.e., the word was displayed on the screen for 300 ms and followed by a 200 ms interstimulus interval). After each sentence there was a two second delay and five plus signs appeared on the screen as a cue for the participant to blink, as blinks during the presentation of the target word would result in the recording being rejected from analysis. Following the end of the story a comprehension comment was displayed and the participant was to respond by pressing a button marked "Yes" to indicate that the comment was consistent with the story or "No" if it was not.

Electroencephalogram (EEG) recording and analysis. EEG was recorded from 64 electrodes distributed evenly over the scalp. 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 5KΩ. EEG was processed through a Neuroscan Synamps2 amplifier set at a bandpass of 0.05 - 100 Hz, and digitized at 250 Hz.

Design

E1 was a 2 X 2 X 2 X 62 repeated-measures design. The main variables of interest were grammatical aspect (perfective versus imperfective), lexical aspect (accomplishment versus activities), tense (past versus present) and electrode site. In addition, list was used as a between participant factor to stabilize any variance caused by rotating participants across the different lists (Pollatsek & Well, 1995). In order to simplify the analysis, we conducted separate 3-way ANOVAs for Accomplishments and Activities on the mean amplitudes at the N400 region (300-500 ms) and Late Component region (600 - 1000 ms).

Results

Data were 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 target words to 1000 ms after their onset. Trials contaminated by blinks, eye-movements, and excessive muscle activity were rejected off-line before averaging. Amplitudes of greater than ±75 μV were rejected before averaging; a total of 23% of trials were lost due to such artifacts. Figure 2 shows the mean amplitudes at a frontal and central electrode located down the midline of the head.

Accomplishments

300 – 500 ms (N400 component). There was a significant main effect of grammatical aspect. Mean amplitudes for target words that were originally presented in perfective sentences were more negative (M = 0.73 μV) than when they were presented in imperfective sentences (M = 1.19 μV), $F(1, 48) = 4.03$, $p = .05$; See Figure 3).

600 – 1000 ms (late component). There was a significant main effect of grammatical aspect which reflected the continuation of the N400 effect into the late component region. Mean amplitudes for target words that were originally presented in perfective sentences were more negative ($M = 0.52$ μV) than when they were presented in imperfective sentences ($M = 1.25$ μV), $F(1, 48) = 6.72$, $p < .02$).

Activities

300-500 ms (N400 component). There were no significant main effects or interactions in this region for any factors of interest (See Figure 4).

600 – 1000 ms (Late components). There were no significant main effects or interactions in this region for any factors of interest.

Discussion

The main finding of the present experiment was that mean amplitudes in the N400 and late component region were more negative for target words that were originally presented in perfective than imperfective sentences, but this difference was only observed for antecedent sentences that contained accomplishments. These results are consistent with previous research demonstrating an advantage in availability of event information over subsequent discourse when that information is initially presented with imperfective than perfective aspect (Magliano & Schleich, 2000). The present findings extend this research by showing how the brain responds to this imperfective advantage, and by demonstrating that it is not found with activities. One possible reason for this finding is that whereas activities do not have natural end points, accomplishments do. Inflecting accomplishment events with imperfective aspect may be more of a benefit (in terms of availability of event contents) relative to perfective aspect, whereas for activities there is no natural endpoint and thus the advantage gained by imperfective aspect over

perfective aspect is less.

A second important finding is that unlike previous research by Carreiras et al. (1997), there was no statistically reliable differences to suggest that verb tense had an influence on availability of event information over the discourse passages. There was no main effect or interactions that involved tense, which also held true for both accomplishments and activities. At this point, it is not clear why tense did not have an influence, but it appears that grammatical and lexical aspect play a larger role in modulating the availability of event information in discourse.

Experiment 2

In Experiment 2 we build upon the results of Experiment 1 by examining the influence of short versus long time shifts for the past tense form of accomplishments and activities. The predictions are broken down for accomplishments in Table 2a and activities in Table 2b. Following Kelter et al.'s (2004) demonstration that target events are accessed more easily when probed after short intervening events than after long intervening events, we expect to replicate this effect, with stronger effects for target events in the imperfective than perfective aspect, as imperfective aspect leaves the event more open/ongoing and thus more available in general. The past tense results of Experiment 1 demonstrated an advantage in availability for event information when presented initially with imperfective than perfective aspect, but this was only true for accomplishments. Thus, we do not expect to find an advantage in the present experiment for information associated with imperfective activities over perfective activities, and this should be true regardless of short or long time shifts. Alternatively, we do expect to find an advantage for the availability of information associated with imperfective accomplishments, at least at short time shifts. At long time shifts, it is not clear whether this advantage will persist or if moving the time line much further along will dissipate the availability of antecedent event information.

However, based on the findings of previous researchers that manipulated time-shifts but not grammatical or lexical aspect (e.g., Ditman et al., 2008; Kelter et al., 2004), the imperfective advantage may only be limited to short time shifts.

Method

Participants

Fifty-two participants (21 male; median age 19) from Wilfrid Laurier University participated for partial fulfillment of course credit or monetary compensation.

Materials

The same materials used in Experiment 1 were used in Experiment 2, with two exceptions. First, all passages were presented in past tense form. Second, instead of two filler sentences between the first and second presentation of the target word, the first presentation was immediately followed by short/long duration time shift, and then a filler sentence that did not move the time-line along. See Tables 5 and 6 for examples of accomplishment and activity passages.

In order to ensure that the intervening events were indeed short or long, we conducted a norming study in which 11 participants provided estimates for how long the short and long events typically take to occur from beginning to end. In this norming study, all events were distributed across two lists such that participants estimated the duration of the short or long event for each passage. They estimated the duration by writing down a number for hours, minutes, and seconds. The results of this norming study indicated that short events (M = 5.57 minutes) were indeed estimated to be shorter than the long events (M = 3 hrs), $t(11) = 3.45$; $p < 0.01$.

Procedure and EEG recording and analysis

The procedure and EEG recording and analyses were identical to Experiment 1.

Design

E2 was a 2 X 2 X 2 X 62 repeated-measures design. The main variables of interest were grammatical aspect (perfective versus imperfective), lexical aspect (accomplishment versus activities), time-shift (long versus short) and electrode site. These variables were all within-participant variables. In addition, list was used as a between participant factor to stabilize any variance caused by rotating participants across the different lists. Similar to Experiment 1, we conducted separate 3-way ANOVAs for Accomplishments and Activities on the mean amplitudes at the N400 region (300-500 ms) and Late Component region (600-1000 ms).

Results

Data were 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 target words to 1000 ms after their onset. Trials contaminated by blinks, eye-movements, and excessive muscle activity were rejected off-line before averaging. The same rejection criteria employed in Experiment 1 was employed in Experiment 2; a total of 20% of trials were lost due to such artifacts. Figure 6 shows the mean amplitudes at selected electrodes from all regions of the head.

Accomplishments

300 – 500 ms (N400 component). The grammatical aspect by duration interaction was significant, $F(1, 48) = 4.94$, $p = 0.03$). Following a short time shift, mean N400 amplitudes for target words presented in perfective antecedent sentences were more negative than targets presented in imperfective antecedent sentences, $F(1, 48) = 5.32$, $p < 0.03$; (See Figure 6). Alternatively, following long time shifts N400 amplitudes for target words did not vary as a function of verb aspect, $p > 0.1$. No other effects were significant.

600-1000 ms (Late Positivity Components). There were no significant main effects or interactions in this region.

Activities

300 – 500 ms (N400 component). There were no significant main effects or interactions in this region (See Figure 7).

600-1000 ms (Late Components). There were no significant main effects or interactions in this region.

Discussion

The ERP results of E2 replicate and extend the findings of Experiment 1. When there were intervening sentences with short time shifts, an advantage in availability of targets was found when they appeared in imperfective as opposed to perfective antecedent sentences, and this effect was again only found for accomplishments. After long time shifts, N400 amplitudes did not vary as a function of grammatical aspect for either accomplishments or activities. In the late component region, the imperfective advantage for accomplishments was smaller and did not reach significance as it did in E1.

These results suggest that although there was still an availability advantage for targets initially presented in imperfective accomplishments, as shown by N400 amplitudes, readers had relatively similar difficulty in updating their situation models with the target information (as shown in the late component region). Thus, adding a short time shift appears to not remove the imperfective availability advantage, but it does appear to lessen the advantage seen in Experiment 1 for integrating the target concepts into situation models. In contrast, the long-time shifts move the narrative timeline too far forward to see an advantage as a result of grammatical aspect. In this regard, the present findings are consistent with recent findings suggesting

information becomes less available after long time shift than after short time shifts (Ditman et al., 2008; Kelter et al., 2004). Here we extend those findings by showing that this difference is modulated by grammatical and lexical aspect.

General Discussion

Each temporal dimension manipulated in this thesis had a factor level that should have either increased or decreased the availability of the target. The results of these two experiments suggest that some factors are more robust than others, and possibly that the interaction among factor levels both thought to increase the availability of the target may not be an additive relationship (e.g., present tense, imperfective grammatical aspect, and activities). For example, past tense could have made the event less available than the present tense, however, tense did not significantly factor into our results. On the other hand, grammatical aspect was found to have a more robust influence on the availability of discourse concepts. Specifically, we found evidence in both experiments that imperfective aspect acted to keep the target available for later processing, whereas perfective aspect acted to background the target.

An important finding of the present results was that event syntax and event semantics interacted to constrain the availability of information in situation models. Specifically, imperfective aspect was only a benefit to the availability of event information when the antecedent sentences contained accomplishments. Across two experiments we found that both grammatical aspect and tense had no influence on the availability of event information when the antecedent sentences contained accomplishments. This interaction between grammatical and lexical aspect is a novel finding and more research will be necessary to clarify the nature of the interaction. However, the main difference between accomplishments and activities is that the former have temporal end points whereas the latter do not. As discussed above, one possibility is

that accomplishments benefit more from being left open/ongoing, as they otherwise would run to completion, whereas activities would not.

E2 provided further insight into the availability advantage for imperfective accomplishments by demonstrating temporal shifts in the narrative time line modulated the advantage. Specifically, the advantage was only found following short time shifts. This finding is presumably due to the fact that the events are more likely to be still ongoing at the later time point in the story when the intervening event was short than when it was long (Ditman et al., 2008; Kelter et al., 2004).

Implications for Theories of Situation Models

The present research contributes to the knowledge of how the temporal aspects of language and events constrain situation model construction – something currently not understood despite its critical importance to language comprehension. The results from E1 and E2 are consistent with a situational availability account (Barsalou & Weimer-Hastings, 2005) and also a dynamic account (Kelter et al., 2004) of the updating and maintaining of information as discourse is processed. First, the situation availability account suggests that abstract concepts such as the word/concept TIME make situational information available such as the sights and sounds of an event, and these experiments show that temporal properties have the same effect in that "ongoingness" and duration are understood through experience with the external world and not through the activation and overlap of propositional nodes as with the Construction Integration Model (Kintsch, 1988). If the latter were true then differences between verb aspects would not matter. Second, the dynamic model explains how continuous tracking of the current situation model, guided by event syntax, affects situation model construction. For example, the results from E1 and E2 are similar in that the difference between how the perfective and

imperfective aspect constrain the availability of information is only for accomplishments and not activities. But there is one important difference that may be a clue to the process of shifting. In E1, targets initially presented in perfective accomplishments were more negative than their imperfective counterparts at both the N400 region and the late component region, whereas in E2 this difference was only found in the N400 region. This may mean that there is a gradient of shifting with respect to other temporal cues. Thus, the effects of verb aspect are strongest when there are no shifts, less strong when there is a short shift, and no difference following a long time shift. A temporal gradient of the availability of information is distinctly different from the shifting process suggested by the Structure Building Framework (Gernsbacher, 1990) or the Event Indexing Model (Zwaan et al., 1995). In both of the latter approaches to shifting, the shift occurs in a static, all-or-none, fashion.

Critics of the dynamic view may ask, *What is the mechanism?* The answer thus far, based on previous research, is working memory. Magliano and Schleich (2000) have made it clear that imperfective aspect functions to maintain information in working memory, whereas perfective backgrounds it. Ferretti et al (2007) manipulated grammatical aspect and found that slow cortical potentials, which are known to be sensitive working memory constraints, were modulated by verb aspect. Here we extend this body of research by showing the interactions between lexical and grammatical aspect, and how long time shifts can reduce their effects.

Not only do these experiments add to the literature on the electrophysiological measures of discourse processing, but they are also an extension to the literature on coreferential processing. Recall from the introduction that Burkhardt and Roehm (2007) found that saliency manipulations (i.e., repeated-noun phrases) did not reduce N400 amplitudes. They showed that the saliency of antecedents had no impact on later coreferential processing with repeated

concepts, just concepts that were bridged through more detailed inferencing processing. However, the results presented in this thesis show how aspect influences the saliency or availability for antecedents and modulated N400 amplitudes for repeated concepts in discourse. Thus, Burkhardt and Rhoem's findings do not hold for all saliency manipulations, in particular manipulations that involve verb aspect. Further research is needed to explore and clarify this inconsistency.

The understanding of the temporal dimension of situation models is still unclear. However, these experiments suggest that the interplay between event syntax and event semantics is a fruitful avenue of research into providing a better understanding of how information is maintained and kept available. The availability of events for later recall is important to the transfer of knowledge about procedures such as making wine. How people understand time as change is an integral part of communication as well as general cognition.

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Table 1a.

Predictions for Experiment 1: Accomplishments and Event Syntax on Situational Availability. Note that darker circles mean that attention is shifting from the event to the resultant state and to the next piece of information in the story, and the event is being moved to the background. The darker the circles entail a prediction that anaphors should elicit greater N400 amplitudes.

		Tense	
		Past	Present
Grammatical Aspect	Perfective		
	Imperfective		

Table 1b.

Predictions for Experiment 1: Activities and Event Syntax on Situational Availability. Note that darker circles mean that attention is shifting from the event to the resultant state and to the next piece of information in the story, and the event is being moved to the background. The darker the circles entail a prediction that anaphors should elicit greater N400 amplitudes.

		Tense	
		Past	Present
Grammatical Aspect	Perfective		
	Imperfective		

Table 2a.

The Predictions for Experiment 2: Accomplishments, Grammatical Aspect, and Time Shifts. Note that darker circles mean that attention is shifting from the event to the resultant state and to the next piece of information in the story, and the event is being moved to the background. The darker the circles entail a prediction that anaphors should elicit greater N400 amplitudes.

		Time Shifts	
		Short	Long
Grammatical Aspect	Perfective		
	Imperfective		

Table 2b.

The Predictions for Experiment 2: Activities, Grammatical Aspect, and Time Shifts. Note that darker circles mean that attention is shifting from the event to the resultant state and to the next piece of information in the story, and the event is being moved to the background. The darker the circles entail a prediction that anaphors should elicit greater N400 amplitudes.

		Time Shifts	
		Short	Long
Grammatical Aspect	Perfective		
	Imperfective		

Table 3. A present tense story from E1 where the critical antecedent sentence is an accomplishment.

Sentence type	*The sentence*
Context sentence	*Amy gets home before her parents one Saturday night.*
Context sentence	*She is surprised that they aren't home yet.*
Context sentence	*She lets herself inside and gets changed into her pajamas.*
Critical tense/aspectual sentence	*Amy leaves/is leaving a message on her mother's voicemail asking where they are.*
Intervening sentence	*Her pajamas are warm.*
Context sentence	*They are just out of the dryer.*
Sentence containing target word (in bold)	*She thinks about the* ***message*** *and wonders if her mother got it.*
Context sentence	*Amy feels like she's the parent and they are the kids tonight.*
	<1000ms pause>
Comprehension question (answer)	*Amy expected her parents to be home when she got there. (yes)*

Table 4. A present tense story from E1 where the critical antecedent sentence is an activity.

Sentence type	*The sentence*
Context sentence	*Tim books an appointment with his hairstylist, Susan.*
Context sentence	*When he arrives, she smiles and shows him to his chair.*
Context sentence	*She asks him how things are going as she washes his hair.*
Critical tense/aspectual sentence	*Susan talks/is talking about her divorce.*
Intervening sentence	*He likes getting his hair washed.*
Context sentence	*Tim feels comfortable with this hairstylist.*
Sentence containing target word (in bold)	*He thinks about her* ***divorce*** *and wonders if he should ask her out.*
Context sentence	*At least he knows she would like his haircut.*
	<1000ms pause>
Comprehension question (answer)	*Tim hates going to the hairstylist. (no)*

Table 5. A past tense story from E2 where the critical antecedent sentence is an accomplishment.

Sentence type	*The sentence*
Context sentence	*Joanna was going back to school and needed some financial help.*
Context sentence	*She decided she would have to take out a loan for a few years.*
Context sentence	*The loan advisor at the bank around the corner made her the best offer.*
Critical tense/aspectual sentence	*He calculated/was calculating the interest for her loan.*
Critical short duration sentence	*She signed one of the forms for the loan.*
Critical long duration sentence	*She studied all of the forms for the loan.*
Context sentence	*Joanna had chosen a five-year loan.*
Sentence containing target word (in bold)	*She thought about the* ***interest*** *and how she would hate paying it back.*
Context sentence	*She knew that it was the only means to reach her goals, so she would find a way.*
	<1000ms pause>
Comprehension question (answer)	*Joanna could easily afford school without a loan. (no)*

Table 6. A past tense story from E2 where the critical antecedent sentence is an activity.

Sentence type	*The sentence*
Context sentence	*Rachel and Eric had a large garden in their backyard.*
Context sentence	*They loved vegetables so they grew several varieties.*
Context sentence	*Rachel went outside to water the vegetables.*
Critical tense/aspectual sentence	*She watched/was watching a rabbit in the garden.*
Critical short duration sentence	*She picked a tomato.*
Critical long duration sentence	*She weeded the garden.*
Context sentence	*She wondered why there was so much rain that year.*
Sentence containing target word (in bold)	*She thought about the* ***rabbit*** *and how it probably enjoyed the leafy vegetables.*
Context sentence	*Eric and Rachel had been trying to get rid of that rabbit for weeks.*
	<1000ms pause>
Comprehension question (answer)	*Rachel disliked vegetables. (no)*

Figure Captions:

Figure 1. A depiction of the availability of information for a perfective sentence versus an imperfective sentence.

Figure 2. Grand averages at one frontal (Fz) and central (Cz) electrode for Experiment 1.

Figure 3. Grand averages at one frontal (Fz) and central (Cz) electrode for Experiment 1 for only accomplishments.

Figure 4. Grand averages at one frontal (Fz) and central (Cz) electrode for Experiment 1 for only activities.

Figure 5. Grand averages at one frontal (Fz) and central (Cz) electrode for Experiment 2.

Figure 6. Grand averages at one frontal (Fz) and central (Cz) electrode for Experiment 2 for only accomplishments.

Figure 7. Grand averages at one frontal (Fz) and central (Cz) electrode for Experiment 2 for only activities.

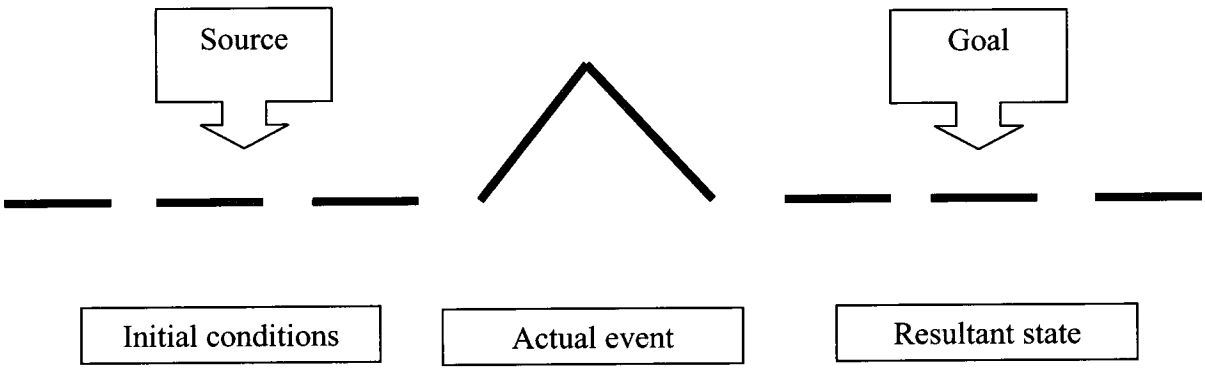

Figure 1.

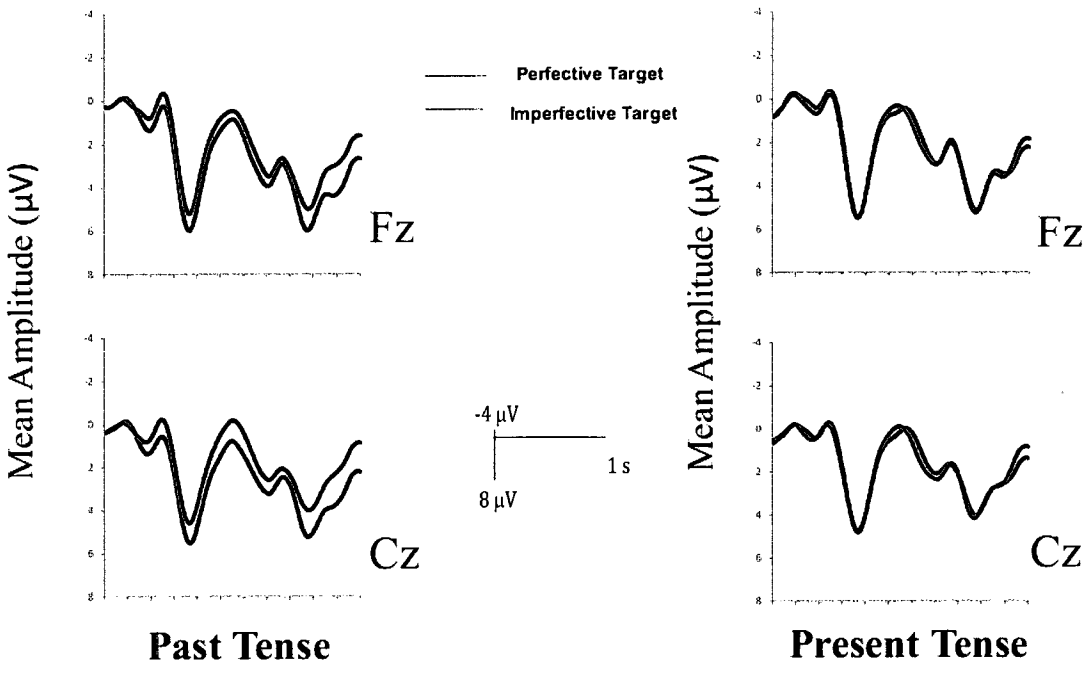

Figure 2.

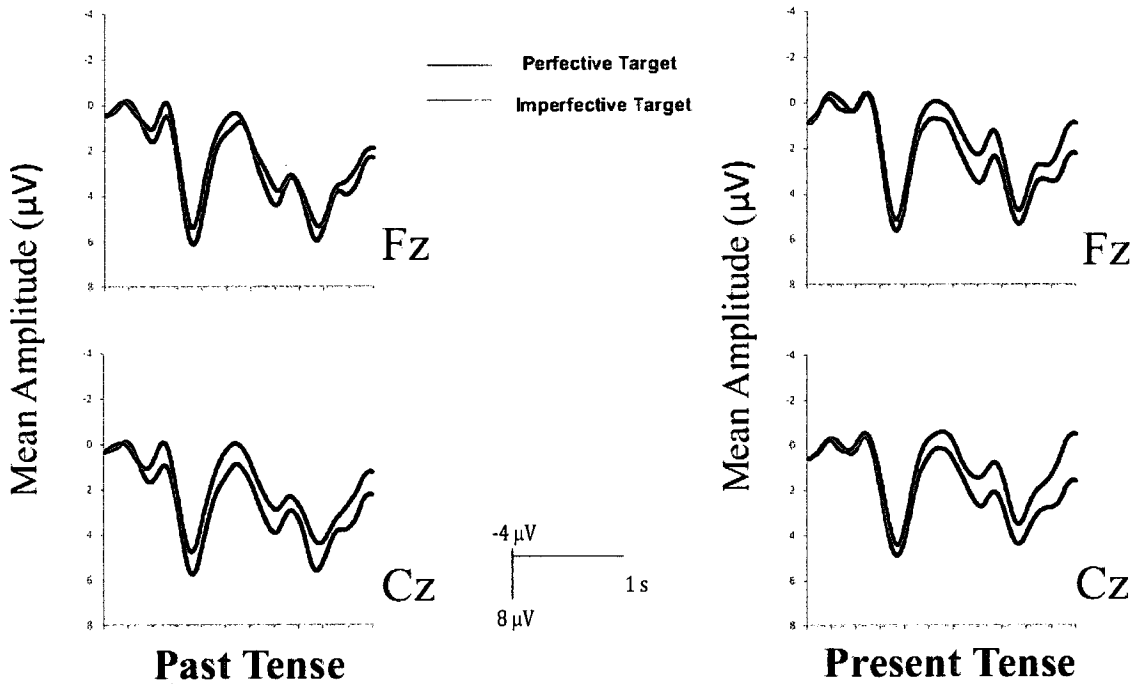

Figure 3.

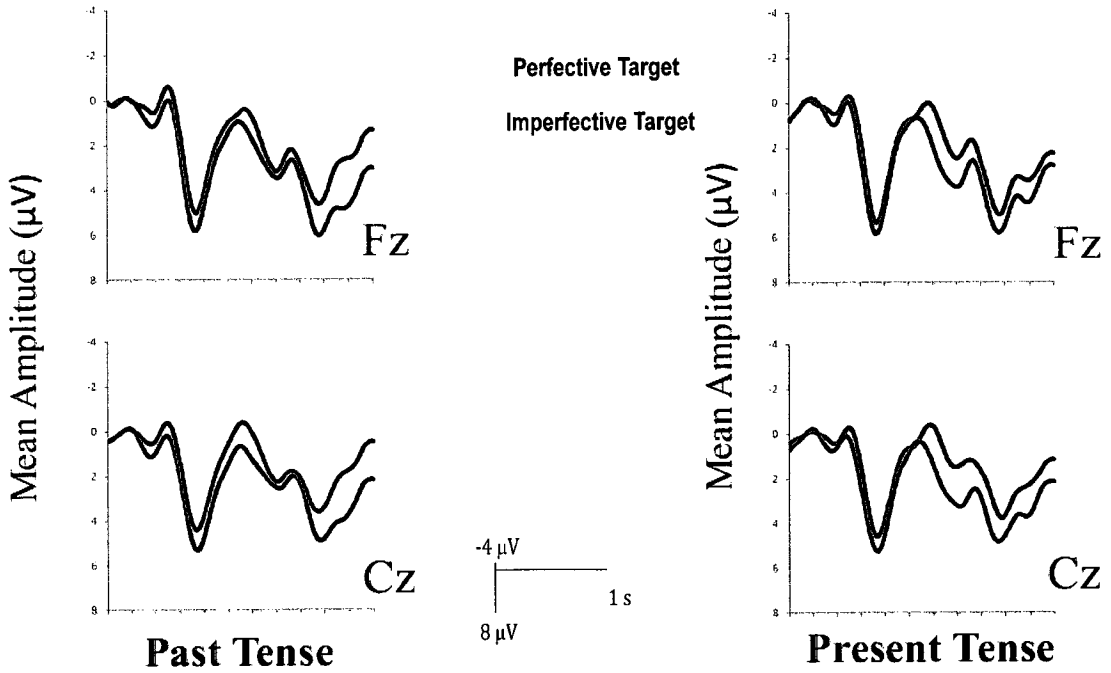

Figure 4.

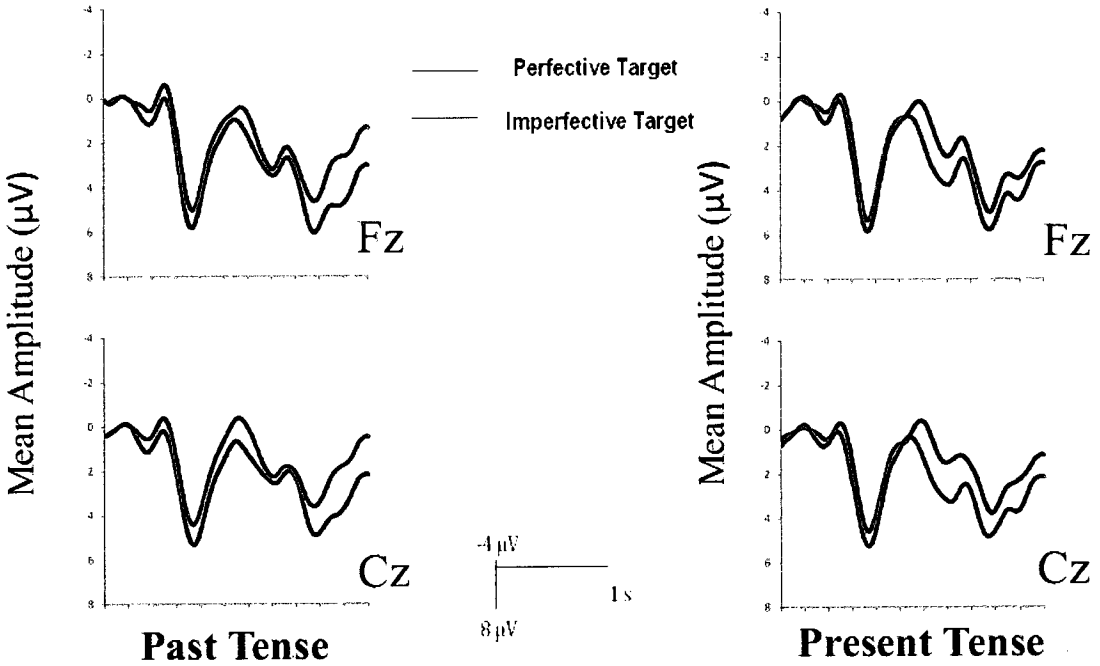

Figure 4.

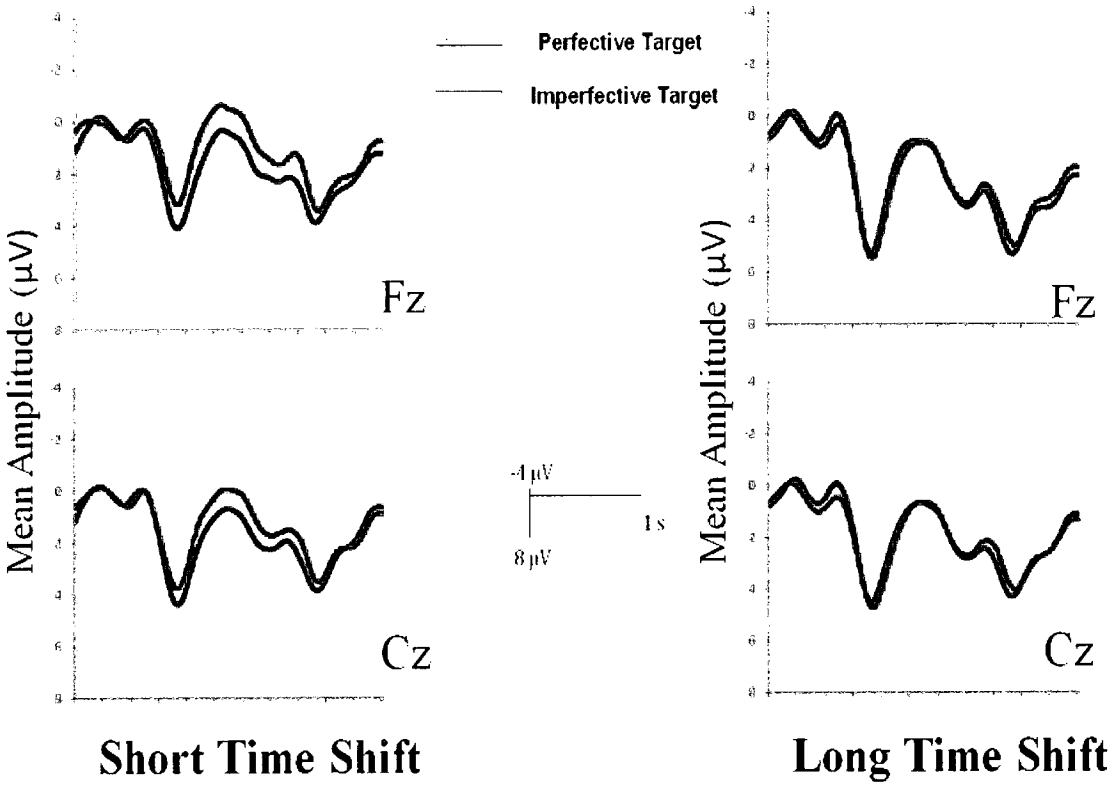

Figure 5.

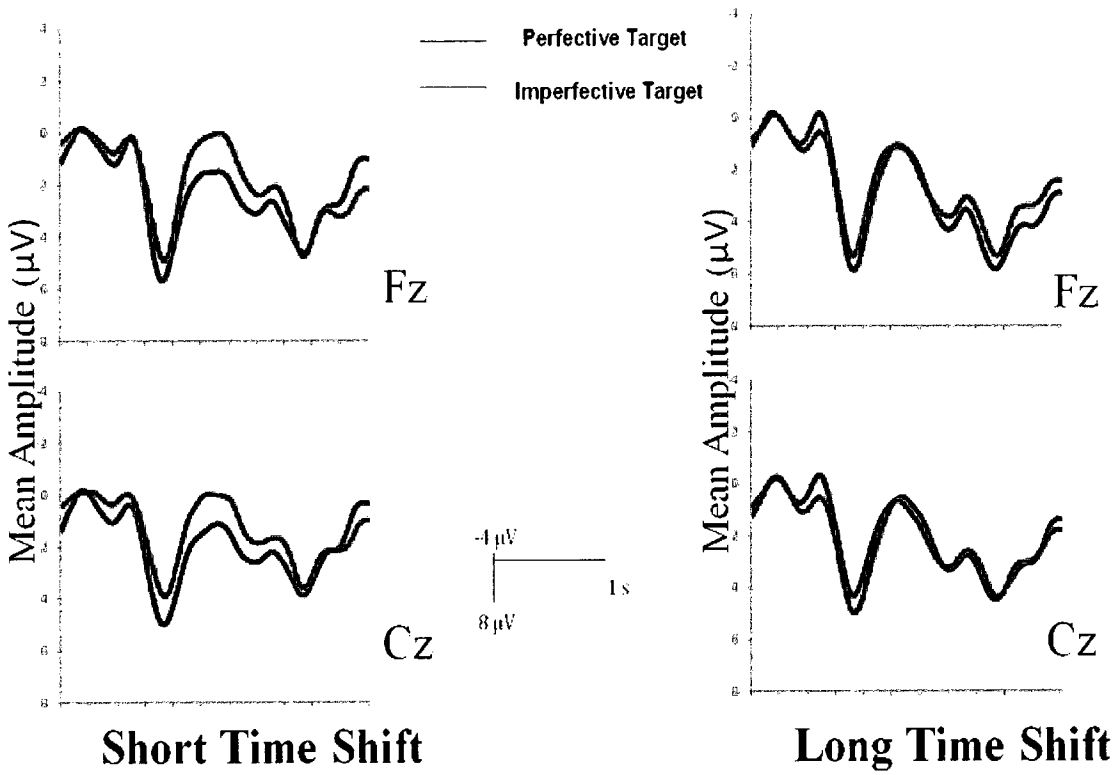

Figure 6.