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Investigating the Influence of Grammatical Aspect on Eye-Movements

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Abstract

People's ability to understand language is influenced by numerous factors, one of which is grammatical aspect. The present study focused on whether hearing the imperfective aspect ("The man was slicing the vegetables"; ongoing action) versus the perfective aspect ("The man had sliced the vegetables"; completed action) affects the activation of the mental representation of an outcome (e.g., a sliced carrot) and of the instrument used for a specific action (e.g., a knife for slicing). We conducted a visual-world paradigm eye-tracking study to investigate moment-by-moment language understanding (Heuttig et al., 2011). Participants listened to sentences such as those above while viewing four pictures on a computer screen. Each trial contained one picture depicting the instrument employed for the action mentioned in the sentence (a knife), one depicting the patient that is being acted upon (a carrot), and two unrelated distractors (a basket and a present). We measured the time course of participants' eye-movements to the pictures, as well as the duration of their fixations. Overall there was an increase in looks to the instruments for the imperfective over the perfective in the time period between the verb and the noun. However, there was not an increase in looks to the patient in the perfective over the imperfective. Our results demonstrate that people are sensitive to grammatical aspect as a sentence unfolds, including as the verb is being heard. This suggests that aspect dynamically influences how people interpret and process events.

Keywords: grammatical aspect, sentence comprehension, eye-tracking, visual-world paradigm

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Introduction

To organize and understand the continuous stream of information from our surrounding world, humans classify objects (e.g., tables), entities (e.g., types of animals and people), and locations (places such as kitchens) into sets or categories. Classification enables inferences and predictions about our behavior and the behavior of others (Murphy, 2002). In addition, objects, entities and locations serve as components of events. As stated by Radvansky and Zacks (2001), "We perceive events when we observe the world unfolding around us, participate in events when we act on the world, simulate events that we hear or read about, and use our knowledge of events to solve problems" (p. 02). In other words, humans segment the ongoing activity around them into specific, discrete events (Zacks, 2007). Learning about and processing events differs from categorizing objects and entities, in that events are more complex and have temporal contours and boundaries. Events having a specific beginning and end allows for (and sometimes necessitates) a particular classification (Zacks, 2001).

Consider a typical weekday morning. You may segment your morning into events such as showering, brushing your teeth, putting on makeup, and getting dressed. This may be followed by preparing breakfast, eating breakfast, and then driving to work. Experiencing similar sets of events over time enables the formation of generalized knowledge (akin to a prototype, in contrast to specific instances of events). This type of knowledge, including the temporal flow of events, and the objects, entities, and locations that tend to be involved, provides important information that we use every day. It assists us in breaking our days into specific elements as we evaluate what is happening, and we can relate these pieces back to one another or to elements from past experiences (Zacks,

2007). The term ‘event knowledge’ is used to refer to the collective information we possess regarding specific events that we have experienced, heard about, or studied so far in our lives. For example, we may remember the specific breakfast that we had this morning, but we can also draw on a general idea about the collective knowledge concerning what the event ‘breakfast’ generally entails. This knowledge accrues over our lifetime as we experience the world and how people, things, and places interact in various situations.

Event knowledge is important information that we use every day to fluidly and effortlessly process what is happening in our environment. As the interpreters of massive amounts of information, our job is to decide what information is important and relevant to whatever task is at hand. Therefore, when we attend to an event, our ability to perceive discrete pieces of information in the dynamic and continuous stream of information allows us to better understand and remember what is happening, and guides our interactions with our surroundings (Zacks, 2001). We rely on this information for experiencing an event first hand, interpreting images or words that represent them, and comprehending verbal descriptions of past or current situations.

Event knowledge plays an essential role in our ability to process and understand language quickly. The faster we can access meaning, the faster we can comprehend what is being spoken, and the easier it is to predict upcoming concepts and ideas (DeLong, Urbach, & Kutas, 2005). It has long been thought that the processes underlying our ability to comprehend spoken language and our ability to predict what might come next is heavily influenced by our event knowledge (Bransford & Johnson, 1972; Metusalem et

al., 2012; Sanford & Garrod, 1981; van Dijk & Kintsch, 1983). It is therefore a key concept to consider when studying language processing.

The present study investigates how people use event knowledge, with a specific focus on the temporal and causal nature of events when processing verbal information. In particular, this thesis investigates the event information triggered by different forms of grammatical aspect during a visual-world paradigm eye-tracking task. The remainder of this section consists of a brief outline of the specific event components that exist within an action-based event, followed by a description and some examples of how event knowledge is tied to language comprehension. Finally, there is a discussion of the temporal nature of events and its interaction with the temporal nature of language.

Event Components and Language Comprehension

Although there are many types of events, this thesis focuses on action events, which are of particular importance because they involve a specific interaction with the environment and contain particular event components of interest (Radvansky & Zacks, 2001). For example, take the sentence "The man washes the car outside with a sponge", as a sample action. The stated event components include the 'agent', which is the person or thing that is performing the action (in this example, 'the man'). The 'patient' refers to the object on which the action is being performed ('the car'). The 'instrument' is the item used to perform the action ('the sponge'). The 'location' refers to where the event is taking place ('outside'). Across events, specific components regularly co-occur, building upon our previous knowledge of interrelationships, until over time they become inherently tied to one another and can be processed more quickly. For example, the agent 'chef' could be closely tied to the patient 'vegetable', the location 'kitchen', and the

instrument ‘knife’ when thinking about cooking. These regularities across events and actions allow us to process scenarios at a much faster pace because we can predict what might be coming next.

Event components have played an integral role in language studies (particularly in the study of thematic roles), and they shed light on how we are able to use event knowledge to comprehend language and predict upcoming linguistic information. For example, Ferretti, McRae, and Hatherell (2001) investigated how verbs can prime event components such as agents, patients, and instruments. They found that a word denoting an action (a verb - e.g., to arrest) activates typical agents (e.g., cop), patients (e.g., criminal), and instruments (e.g., handcuffs) associated with the action. These findings demonstrate the strength of the predictive ties between components of events. Although only a few studies have investigated semantic priming for event components, they demonstrate the crucial role these components have in processing linguistic information (Ferretti et al., 2001; Ferretti et al., 2007; Matsuki, Chow, Hare, Elman, Scheepers, & McRae, 2011).

It seems intuitive that people use event knowledge both when describing a situation and when comprehending speech. Indeed, a great deal of research suggests that event knowledge is used rapidly during sentence comprehension (DeLong, Urbach, & Kutas, 2005; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Kamide, Altmann, & Heywood, 2003; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Van Berkum, Brown, Zwitserlood, Kooijman, & Hagoort, 2005; Vu, Kellas, Petersen, & Metcalf, 2003). For example, Matsuki et al. (2011) examined whether event knowledge can influence language understanding, specifically focusing on how instruments combine with actions

to influence the ease with which other event components can be understood. Triplets of words containing related instruments (e.g., shampoo), actions (e.g., wash), and patients (e.g., hair) were used to create sentences for self-paced reading and eye-tracking experiments. They found that knowledge about the events in question, as guided by the instrument and action, determined how quickly people processed the patient in the sentence. When the patient was related to the instrument-action combination (e.g., "Donna used the shampoo to wash her hair"), participants were faster to read the patient noun 'hair' than if it was not as strongly related (e.g., "Donna used the hose to wash her hair"). This study and others demonstrate that event knowledge is rapidly accessed when comprehending language.

Research has also demonstrated that event knowledge influences our ability to predict upcoming events and drives expectations about what might happen next. Prediction is crucial to our ability to quickly process information while language is unfolding. In fact, the ability to predict upcoming information is thought to be a major factor that supports rapid and efficient sentence processing (Altmann & Kamide, 1999; Altmann & Mirkovic, 2009; Federmeier, 2007; Van Petten & Luka, 2012). Altmann, Kamide, and Haywood (2003) showed that event knowledge aids in predicting upcoming event components by measuring anticipatory eye movements in an eye-tracking experiment. Eye-tracking has been a critical tool for investigating dynamic ongoing processes in language research because we can measure where participants are looking while they simultaneously process speech (Rayner, 1998; Tanenhaus, 1995; Huettig, Romers, & Meyer, 2011). In Altmann et al. (2003), participants heard the phrase 'the man will ride' or 'the girl will ride' while looking at a scene containing images of a

carousel and a motorcycle. Participants looked more at the motorcycle after processing the agent ‘the man’, and more to the carousel when the agent was ‘the girl’, because our event knowledge steers us towards the more likely or probable outcome based on experience.

DeLong et al. (2005) presented participants with sentences up until the verb and asked them to complete each sentence. For example, participants completed “The day was breezy so the boy went outside to fly __ ____”. DeLong et al. found that the completion probabilities were much higher for ‘a kite’ than ‘an airplane’ because boys are much more likely to fly kites than airplanes outside on a windy day. These preferences were seen in event related potential (ERP) recordings as participants read the full sentences ending in either ‘a kite’ or ‘an airplane’. They looked at the N400, which is a negative ERP deflection that peaks around 400 ms, which is known to respond to words and other meaningful stimuli. They found that the N400 was larger while processing the article ‘an’ than when processing ‘a’ due to the participants’ expectation of ‘a kite’ over ‘an airplane’. This finding reflects participants’ ability to anticipate what should happen next based on their knowledge of common events. These studies highlight the essential role event knowledge plays when processing linguistic input.

Research to date has demonstrated that people use their event knowledge in on-line language comprehension tasks. While there is a great deal of evidence that event components are activated while people hear or read sentences, the majority of language research to date has focused on single events without manipulation of temporal information. This has involved looking at thematic roles, scripts, and schemas related to a particular event occurring at a specified time. However, the process may be significantly

more complex, and there is much to be gained by studying what processes are utilized as sentences unfold. For example, there may be subtle linguistic cues that can influence the relative degree to which event components are activated or expected. Cues that signal time, for example, may influence expectations about whether an event is being described as already having happened, is in the process of happening, or is about to happen. Therefore, the current study focuses on manipulation of this temporal information to investigate how it influences accessing and processing event components.

Temporal Flow of Events

Many broad and complex theories have been proposed to explain the theoretical constructs related to the temporal structure of events both as they occur in the world and in terms of how they are represented in language (Hayes, Barnes-Holmes, and Roche, 2001; Pustejovsky, 1991; Altman & Mirkovic, 2009; Elman, 2009). While we have gained important insights from these theories, further study is required to understand the complex connection between real world events and how they are represented within language. Moens and Steedman (1988) focused on the connection between language and events, and this work has been further expanded upon by Ferretti, Kutas, and McRae (2007; see Figure 1).

Moens and Steedman's (1988) model includes three causal properties, or stages, underlying the temporal structure of action events in the real world: initiating conditions, the actual event, and the resultant states (Figure 1). These three stages segment the flow of a real event, and provide insight into how the relative saliency of event components changes between the stages. The Moens and Steedman (1988) model provides a connection between what we know of real-world events and certain aspects of language

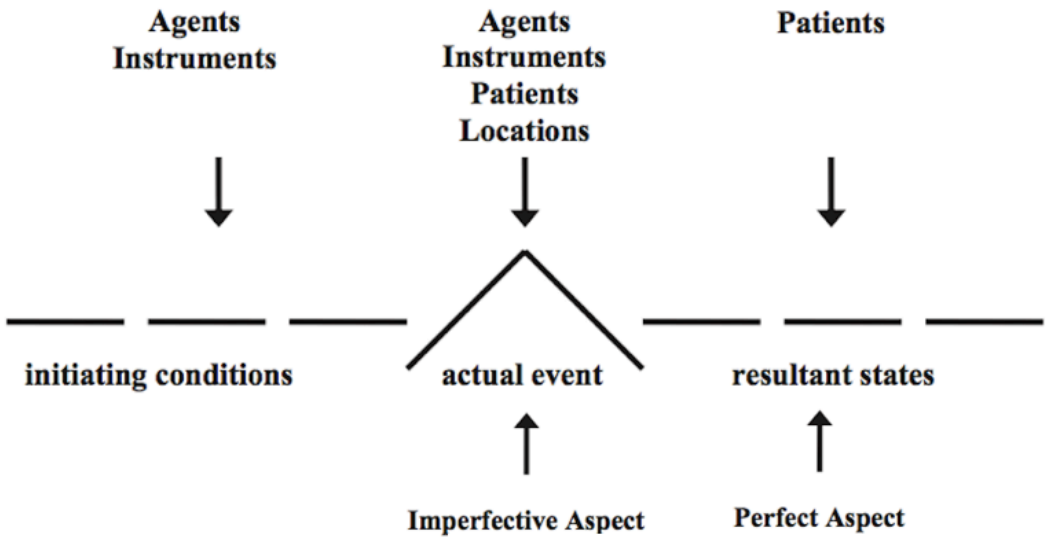

Figure 1. Grammatical aspect, event components, and their relationship with the temporal and causal structure of events.

comprehension. Take, for example, the action of chopping down a tree. The 'initiating conditions' refer to the steps leading up to the action, and are generally thought to be the cause of the event. This stage therefore highlights the agent and the instrument being employed. Referring to the example, it would be the lumberjack holding an axe, and winding up getting ready to swing. The 'actual event' refers to the performance of the action itself. Here, all event components are relevant, as the action is currently happening - the lumberjack actually swings the axe into the tree. Finally, the 'resultant states' refers to the outcome of the action having taken place. At this stage, the focus is typically on the patient, because the patient undergoes a change of state as a result of the action. In our example, this refers to the tree lying on the ground after being cut by the axe.

The three causal properties (initiating conditions, actual event, and resultant states) allow us to understand the structure of the action by providing information about both the temporal span of the event, and how the event components (agent, instrument, patient, location) correspond to them. Event components are common elements that bridge the gap between actual events and how events are represented in language. Therefore, this model allows us to explore

these connections by using linguistic manipulations to highlight specific parts of an event's temporal structure and to investigate how that helps us more effectively process language.

The connection between unfolding events and language is complex. However, there are subtle verbal cues that relate to actual events that help us quickly process, understand and predict events through the language we use to describe them. Incoming linguistic information relating to a particular event can highlight specific aspects of the temporal

structure of an event, which allows us to make specific predictions about, or narrow-down, what is most likely to happen next. It is possible that linguistic cues can highlight an individual stage of an event, which can then change the relative salience of event components. This was demonstrated by an eye-tracking study conducted by Altmann and Kamide (2007) in which they presented participants with either future or past-tense auditory sentences such as "The man will drink the beer" or "The man has drunk the wine" accompanied by a visual scene containing a man, an empty wine glass, a full glass of beer, some cheese, and some Christmas crackers. Altmann and Kamide found increased anticipatory looks toward the full glass while participants listened to the sentence containing the future tense, and more anticipatory looks to the empty glass while listening to the past tense. This study demonstrates that past tense versus future tense can be used to cue the temporal information associated with the particular event structure, leading to increased fixations on the corresponding, more relevant images.

While there are several ways that language can cue the temporal structure of events, this study demonstrates that subtle linguistic manipulations can have a significant impact on our processing of broader conceptual input, effectively highlighting the correlation between language and event structure. To further investigate this relationship, the current study focused on another subtle way that temporal span is cued, through the manipulation of what is called grammatical aspect.

Grammatical Aspect

The present study focuses on grammatical aspect and its effects on understanding the temporal nature of events. Grammatical aspect "denotes an event's duration, onset, and completion status" (Madden & Zwaan, 2003). These constructs have been thoroughly

studied in the linguistic literature for many years (Comrie, 1976; Dowty, 1986; ter Meulen, 1995; Vendler, 1957, 1967; Verukyl, 1996). However, psycholinguistic study into its effects on the comprehension and fluid use of language is less understood (Madden & Zwaan, 2003; Magliano & Schleich, 2000; Ferretti, Kutas, & McRae, 2007). We were specifically interested in how this concept can be used to draw attention to specific knowledge regarding the event structure of actions.

While there are many forms of grammatical aspect (Comrie, 1976), psycholinguistic studies often focus on two types: the imperfective and the perfective. The imperfective aspect is expressed in the form 'was verb+ing' and it signals an ongoing event (e.g., "Stephanie was changing the tire."; Magliano & Schleich, 2000). The perfective aspect is expressed in the form 'had verb+ed' and it signals a completed event (e.g., "Stephanie had changed the tire."; Magliano & Schleich, 2000). Another way of thinking about this distinction relates to what is focused on, through language, related to the various elements of a referenced event. Madden and Zwaan (2003) suggest that the imperfective aspect promotes readers or listeners to view the event as ongoing, resulting in a focus on all components of the event. In contrast, when the perfective aspect is used, the primary focus is on the outcome, since it refers to a completed action. These two types of grammatical aspect provide an interesting test case as they both refer to events that occur in the past while differing in their aspectual form. With this approach, researchers are able to hold tense constant and can therefore get a better idea of the specific influence of grammatical aspect.

Grammatical Aspect and Temporal Structure of Events

Of particular interest for this study is the ability of grammatical aspect to stress or highlight different components of events based on the temporal stage of the event to which it corresponds. When we hear the imperfective aspect ("The man was slicing the vegetables"), this signals an increase in the importance of information we get from paying attention to the components that are most salient during the 'actual event' stage (Figure 1). In contrast, when we hear the perfective aspect ("The man had sliced the vegetables"), this signals an increase in the importance of information we get from paying attention to the components during the 'resultant states' stage - in particular to the patient (Figure 1).

In investigating the idea that grammatical aspect cues temporal structure, two studies have demonstrated that imperfective and perfective aspect highlight the associated instruments and patients respectively. To investigate the effect of grammatical aspect on the instrument used in an action, Truitt and Zwaan (1997) conducted a study in which they presented participants with a short story about an action (in which an instrument was implied but never overtly stated). Participants were then asked to name the implied instrument from the story. For example, they either heard a story containing the phrase "was pounding the nail" or "had pounded the nail", and then read aloud the visually-presented word 'hammer'. Truitt and Zwaan found that participants had shorter naming latencies for the instrument after hearing the imperfective (was pounding), than the perfective aspect (had pounded). This suggests that processing the imperfective aspect made the instruments more available to participants for the subsequent naming task.

Mozuraitis, Chambers, and Daneman (2013) investigated how grammatical aspect influences the perception of the patient. In their experiment, participants read short passages that included a sentence in either the imperfective or perfective aspectual form (e.g., "The woman was knitting/knitted a sweater"), followed by a second event that included the patient from the previous sentence in its completed form (e.g., "She wore the sweater…"). They found that readers had greater difficulty processing this second event if they had previously heard the imperfective rather than the perfective aspect. This demonstrates that the perfective highlights completed events, which leads to increased focus on the patient (the element that changes state, in this case the sweater). Taken together, Truitt and Zwaan (1997) and Mozuraitis et al. demonstrate that imperfective aspect preferentially highlights instruments whereas perfective aspect preferentially highlights patients, as suggested by Moens and Steedman's (1988) model. Note, however, that both of these studies measured processing on individual words or sentences that were presented after the manipulation of aspect.

Upstream processing refers to effects of grammatical aspect that are observed in tasks that occur later in the sentence or after the sentence has been completely processed. Many other studies have also found an influence of grammatical aspect on follow-up tasks (Matlock, 2011; Barsalou, 2009). For example, Magliano and Schleich (2000) found participants responded faster to questions of whether the verb phrase occurred in a previous sentence after hearing the imperfective version of a sentence. Madden and Zwaan (2003) conducted forced-choice decision making tasks. One experiment found that participants were more likely to choose images depicting completed rather than ongoing events after hearing the perfective aspect. Another experiment demonstrated that

after reading a perfective sentence, participants were faster to respond ‘yes’, that an image is related to the sentence, for one that showed a completed action compared to one depicting an ongoing action. Finally, in an ERP study, Ferretti, Kutas, and McRae (2007) found that the N400 was larger to a location when it was followed by the perfective version of a sentence (“had skated in an arena”) versus the imperfective version (“was skating in an arena”). These studies demonstrate how grammatical aspect influences performance on subsequent tasks that depend on how people interpret or remember verb phrases (Madden & Zwaan; Truitt & Zwaan), as well as comprehension of linguistic input that occurs later in a sentence (Ferretti et al. 2007) or in a subsequent sentence (Mozuraitis et al. 2013).

While these studies that demonstrate upstream effects of grammatical aspect are informative, few studies have considered these effects while participants are processing the verb phrase itself. Of critical interest in this case is when the measure is being taken relative to the point in the linguistic stream at which aspect is manipulated. Although the experiments described above show that aspect influences comprehension at some point in time, they do not provide definitive insight into the question of precisely when aspect affects sentence comprehension. In particular, it would be useful to see if aspect influences processing while participants read the verb phrase. One study has demonstrated the effects of grammatical aspect on the immediate access of concepts. Zhou, Crain, and Zhan (2014) investigated how people processed a visual depiction of an event while grammatical aspect was manipulated. Sentences describing an event in either imperfective or perfective aspect were paired with two images, one of which showed the completed event, whereas the other was a picture of the ongoing event. They measured

fixations on the two images while the participants listened to a sentence. For example, they heard either the imperfective sentence stated in present tense (e.g., "The old lady is planting the flower") or its perfective counterpart stated in past tense (e.g., "The old lady has planted the flower"). One picture showed an old woman in the process of planting a flower (kneeling down, holding the stem), whereas the other showed an old woman standing near a fully planted flower. Zhou et al. found increased looks to the completed action while hearing the perfective aspect, and increased looks to the ongoing event while hearing the imperfective aspect. This experiment provides evidence that these linguistic manipulations of the temporal spotlight influence processing while people are hearing the aspectual morpheme (the verb). However, it is unclear which components of the scene are of particular interest as participants are processing the manipulation of aspect.

The Present Study

Previous studies provide compelling evidence that there is an influence of grammatical aspect during sentence comprehension for completed and ongoing pictures of events, and an upstream influence of grammatical aspect on the instruments and patients involved in the event. However, what has yet to be determined is whether (and how) the match between aspect and temporal structure modulates activation of particular components of events as the sentence unfolds. This is the aim of the current study.

In order to investigate this connection, we chose to look at the imperfective and perfective forms of grammatical aspect. Since we are looking at the differences between ongoing and completed events, we decided on the perfective aspect to refer to the completed events (e.g., "He had sliced the vegetables") and the imperfective to refer to ongoing (e.g., "He was slicing the vegetables"). We decided on these particular forms as

they both function well in referring to past events, which allowed us to control for the variable of tense. In addition, we ensured the sentences were all the same length by including an auxiliary prior to the verb in both conditions (e.g., 'was' or 'had') to control for linguistic timing effects. The use of an auxiliary does not signal an upcoming verb and therefore did not provide predictive abilities to the participants. For example, it is possible to have sentences like "The woman was tall" or "She had a fast car", neither of which contain an action verb. In other words, in no case was the agent of the action related to any of our images.

Our experiment employed the visual-world paradigm in which participants simultaneously listened to sentences while viewing four pictures. The auditory stimuli were simple sentences such as "The man was slicing the vegetable". It is important to note that the instruments were never mentioned in our sentences (e.g., there were no phrases such as 'using the knife' or 'with a knife'). In addition, unlike most visual-world eye-tracking studies of this nature, the name corresponding to the patient was presented in a generic form (e.g., we used the word 'vegetable' instead of 'carrot'). Each sentence was paired with four visual stimuli: one depicting the patient (e.g., a carrot), one depicting the instrument (e.g., a knife), and two distractor stimuli (e.g., a present and a basket). All were basic black and white line drawings. We measured the time course of participants' eye-movements to the pictures and the proportions of time they fixated on each picture.

Our specific research question is: Does hearing the imperfective versus the perfective version of a sentence affect the activations of mental representations for the event's patient and instrument during on-line language comprehension? We hypothesized

that hearing the imperfective aspect (which implies an ongoing action) should activate the instruments used for an action to a greater degree than does the perfective aspect. Additionally, we hypothesized that hearing the perfective aspect (which implies a completed action) should activate the patients of a specific action to a greater degree than does the imperfective aspect. In other words, participants should fixate on the knife more often when hearing 'was slicing' versus 'had sliced', whereas they should fixate more on the 'carrot' when hearing 'had sliced' versus 'was slicing'.

Method

Participants

Sixty-four subjects (55 females) from the University of Western Ontario student population took part in this study. Participants ranged in age from 17 to 43 (M = 18 years, SD = 3). On the day of testing, 6 participants were excluded due to an inability to track their pupil. Participants were recruited through the SONA system of the Psychology Department Undergraduate Research Participant Pool, which is available to students enrolled in undergraduate psychology courses during the Fall and Winter semesters. Students received compensation based on information provided in the course outline for the course in which they were registered. All participants had normal or corrected to normal visual acuity and had English as a first language as ascertained through self-report. Participants had never endured a traumatic brain injury or illness and were not currently diagnosed with any major psychiatric illness, also determined by self-report.

Stimuli and Apparatus

Sentences. Participants were presented with 64 items consisting of 32 experimental and 32 filler items (See Appendix A and B, respectively). The experimental

items were 32 action verbs that were paired with two related images and two unrelated images. The verbs were chosen specifically to ensure that there was a strongly associated instrument required for each particular action, as well as a patient (or a class of patients) that are commonly acted upon by that particular instrument. For example, the verb 'slice' had related images for the inherent instrument 'knife' and a patient 'carrot', as well as unrelated images 'present' and 'basket' (see Figure 2). In addition, we ensured that the representation of the events had actions that extended for a reasonable period of time, and had a clear endpoint for when the action was completed. These verbs were used to create sentence versions in both imperfective (e.g., "The man was slicing the vegetables") and perfective aspect ("The man had sliced the vegetables"), resulting in 32 sentences of each type (64 total). In order for the participants to hear each verb only once, two lists were created so that every verb was in each list and there was an equal number of imperfective and perfective sentences. Each list contained 16 perfective and 16 imperfective sentences corresponding to the 32 action verbs and their respective images. All sentences started with a pronoun such as 'He' or 'She', or a generic noun phrase such as 'The man' or 'The woman' to avoid predictive eye movements to our target images, prior to the verb. Thirty-two filler sentences were added to each list to create a total of 64 trials. The filler sentences varied in complexity of sentence structure and each had a verb and a noun corresponding to an image on the screen, just as the experimental items had two related images. This was to ensure that participants weren't simply getting used to a particular sentence structure and made it necessary for them to pay attention to the content of the sentences. For example, the filler sentence "The baby would throw fruit in the highchair"

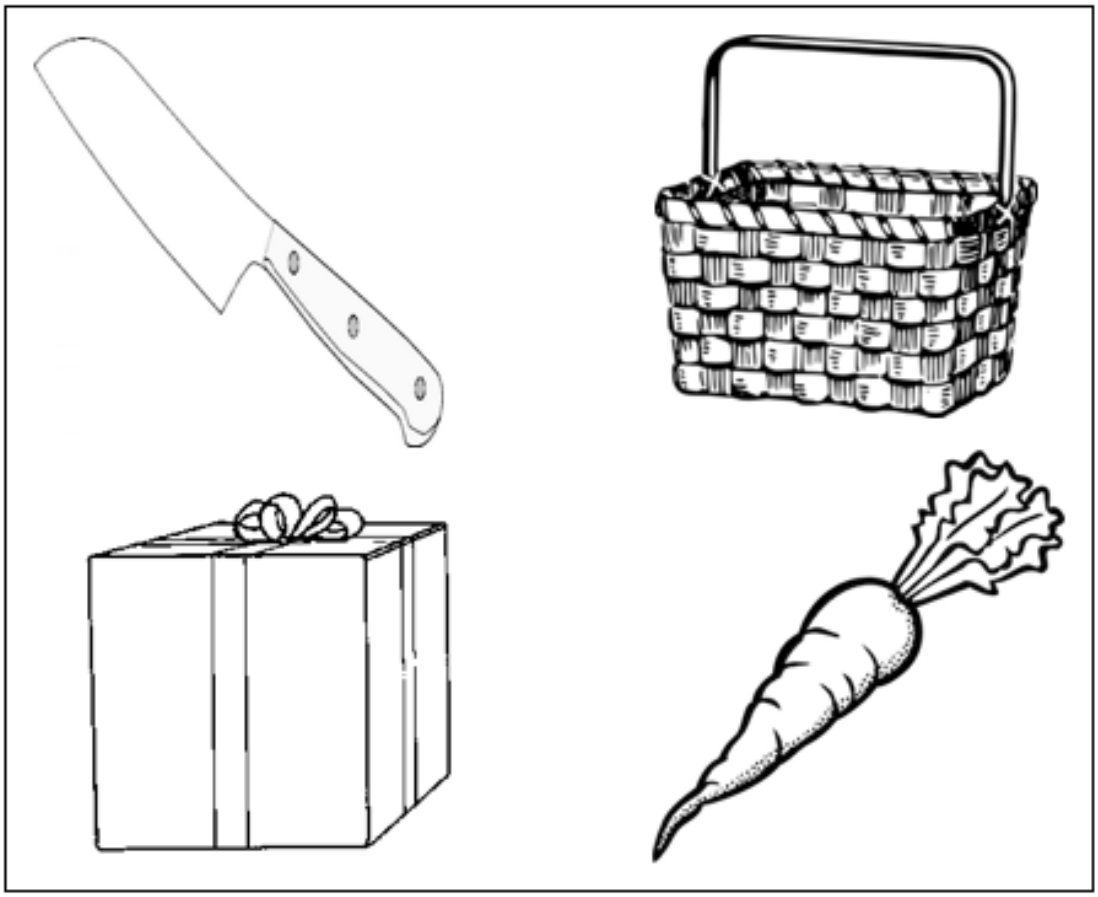

Figure 2. An example of trial images for the sentence “The man was slicing/had sliced the vegetables”. Visual stimuli contain the instrument (the knife), the patient (the carrot), and two distractor stimuli (the basket and the present).

was presented with related images ‘highchair’ and ‘lemon’, and unrelated images ‘ocean’, and ‘boat’.

Visual stimuli. All images were presented at 300 x 300 pixels as black and white line drawings selected from the International Picture Corpus (Szekely et al., 2004) and from online open sources “flickr.com” and “clipart.com”. Each of the four pictures were placed in a different quadrant of the screen at a 45-degree angle from the center of the screen. The location of the four images was randomized across trials and participants.

Auditory stimuli. All sentences were recorded by the same female native English-speaker, with a mean intensity of 77 dB (Min = 73, Max = 80, *SD* = 1.3). The sentence stimuli were recorded using a Sennheiser e845S mic with Audacity, Version 2.0.2 (build date August 20, 2012), in a 4” thick sound-proof booth (Model CL-13 LPMR), with a Sound Devices USB Pre2 preamp on a MacBook Air OSX. To ensure consistency across stimuli, all files were RMS (Root Mean Squared) compressed in Audacity, and were edited to remove silence at the beginning and end of the utterance. In addition, the files were annotated by marking relevant points of the utterance using a customized script in Pratt, Version 6.0.15. Of critical importance, the time from the start of the sound file to the onset of the auxiliary verb was set to 750 ms, and 300 ms of silence was added to the end of each sound file. Using a PC computer (Windows XP) with an Audiomedia 2 soundcard, the sound files were played through Logitech X-120 speakers (120V ~ 60Hz).

Eye-tracker. The experiment used a desktop mounted Eyelink 1000 eyetracker to record eye-movements, and Experiment Builder, Version 1.10.1241 software to coordinate and present the stimuli (SR Research Ltd.). The camera lens was positioned

approximately 60 cm away from the participant's head at an approximately 35-degree angle to the participant's eyes. Participants were positioned 70 cm away from the 16-inch monitor displaying the visual stimuli (resolution set to 1024 x 768 dpi). Calibration was performed prior to the start of the experiment, as well as at any time the equipment registered significant head movement. The fixation point presented at the beginning of each trial served as a calibration check to ensure that if the camera ever lost the pupil, the program automatically went to camera setup to allow for calibration to be completed.

Procedure

Each trial began with the presentation of a fixation cross for a maximum of ten seconds. If this time limit was reached, then the participant was redirected to calibration. Once the participant had focused on the fixation cross for three seconds, the cross disappeared and was replaced by the four trial images (one in each quadrant). Participants were given one second to become familiar with the images before the auditory stimulus was presented. Following this preview period, a series of red circles were flashed in the center of the screen to bring the participant's attention back to the fixation cross. Once the focus on the fixation cross was registered, this signaled the program to begin playing the sentence. With the images still on the screen, the sentence was played over speakers while eye movements were recorded, with an additional 300 ms of silence at the end of the sentence before the images disappeared and the next trial began with the fixation cross (Figure 3).

At the beginning of the session, participants were randomly assigned to either list one or two, both of which contained three blocks of trials. At the start of the experiment, participants were given the following instructions: "You will see a display with four

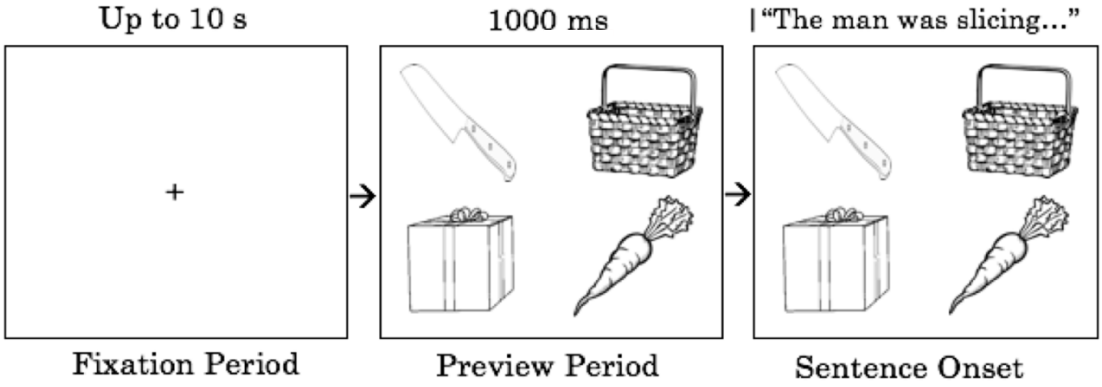

Figure 3. Illustration of a trial procedure.

pictures while hearing a sentence. There is no task involved; just look at the pictures and listen to the sentences. We'll start with some practice trials to see how it works.". Block one contained four practice trials to get participants used to the trials. After the practice trials, participants saw the following message: "This is the end of the practice sessions for part one. Do you have any questions before the experiment begins?". The other two blocks of trials contained the experimental and filler trials without practice trials, but participants were reminded of the task at the start of each block.

Within each list, half of the items were seen in block two while the remainder were seen in block three. An equal number of imperfective and perfective forms of the sentences were presented in each block with an equal number of filler items included in each block. The order of trials within each block was randomized for each participant. Participants were given a short break between blocks two and three to rest their eyes.

Results & Discussion

General Overview

The analyses focus on the differences in the proportions of fixations between patient and instrument within and between the perfective and imperfective conditions. Prior to analyzing the data, all blinks and fixations to anywhere other than the images on the screen were removed. Fixations were then averaged over 10 ms time bins that specified what proportion of the fixations within each bin was spent looking at each image. From here, we split this information into time windows based on critical times during the sentence in order to conduct our analyses. There are three critical times; the onset of the auxiliary verb at 750 ms, the average onset of the verb at 925 ms, and the average onset of the noun at 1495 ms. Based on these critical times, the analyses were

split into distinct time windows of interest. The first is the time period prior to the onset of the auxiliary which contains the agent (e.g., 'The woman'/'The man'; 'She'/'He'). The next window is the duration of the auxiliary verb (e.g., 'was'/'had'). Next is the verb + 'the' window which lasts from the onset of the verb until the onset of the noun (e.g., 'slicing the'/'sliced the'). Finally, the noun window spans from the onset of the noun until the average offset of the noun at approximately 2000 ms (e.g., 'carrot'). The respective time windows and the corresponding auditory input are illustrated in Figure 4.

Introduction to Linear Mixed Effects Models

The analyses were conducted using R version 3.3.0 (2016-05-03) using the lmer() function from the linear mixed effects package lme4 (Bates et al., 2015). Linear mixed effects (LME) models, also referred to as 'hierarchical regression' or 'multilevel regression', provide a method that is used to model item and participant effects simultaneously in a single analysis (Baayen, 2008; Baayen et al., 2008; Barr et al., 2013). This type of analysis is similar to multiple linear regression, but it specifically focuses on repeated measures analyses and includes terms that account for the variability above and beyond the intended experimental manipulations (Baayen, 2008). We modelled the proportion of eye fixations as a function of the parameters described below, and fit one model for each of the four time windows of interest described in Figure 4, as well as one model for the preview period. The five models were structured to utilize both fixed and random effects. Fixed effects refer to those elements that were experimentally manipulated by the researchers, whereas the random effects refer to elements that cannot be controlled for experimentally. In this study, the fixed effects consist of the condition (either perfective or imperfective), the area of interest (AOI), which is the quadrant of the

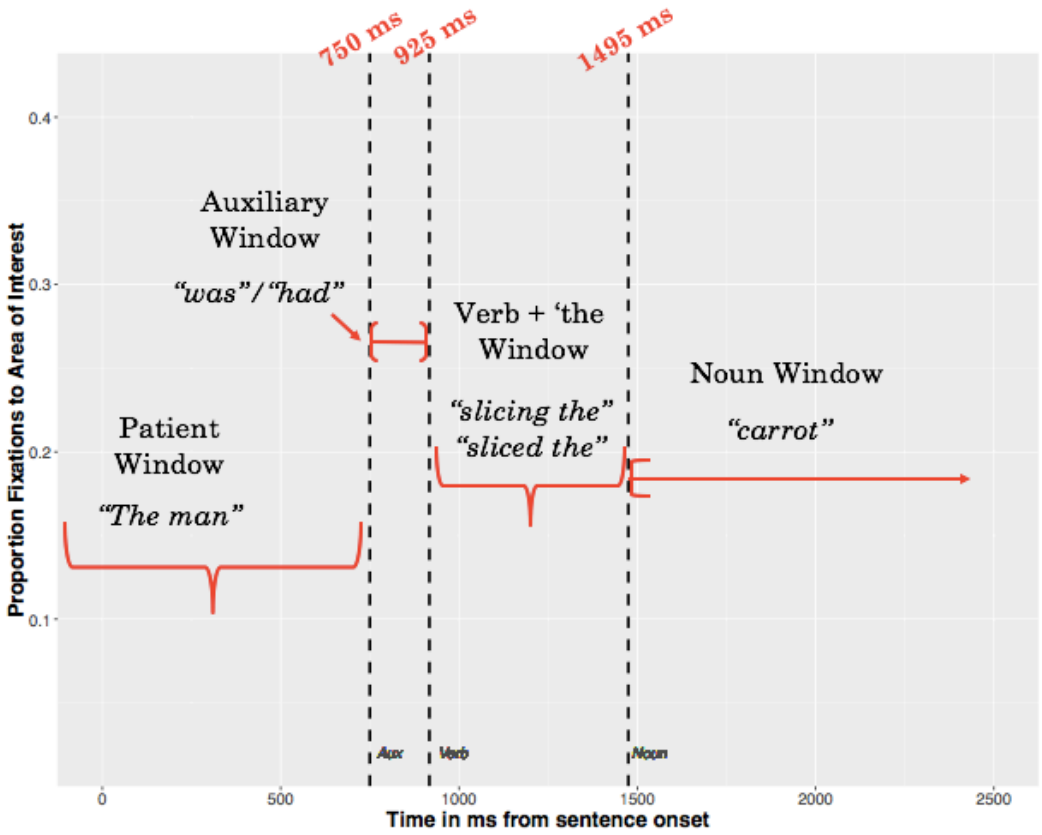

Figure 4. Illustrates the sentences segmented into the time windows of interest and their auditory onsets and offsets.

screen at which the participants are looking at any given point in time during the sentence, and the interaction between these two terms. The models' random effects consist of by-participant and by-item random intercepts (baselines). For each of the models, the fixed and random effects remain stable for all of the analyses conducted on this data set. There are many benefits of using LME in analyzing this data. Of critical importance, it can be used in a very flexible way to model time effects. This is of particular interest for eye-tracking data because variability can differ over time and between groups, which allows us to get a better handle on these variables. In addition, LME handles missing data very well and is very robust compared to other models.

Analyses focused on the differences in fixations to the various images, including both of the distractor stimuli which were randomly assigned to either 'Distractor one' or 'Distractor two' prior to being programmed so that we were able to fully randomize all of the image locations. The analyses specifically focus on differences between the instruments and the patients. We looked at these differences both within and across the imperfective and perfective conditions (Figures 5 & 6). Each analysis referenced the general linear mixed effects model for the time window, followed by the statistics for pairwise comparisons of interest.

Agent & Auxiliary Windows

There are two windows of interest prior to the verb window: the agent window (containing the phrase 'The man'/'The woman'), and the auxiliary window (containing the word 'was'/'had'). In the general model, there was a significant main effect of AOI and condition, as well as an interaction between AOI and condition for both the agent and auxiliary windows. To understand where these differences are being expressed, we

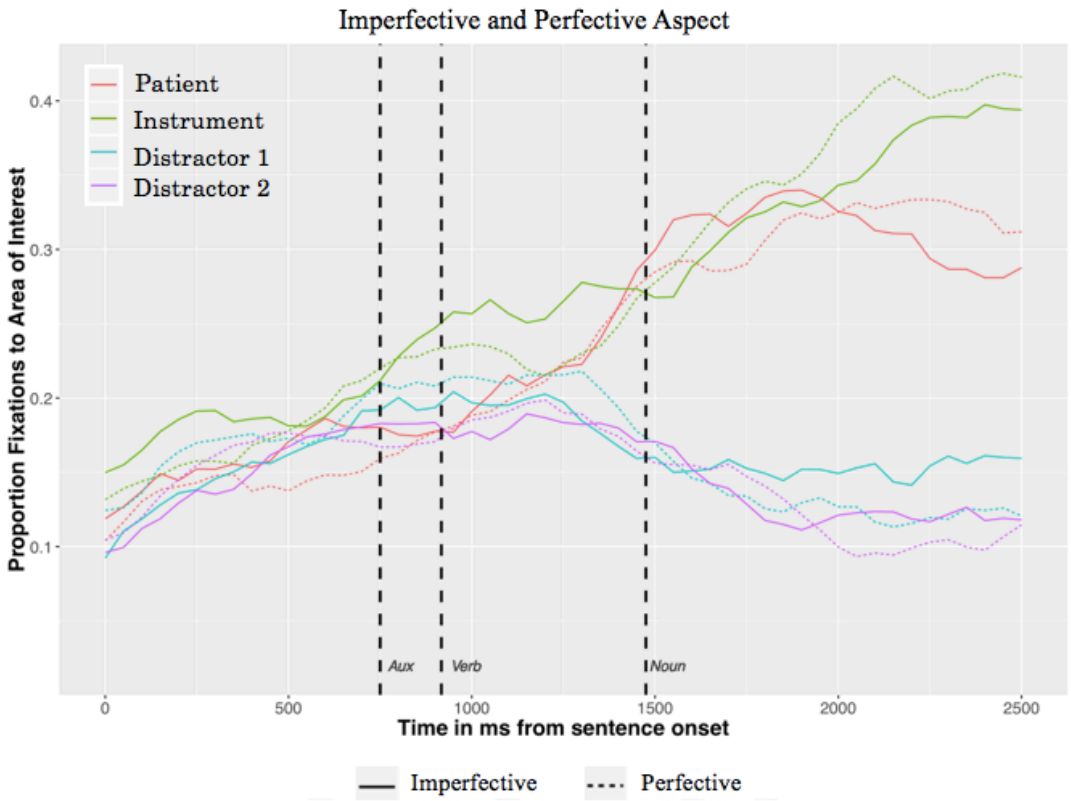

Figure 5. The average proportion of looks to the targets and distractors for the imperfective and perfective conditions. The start of the graph is at auditory onset and the time scale continues until asymptote.

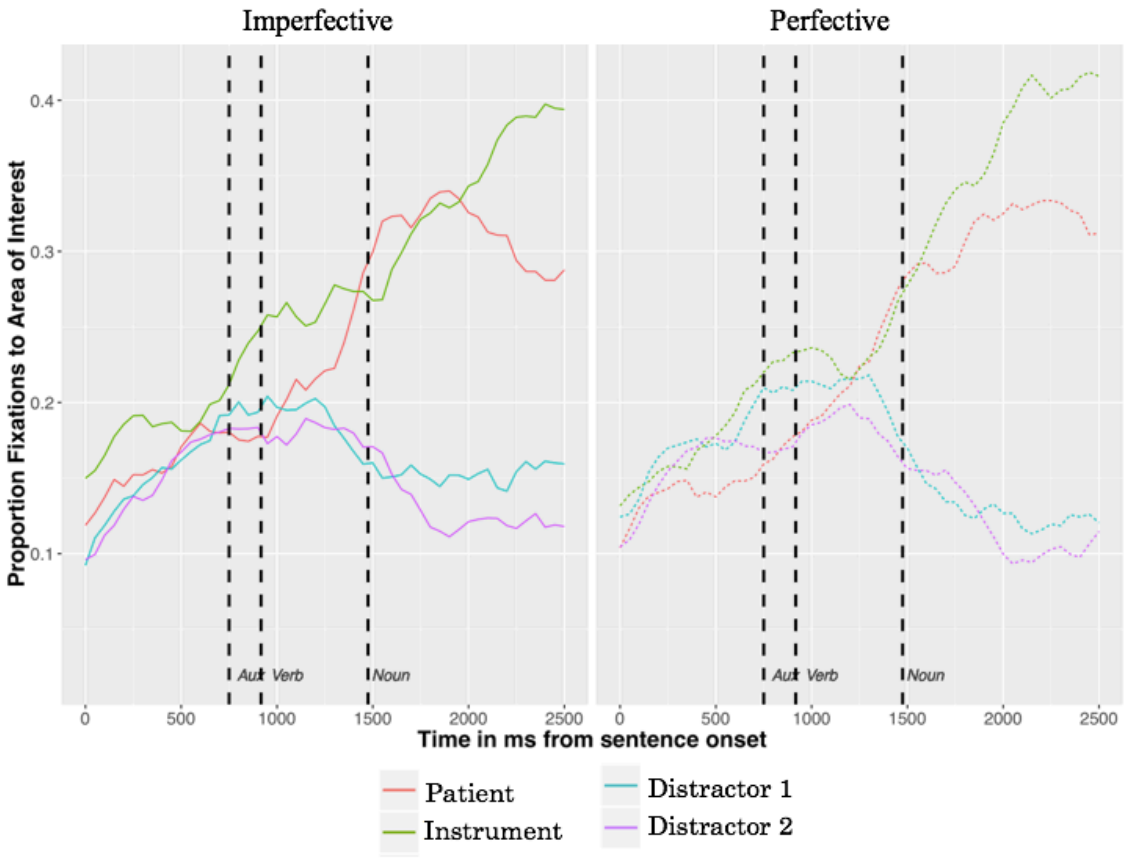

Figure 6. The average proportion of looks to the targets and distractors in the imperfective and perfective conditions. The start of the figure is at auditory onset and the time scale continues until asymptote.

focused on the individual pairwise comparisons. Table 1 displays the pairwise comparisons for the agent window and Table 2 displays the pairwise comparisons for the auxiliary window.

Instruments versus patients between conditions. Looks to the instruments did not differ between the imperfective and perfective conditions during the agent or auxiliary window. The same results were found for the patients.

Instruments versus patients and distractors within each condition. In addition to the comparisons between the conditions, it is also important to determine whether there are any differences between stimuli types within the conditions themselves. In the imperfective condition, during the agent window, there were significantly more looks to the instruments than to either of the distractors, and marginally more looks to the instruments than to the patients. During the auxiliary window, there were significantly more looks to the instruments than to either of the distractors and the patients. For the perfective aspect, participants looked more at the instruments than the patients, and marginally more at the instruments than the distractors. During the auxiliary window, there were significantly more looks to the instrument than to the patient and to distractor two, but not distractor one. Overall, there is a trend towards greater looks to the instruments over the other stimuli types even prior to hearing the verb.

Patients versus distractors within each condition. Participants did not look more often at the patients than at either of the distractors, except for distractor one during the agent and auxiliary windows in the perfective condition only.

Significance. These results are important because they demonstrate that there were not any differences between conditions prior to the onset of the verb for our main

Table 1. Pairwise Comparisons for AOIs During the Agent Window

Comparison	***Estimate***	***t-value***	**SE**	***p-value***
Instruments (IA) vs. Instruments (PA)	0.013	1.16	0.0115	.246
Patients (IA) vs. Patients (PA)	0.019	1.67	0.0115	.096
Patients (IA) vs. Instruments (IA)	-0.021	-1.86	0.0115	.063
Instruments (IA) > Distractor 1 (IA)	0.034	2.92	0.0115	**.004 ***
Instruments (IA) > Distractor 2 (IA)	0.034	3.00	0.0115	**.003 ***
Patients (PA) < Instruments (PA)	-0.027	-2.37	0.0115	**.018 ***
Instruments (PA) vs. Distractor 1 (PA)	0.000	-1.76	0.0115	.079
Instruments (PA) vs. Distractor 2 (PA)	0.013	-1.84	0.0115	.066
Patients (IA) vs. Distractor 1 (IA)	0.012	1.06	0.0115	.063
Patients (IA) vs. Distractor 2 (IA)	0.013	1.14	0.0115	.254
Patients (PA) < Distractor 1 (PA)	-0.027	-2.37	0.0115	**.018 ***
Patients (PA) vs. Distractor 2 (PA)	-0.014	-1.25	0.0115	.210

Table 2. Pairwise Comparisons for AOIs During the Auxiliary Window

Comparison	***Estimate***	***t-value***	**SE**	***p-value***
Instruments (IA) vs. Instruments (PA)	-0.004	-0.22	0.0161	.825
Patients (IA) vs. Patients (PA)	0.016	1.00	0.0161	.315
Patients (IA) < Instruments (IA)	-0.049	-3.02	0.0161	**.003 ***
Instruments (IA) > Distractor 1 (IA)	0.034	2.11	0.0161	**.035 ***
Instruments (IA) > Distractor 2 (IA)	0.045	2.78	0.0161	**.005 ***
Patients (PA) < Instruments (PA)	-0.068	-4.25	0.0161	**< .0001 ***
Instruments (PA) vs. Distractor 1 (PA)	0.022	1.38	0.0161	.168
Instruments (PA) > Distractor 2 (PA)	0.063	3.92	0.0161	**< .0001 ***
Patients (IA) vs. Distractor 1 (IA)	-0.015	-0.91	0.0161	.361
Patients (IA) vs. Distractor 2 (IA)	-0.004	-0.24	0.0161	.811
Patients (PA) < Distractor 1 (PA)	-0.046	-2.87	0.0161	**.004 ***
Patients (PA) vs. Distractor 2 (PA)	-0.005	-0.33	0.0161	.745

stimuli of interest (the instruments and the patients). Furthermore, while we did not expect there to be any significant differences between our images prior to the verb, it appears that there is a general trend towards greater looks to the instruments across both conditions in the agent and auxiliary windows. This suggests a possible difference in saliency in our instruments compared to the other stimuli types. We return to this idea later in the discussion and investigate what might underlie this consistent difference.

Verb + 'the' Window

The verb window contains the main comparisons of interest, specifically, whether there are differences in looks to the instruments or patients between the two aspect conditions. In the general model, there was a significant main effect of AOI and condition, as well as an interaction between AOI and condition. Pairwise comparisons were conducted to determine what is driving the effects displayed in Table 3.

Instruments versus patients between conditions. Participants looked at the instrument more often when hearing imperfective than perfective verbs. This supports the hypothesis that the imperfective aspect highlights the ongoing action to a greater degree than does the perfective, resulting in more looks to the instrument. The second part of the hypothesis was not supported however, in that there were not more looks to the patients in the perfective than in the imperfective condition.

Instruments versus patients and distractors within each condition. In the imperfective condition, there were significantly more looks to the instruments than to the patient and either of the distractors. For the perfective aspect, participants looked significantly more at the instruments than distractor two but not distractor one, and there was not a difference in looks to the patients versus the instruments. The imperfective

Table 3. Pairwise Comparisons for AOIs During the Verb + 'the' Window

Comparison	*Estimate*	*t-value*	SE	*p-value*
Instruments (IA) > Instruments (PA)	0.032	2.37	0.0134	**.018 ***
Instruments (IA) > Distractor 1 (IA)	0.073	5.44	0.0134	**< .0001 ***
Instruments (IA) > Distractor 2 (IA)	0.084	6.30	0.0134	**< .0001 ***
Patients (IA) > Distractor 1 (IA)	0.027	1.99	0.0134	**.046 ***
Patients (IA) > Distractor 2 (IA)	0.038	2.85	0.0134	**.004 ***
Patients (IA) < Instruments (IA)	-0.046	-3.45	0.0134	**< .0001 ***
Patients (IA) vs. Patients (PA)	0.003	0.20	0.0134	.845
Patients (PA) vs. Distractor 1 (PA)	0.005	0.039	0.0134	.694
Patients (PA) > Distractor 2 (PA)	0.029	2.17	0.0134	**.030 ***
Instruments (PA) vs. Distractor 1 (PA)	0.022	1.66	0.0134	.098
Instruments (PA) > Distractor 2 (PA)	0.046	3.44	0.0134	**< .0001 ***
Patients (PA) vs. Instruments (PA)	-0.017	-1.26	0.0134	0.207

condition continues to show a strong indication of greater looks to the instruments over all of the other images, as predicted. The perfective condition no longer shows this increase in looks to the instruments now that the verb has been processed.

Patients versus distractors within each condition. Participants looked more at the patients than either of the distractors in the imperfective condition, and more to the patients than distractor two but not distractor one in the perfective condition. Despite there being

no difference between the conditions in looks to the patients, we started to see a separation between the looks to the patients and distractor one and two in both the imperfective and perfective conditions. This suggests that participants are starting to focus on the images implied by the sentence and are predicting the potential patient based on the verb.

Significance. The results from the verb window critically demonstrate an increase in looks to the instrument for the imperfective over the perfective condition as predicted. However, somewhat surprisingly, participants did not look at the patients more often when hearing the perfective sentences. We see that there remains a general increase in looks to the instruments over all of the other stimuli types. However, it is important to note that this increase remains substantial within the imperfective, but is no longer significant in the perfective condition. This demonstrates the effects of our experimental manipulation. As participants finish processing the combination of the auxiliary and the verb, there remains a strong focus on the instrument in the imperfective, while there now exists a balance of looks to the patients and instruments in the perfective.

Noun Window

The noun window utilized a broad verbal description for the patient (‘vegetable’) accompanied by a more specific pictured object (‘carrot’). That is, the image of a ‘carrot’ accompanies the sentence “He was slicing the vegetable”. The general model suggests that there was a significant main effect of AOI and condition, as well as an interaction between the AOI and condition. Pairwise comparisons were conducted to determine what is driving this effect, as displayed in Table 4.

Instruments versus patients between conditions. There was not a statistically significant difference in looks to both the patients and instruments for either the imperfective or perfective conditions.

Patients versus instruments within conditions. Of critical interest in this time window was whether there would be more looks to the patient now that the noun has been processed. We found that there was not a significant increase in looks to the patients over the instruments for both the imperfective and perfective conditions.

Patients and instruments versus distractors within conditions. Finally, we investigated whether participants were indeed focusing on the relevant images in relation to the sentences they were hearing. We confirmed that participants were looking significantly more at the instruments over both of the distractors within the perfective and the imperfective conditions. We also found that participants were looking significantly more at the patients than either of the distractors in both conditions.

Significance. After hearing the sentence to completion, there was no longer an increase in looks to the instruments over the patients. Since the critical time window has passed where we expected to see differences between the conditions, it is not surprising

Table 4. Pairwise Comparisons for AOIs During the Noun Window

Comparison	***Estimate***	***t-value***	**SE**	***p-value***
Patients (IA) vs. Instruments (IA)	0.021	1.56	0.0135	.120
Patients (PA) vs. Instruments (PA)	-0.020	-1.47	0.0135	.140
Instruments (IA) vs. Instruments (PA)	-0.017	-1.28	0.0135	.200
Patients (IA) vs. Patients (PA)	0.024	1.76	0.0135	.080
Patients (IA) > Distractor 1 (IA)	0.171	12.65	0.0135	**< .0001 ***
Patients (IA) > Distractor 2 (IA)	0.024	13.77	0.0135	**< .0001 ***
Patients (PA) > Distractor 1 (PA)	0.157	11.62	0.0135	**< .0001 ***
Patients (PA) > Distractor 2 (PA)	0.158	11.69	0.0135	**< .0001 ***
Instruments (IA) > Distractor 1 (IA)	0.150	1.66	0.0135	**< .0001 ***
Instruments (IA) > Distractor 2 (IA)	0.165	3.44	0.0135	**< .0001 ***
Instruments (PA) > Distractor 1 (PA)	0.177	13.09	0.0135	**< .0001 ***
Instruments (PA) > Distractor 2 (PA)	0.178	13.17	0.0135	**< .0001 ***

to see that there are no statistical differences between the conditions at this time period. These results also demonstrate that participants were indeed paying attention to the verbal input and focusing on the relevant images (the instrument and the patients) more than either of the distractors.

Instruments

A surprising and unanticipated result was that overall, participants showed a strong tendency to fixate more on the instruments compared to all other images. We investigated a potential source of this bias in our data by looking at whether there were differences between the types of images themselves that could be responsible for the overall increase in looks to the instruments.

In most visual world paradigm eye-tracking studies, it is possible to construct items so that each critical image is a target in one trial, and a distractor in another trial. This structure is preferable as it counterbalances the images to ensure effects are not simply due to the specific images used in each condition. In our experiment, we were not able to use this design to control for picture saliency. This is due to the fact that while many instruments can be patients, it is quite difficult to use a patient as an instrument in many cases. For example, the instruments ‘knife’ and ‘sponge’ in our experiment could easily be used as patients (e.g., you can sharpen a knife, or wring out a sponge). However, it is difficult and awkward to devise a sentence in which a patient such as a ‘carrot’ is used as an instrument for a natural action. Because of this inflexibility of some patients, we were unable to build this counterbalancing of images into our experiment design, and were required to use different image quartets for each sentence (event). Given this experimental design, it is therefore possible that there are differences in the pictures

themselves in terms of their saliency or complexity that might result in increased interest in the instruments over the other image types.

Rather than, for example, collecting measures of visual saliency or complexity and using them to estimate participants' interest in the images, we computed a direct measure by analyzing participants' fixations during the preview period. This preview period refers to the time prior to the onset of the sentences during which participants were solely exploring the images (see Figure 3). Analyzing fixation during this period is ideal because it involves the same participants and pictures as the main analyses, but the data was collected prior to the introduction of language on each trial.

The general model suggests that there are significant differences between the visual stimuli, and further pairwise comparisons were conducted to determine what drove the effects as shown in Table 5.

Looks to the instruments over the patients and the distractors in both conditions. Participants looked more at the instruments than at the patients or distractors in the imperfective condition (Figure 7). We see similar results in the perfective condition, with a statistically significant increase in looks to the instrument over the patients and distractor two, and approaching significantly increased looks to the instrument over distractor one (Figure 8).

Looks to instruments and patients between conditions. There was not a significant difference in looks to the instruments or the patients when comparing the two aspect conditions.

Significance. Analyses of the preview period show that, even before hearing any linguistic input, participants looked significantly more at the instruments than any of the

Table 5. Pairwise Comparisons for AOIs During the Preview Period

Comparison	***Estimate***	***t-value***	**SE**	***p-value***
Patients (IA) < Instruments (IA)	-0.027	-3.19	0.0083	**.001 ***
Instruments (IA) > Distractor 1 (IA)	0.026	3.17	0.0083	**.002 ***
Instruments (IA) > Distractor 2 (IA)	0.019	2.25	0.0083	**.024 ***
Patients (PA) < Instruments (PA)	-0.029	-3.48	0.0083	**< .0001 ***
Instruments (PA) vs. Distractor 1 (PA)	0.016	1.93	0.0083	.053
Instruments (PA) > Distractor 2 (PA)	0.019	2.22	0.0083	**.026 ***
Instruments (IA) vs. Instruments (PA)	0.002	0.27	0.0083	.787
Patients (IA) vs. Patients (PA)	0.005	0.56	0.0083	.578
Patients (IA) vs. Distractor 1 (IA)	0.000	-0.02	0.0083	.980
Patients (IA) vs. Distractor 2 (IA)	-0.008	-0.94	0.0083	.348
Patients (PA) vs. Distractor 1 (PA)	-0.013	-1.54	0.0083	.123
Patients (PA) vs. Distractor 2 (PA)	-0.010	-1.25	0.0083	.210

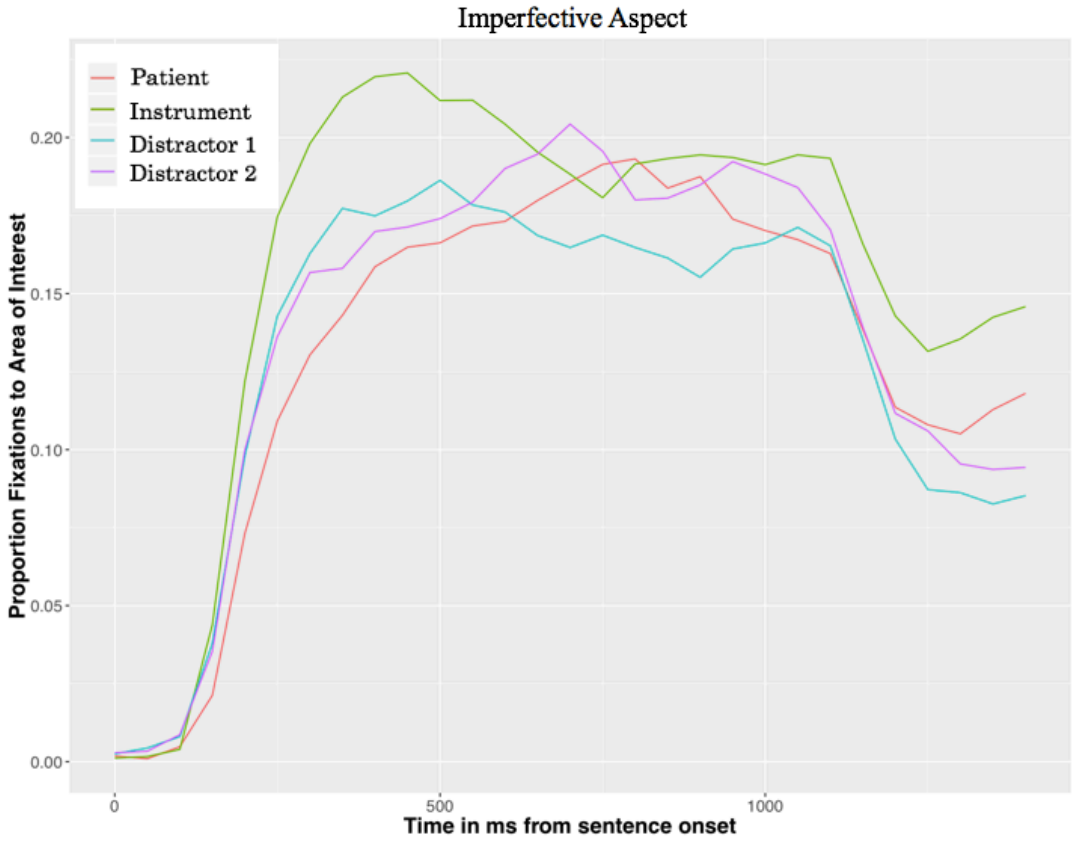

Figure 7. The average proportion of looks to the targets and distractors in the imperfective condition prior to the onset of auditory information. The preview period ends and the re-focusing procedure begins at 1000 ms.

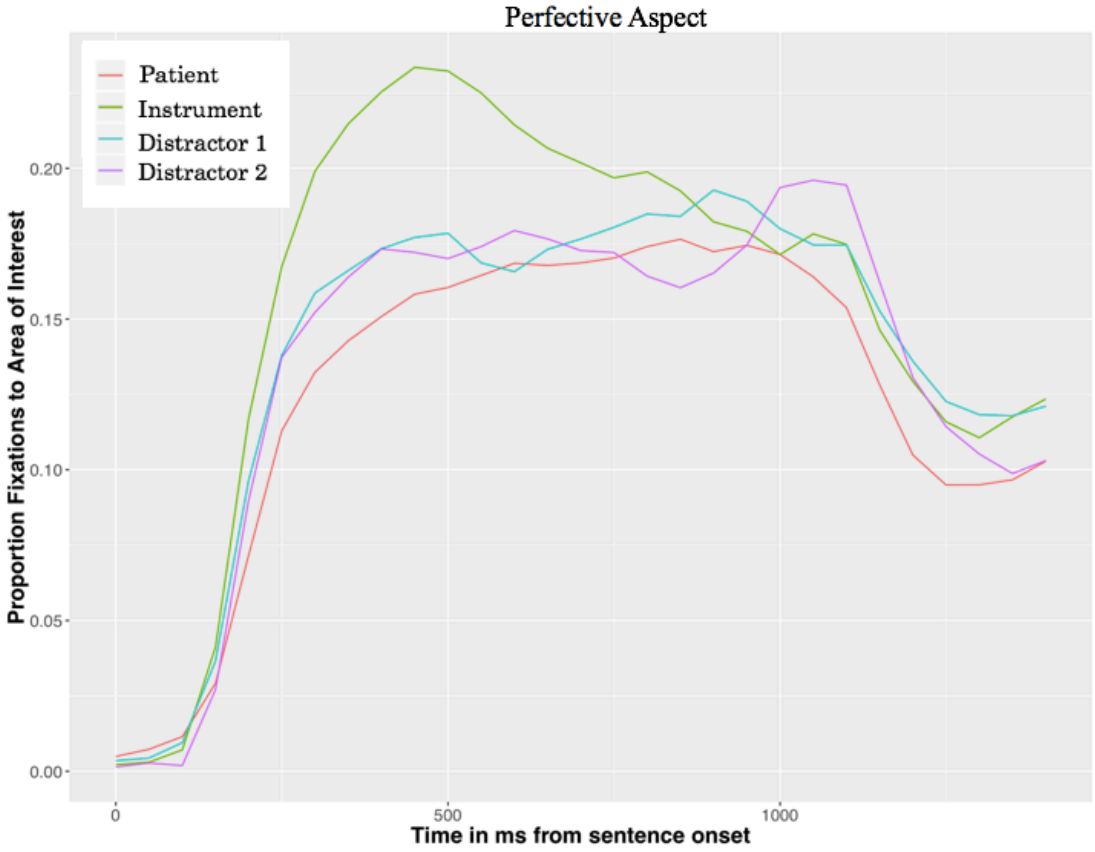

Figure 8. The average proportion of looks to the targets and distractors in the perfective condition prior to the onset of auditory information. The preview period ends and the re-focusing procedure begins at 1000 ms.

other images. This suggests that there is an inherently increased saliency for this type of image that we see not only in the preview period but throughout the duration of the sentence. This increase in looks to the instruments over the patients and the distractors was seen in both the imperfective and perfective trials. Importantly, the looks to the instruments were not significantly different between the two conditions. There are a number of possibilities for why these images were of particular interest to participants. One possible reason for this finding is that instruments are very easy to interact with and manipulate which may make them more interesting for the participants to focus upon. It is important to note that when hearing the imperfective aspect version of the sentence, this interest in the instrument appears to be further heightened.

General Discussion

Our study has built upon previous work, and has contributed to our understanding of how grammatical aspect impacts and influences sentence comprehension. Overall, the results demonstrate that people are sensitive to aspect as sentences unfold, in particular during processing of the verb. Based on Moens and Steedman's (1988) theory regarding the temporal structure of events (illustrated in Figure 1), we predicted that the imperfective aspect would highlight the ongoing nature of events and thus draw attention to the components of events that are of particular importance as an event is taking place. Furthermore, we predicted that the perfective aspect would highlight the completed nature of events and draw attention to the patient. We found that the imperfective aspect condition in our experiment did indeed highlight the ongoing nature of the events by demonstrating that participants focused more on the instruments than on the patients. As for the perfective condition, although there was not a significant increase in looks to the

patient, there was a decrease in looks to the instrument (in that they were no longer statistically more salient at the critical time of interest while hearing the verb). However, there was not a significant increase in looks to the patients over the instruments. These results highlight the importance of studying these subtle nuances of language that can have a rather profound influence on our choices both when producing and comprehending language.

Our results are consistent with many other studies that have demonstrated that grammatical aspect does impact the activation of event components. However, there is also a great deal of variation in the experimental design, and manipulations targeted within these studies, that has resulted in a rather diverse set of findings. These variations relate to a number of critical features, and the following section focuses on how these differences may have impacted what we know so far, and how they could influence future research. In addition, we discuss and compare our results to other studies of grammatical aspect with a focus on what might underlie differences in results.

Potential Influences / Further Inquiries

A main foundational motivation for the current study is the outcome from Truitt and Zwaan's (1997) study on the influence of grammatical aspect on processing the instruments of an event. Their study demonstrated that participants were faster to name an implied instrument after hearing the imperfective rather than the perfective version of a sentence. Truitt and Zwaan (1997) concluded that participants activated the instrument required to carry out the action while they were processing the imperfective version of the sentence, but not the perfective version. Our results demonstrate strong support for this finding. In our study, the focus on the ongoing nature of the event during the

imperfective sentences was shown to increase the availability of the instrument involved in the action, as evidenced by the participants' increased looks to the instrument while processing the verb. This provides an explanation as to why participants demonstrated shorter naming latencies for the imperfective aspect condition in the Truitt and Zwaan (1997) study.

Past perfect vs. simple past. It is also of interest to compare our results to the study conducted by Zhou et al. (2014), which is one of the few studies to investigate what participants focus on as a sentence is unfolding. They found increased looks to the ongoing scene while hearing the imperfective, and more looks to the completed scene while hearing the perfective version of an event. Our results are compatible with their imperfective condition in that we saw increased looks to the 'ongoing' event components (in our study, the instruments). However, we did not find evidence of looks to the 'completed' event components (the patients) for the perfective condition. One main difference between these studies is that Zhou et al. (2014) used the present and past tense as grammatical aspect was manipulated. That is, they used the present tense for the imperfective aspect ("The old lady is planting a flower"), and the past tense for the perfective aspect ("The old lady has planted a flower"). Therefore, it is possible that the difference in tense accounted for a portion of their findings on the influence of the imperfective and perfective aspect. In our study, we wanted to control for tense and only manipulated the grammatical aspect, keeping both versions of our sentences in the past tense and changing only whether the sentence used imperfective or perfective aspect.

While our study controlled for tense, there is another main point of divergence that can be seen in grammatical aspect experiments - the difference between using the

simple past (“She knitted the garment”) versus the past perfect (‘She had knitted the garment”). For our study we chose to use the past perfect, and we ensured the sentences were the same length and included an auxiliary prior to the verb. This was done to control for linguistic timing effects and to allow participants to read both types of sentences together in the same experiment without giving them any obvious cues regarding the imperfective and perfective conditions. In this case, the statements are fairly similar as they both put forward a completed action in the past tense, but is it possible for past perfect to imply a finished product more strongly than the simple past version? If this is the case, is it possible that people are thinking that events in the past perfect are farther away than events in simple past?

Both types of perfective (simple past and past perfect) have been used when studying the effects of grammatical aspect with a range of results, which suggests that this might not be a major reason for the differences. In opting for the concise simple past, Magliano & Schleich (2000) conducted an experiment in which participants rated follow-up sentences following either a perfective (“Wendy drove from Montana to New York”) or imperfective (“Wendy was driving from Montana to New York”) version of a sentence. They found that after hearing the imperfective aspect, sentences were considered ongoing; whereas the same sentences were considered completed after hearing the perfective aspect. Madden & Zwaan (2003) also used the simple past in investigating the differing effects of grammatical aspect on sentence comprehension. Their studies focused on access to either completed or ongoing pictures of events that preceded or followed sentences with either imperfective or perfective aspect. For example, for the sentence “The man ‘was making’ / ‘made’ a fire”, there was an ongoing

image of a man placing logs in a fireplace, and a completed image of a fire burning in the fireplace. All results demonstrated a strong preference for the completed pictures in association with the perfective version of the sentence. However, there was not any evidence linking the imperfective aspect with the ongoing images. This pattern of results is opposite to the pattern of results we saw in our study. These discrepancies highlight that there is still much to be investigated on the topic of linguistic effects and their impact on sentence comprehension while processing visual information. Given these differences in results, a potential follow-up study could further investigate aspectual differences between the use of past perfect and simple past.

Temporal duration. Another key study that demonstrated the effect of aspect on sentence comprehension was Mozuraitis et al.'s (2013) experiment that investigated how aspect influences the perception of the patient in the event. They found that participants had greater difficulty processing a subsequent event that included the patient from a previous sentence if they had heard the imperfective rather than the perfective version of the sentence. They concluded that the perfective form highlights completed events to a greater degree than does the imperfective aspect. From this study we hypothesized that the perfective condition in our experiment would similarly highlight the patient over the instrument and distractors. However, we did not see any significant increase in looks to the patient for the perfective condition, which is inconsistent with Mozuraitis et al.'s (2013) claim. A key difference between the studies is that their study also manipulated a second variable, the temporal duration of the events. The Mozuraitis et al. (2013) study investigated whether a longer event would show a greater difference between the types of aspect than would shorter events. They found that the processing of subsequent events

("She wore the new garment") was influenced by the aspect used for the preceding event ("She was knitting a sweater" versus "She knitted a sweater"), leading to longer processing times when the imperfective ('was knitting') was used for the preceding event. However, of critical importance is that this occurred for actions of long duration, but not for actions of short duration. This is an interesting finding that demonstrates the interplay between temporal duration and grammatical aspect. When further investigating the stimuli used in our study, many events are of a rather short duration (e.g., 'slicing the vegetables', 'photographing the scene', 'shooting the animal') as compared to some of Mozuraitis et al.'s (2013) events of longer duration (e.g., 'sewing a wedding dress', 'serving a 3-year prison sentence', 'recording a music album'). If temporal duration does indeed interact with the effects of grammatical aspect, this might explain the difference in results between studies.

Investigating whether manipulating temporal information can impact the processing of linguistic information has been of critical interest and importance over many years. A few studies have investigated the influences of temporal duration of events on sentence comprehension. For example, Joergensen and Gennari (2013) investigated how processing is influenced by varying event durations in the preceding context (e.g., "She had three hours to spare" versus "She had an hour to spare"). Participants completed an eye-tracking experiment using the visual-world paradigm and they found faster fixations to the object of interest after hearing the long versus the short condition. In addition, a follow-up probe recognition task showed participants were faster to respond to the probe word in the short condition versus the long condition. This study demonstrates the ability of temporal duration information to impact sentence comprehension. Similarly,

Anderson, Matlock, and Spivey (2013) investigated how grammatical aspect interacts with temporal duration using dynamic computer mouse tracking during sentence comprehension. They found that when processing the imperfective aspect paired with a recent temporal context (e.g., "Yesterday Paul was running to the lake"), there were smoother and faster mouse movements than when the imperfective was paired with a distant temporal context (e.g., "Last year Paul was running to the lake"). Likewise, they found similarly smooth and fast movements when the sentence in simple past was paired with a distant temporal context (e.g., "Last year Paul ran to the lake"), than when paired with a more recent one (e.g., "Yesterday Paul ran to the lake"). These results, and others, demonstrate the need to further investigate the interactions among very subtle linguistic characteristics when studying the impact of temporal span on language processing and comprehension.

Imperfective is unique. While both the imperfective and perfective aspect are past tense and relay very similar types of information, there seems to be something inherently unique about the imperfective. When hearing the imperfective in context, it seems to suggest that something else is about to happen after the current event being discussed. Since this information could be important, it follows that participants pay more attention to what is going on because they are anticipating another event of interest will follow. For example, in hearing "She was crossing the street", there seems to be an inherent momentum associated with this sentence that makes it feel like it is not the end of the sentence (or more importantly, not the end of the event; Dowty, 1986). This feeling of momentum is similar to the approach used in storytelling. It certainly would not be out of the ordinary to hear the words '… and then…', or '… when suddenly…', after hearing

a sentence; but may not sound as natural after hearing the perfective version. When you hear “She was crossing the street”, you are more likely to expect that something else is going to happen while she is still crossing the street. Many articles have demonstrated the differences in imperfective and perfective aspect as it relates to the processing and production of natural narrative discourse (Silva-Corvalan, 1983; Nakhimovsky, 1988). It is possible that stories told in the past tense might trend towards using the imperfective rather than the perfective because they are trying to relate what was going on at a certain point in time. This affords the ability to draw the listener's attention to the ongoing components of the event that is being shared, and may do a better job of the ‘mental time travel’ that is intended when telling a story.

This discussion also brings to mind the “imperfective paradox” described by Dowty (1977) which suggests that even if the imperfective aspect is used in a past tense scenario, it does not necessarily secure the event as having happened. Take the previous example “She was crossing the street”. Even though she was doing this in the past, this statement does not necessarily mean that she completed the action. She may have been interrupted, or decided to do something else. This possibility may be inherently implied by the imperfective aspect and could be why the ongoing event components are so readily available to the individuals comprehending the sentences. Since the imperfective aspect focuses the listener on the ongoing, they are more likely to expect to hear something that is relevant to the event that is unfolding. This difference in focus between the types of aspect opens up further avenues to investigate in looking at how linguistic information can impact understanding

The potential underlying influences discussed in this section are very important considerations for future studies of grammatical aspect and language comprehension in general. All of these experimental manipulations have provided different pieces of a larger puzzle. Putting these ideas together may lead to a better understanding of how they all interact with one another within different types of paradigms and stimuli.

Future direction. To build on this work, potential follow-up studies could look at how certain considerations can impact the influence of grammatical aspect on sentence comprehension. One interesting topic is of the distribution of images used in the current study. In most cases, both of the distractor stimuli and the patient are highly likely to be patients in actions, and highly unlikely to be instruments. There is a possibility that this could have increased the saliency of the instruments since they differed conceptually from the other three images. A potential follow-up study could use a distractor image that corresponds to something that is often used as an instrument as well as one that is not, allowing us to see whether this instrument saliency we found was simply a case of the instrument images standing out.

In addition, it would be beneficial for future work to look at the inherent image saliency and complexity in and of themselves. That is, determining a measure of complexity or interest in the particular images prior to their use in an experiment to see whether there are any inherent differences in the four images used for each of the sentences. Having this measure such as that could help determine whether it is the instruments themselves that are conceptually more interesting, or whether it may be the image complexity of the items used that is contributing to the findings.

Finally, additional consideration could be give to choosing the words referring to patients in the sentences. Since we used a generic broad-level classification of the patient, it is possible that the words we chose to use to represent patients were not consistently or strongly enough related to the images that we used. On one hand, there seems to be an inherently strong tie between the verb and the implied instruments used in the sentences (e.g., 'chop' and 'knife'). On the other hand, the ties between the noun used in the sentence (e.g., 'vegetable') and the patient (e.g. 'carrot) may not be as strong comparatively. The fact that these may have differed could have contributed to the pattern of results that we see. That is, there may have been some sentences where there were weaker relations between the patients and their respective images that may have decreased the probability of finding a difference between the perfective and imperfective for patients. Prior to identifying stimuli for use in the study, relatedness or cloze probability studies could be used to test for expectations regarding the instruments and patients as a way of equating their strength in relatedness.

These studies are of particular interest and can help shed light on the differences in patterns of results we have seen in studies of grammatical aspect. The considerations described in this section are of utmost importance in continuing to build our understanding of sentence processing and comprehension.

Conclusion

Sentence comprehension is a complex process that depends on a host of information, including people's knowledge of events. The critical influence that event knowledge plays has been shown to be largely tied to the underlying temporal span and event components involved. However, how these factors interact and influence one

another to create a smooth and effective comprehension process requires further investigation.

Our study has contributed to understanding how people interpret and process events, in that results showed that as sentences unfolded, participants were sensitive to grammatical aspect. This supports the notion that there is an on-line influence of aspect that impacts event comprehension. It appears that sensitivity to aspect is modulated by the temporal and causal structure of events to provide increased activation of different event components. While these results supplement a body of previous research and have added to our understanding of language processing and comprehension, many questions still remain which future research can seek to address.

References

Altmann, G. T., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, *73*(3), 247-264.

Altmann, G. T., & Kamide, Y. (2007). The real-time mediation of visual attention by language and world knowledge: Linking anticipatory (and other) eye movements to linguistic processing. *Journal of Memory and Language*, *57*(4), 502-518.

Altmann, G., & Mirković, J. (2009). Incrementality and prediction in human sentence processing. *Cognitive science*, *33*(4), 583-609.

Anderson, S. E., Matlock, T., & Spivey, M. (2013). Grammatical aspect and temporal distance in motion descriptions. *Frontiers in psychology*, *4*.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of memory and language*, *59*(4), 390-412.

Barr, D. J. (2013). Random effects structure for testing interactions in linear mixed-effects models. *Frontiers in psychology*, *4*.

Barsalou, L. W. (2009). Simulation, situated conceptualization, and prediction. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1521), 1281-1289.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, 67(1), 1-48.Doi:10.18637/jss.v067.i01.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of verbal learning and verbal behavior*, *11*(6), 717-726.

Comrie, B. (1976). *Aspect: An introduction to the study of verbal aspect and related problems* (Vol. 2). Cambridge university press.

DeLong, K. A., Urbach, T. P., & Kutas, M. (2005). Probabilistic word pre-activation during language comprehension inferred from electrical brain activity. *Nature neuroscience*, *8*(8), 1117-1121.

Dowty, D. R. (1986). The effects of aspectual class on the temporal structure of discourse: semantics or pragmatics? *Linguistics and philosophy*, *9*(1), 37-61.

Federmeier, K. D. (2007). Thinking ahead: The role and roots of prediction in language comprehension. *Psychophysiology*, *44*(4), 491-505.

Ferretti, T. R., McRae, K., & Hatherell, A. (2001). Integrating verbs, situation schemas, and thematic role concepts. *Journal of Memory and Language*, *44*(4), 516-547.

Ferretti, T. R., Kutas, M., & McRae, K. (2007). Verb aspect and the activation of event knowledge. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(1), 182.

Garnsey, S. M., Pearlmutter, N. J., Myers, E., & Lotocky, M. A. (1997). The contributions of verb bias and plausibility to the comprehension of temporarily ambiguous sentences. *Journal of Memory and Language*, *37*(1), 58-93.

Huettig, F., Rommers, J., & Meyer, A. S. (2011). Using the visual world paradigm to study language processing: A review and critical evaluation. *Acta psychologica*, *137*(2), 151-171.

Joergensen, G., & Gennari, S. P. (2013). Exploring representations of event duration in language. In *26th Annual CUNY conference on Human Sentence Processing*.

Kamide, Y., Altmann, G. T., & Heywood, S. L. (2003). The time-course of prediction in incremental sentence processing: Evidence from anticipatory eye movements. *Journal of Memory and Language, 49*(1), 133-156.

Madden, C. J., & Zwaan, R. A. (2003). How does verb aspect constrain event representations? *Memory & cognition*, *31*(5), 663-672.

Magliano, J. P., & Schleich, M. C. (2000). Verb aspect and situation models. *Discourse processes*, *29*(2), 83-112.

Matlock, T. (2011). The conceptual motivation of aspect. *Motivation in Grammar and the Lexicon*, *27*, 133.

Matsuki, K., Chow, T., Hare, M., Elman, J. L., Scheepers, C., & McRae, K. (2011). Event-based plausibility immediately influences on-line language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(4), 913.

McRae, K., Spivey-Knowlton, M. J., & Tanenhaus, M. K. (1998). Modeling the influence of thematic fit (and other constraints) in on-line sentence comprehension. *Journal of Memory and Language*, *38*(3), 283-312.

Metusalem, R., Kutas, M., Urbach, T. P., Hare, M., McRae, K., & Elman, J. L. (2012). Generalized event knowledge activation during online sentence comprehension. *Journal of memory and language*, *66*(4), 545-567.

Moens, M., & Steedman, M. (1988). Temporal ontology and temporal reference. *Computational linguistics*, *14*(2), 15-28.

Mozuraitis, M., Chambers, C. G., & Daneman, M. (2013). Younger and Older Adults' Use of Verb Aspect and World Knowledge in the Online Interpretation of Discourse. *Discourse Processes*, *50*(1), 1-22.

Murphy, G. L. (2002). The Big Book of Concepts (Bradford Books).

Nakhimovsky, A. (1988). Aspect, aspectual class, and the temporal structure of narrative. *Computational Linguistics*, *14*(2), 29-43.

R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Radvansky, G. A., & Zacks, J. M. (2014). *Event cognition*. Oxford University Press.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological bulletin*, *124*(3), 372.

Silva-Corvalán, C. (1983). Tense and aspect in oral Spanish narrative: Context and meaning. *Language*, 760-780.

Sanford, A. J., & Garrod, S. C. (1981). *Understanding written language: Explorations of comprehension beyond the sentence*. John Wiley & Sons.

Tanenhaus, M. K., & Trueswell, J. C. (1995). Sentence comprehension.

ter Meulen, A. G. B. (1995). *Representing time in natural language: The dynamic interpretation of tense and aspect.* Cambridge, MA: MIT Press.

Truitt, T. P., & Zwaan, R. A. (1997, November). Verb aspect affects the generation of instrument inferences. In *38th annual meeting of the Psychonomic Society, Philadelphia*.

Van Berkum, J. J., Brown, C. M., Zwitserlood, P., Kooijman, V., & Hagoort, P. (2005). Anticipating upcoming words in discourse: evidence from ERPs and reading times. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*(3), 443.

Van Dijk, T. A., Kintsch, W., & Van Dijk, T. A. (1983). *Strategies of discourse comprehension* (pp. 11-12). New York: Academic Press.

Van Petten, C., & Luka, B. J. (2012). Prediction during language comprehension: Benefits, costs, and ERP components. *International Journal of Psychophysiology*, *83*(2), 176-190.

Vendler, Z. (1957). Verbs and times. *The philosophical review*, 143-160.

Vendler, Z. (1967). Causal relations. *The Journal of philosophy*, *64*(21), 704-713.

Verkuyl, H. J. (1996). *A theory of aspectuality: The interaction between temporal and atemporal structure* (Vol. 64). Cambridge University Press.

Vu, H., Kellas, G., Petersen, E., & Metcalf, K. (2003). Situation-evoking stimuli, domain of reference, and the incremental interpretation of lexical ambiguity. *Memory & Cognition*, *31*(8), 1302-1315.

Zacks, J. M., & Tversky, B. (2001). Event structure in perception and conception. *Psychological bulletin*, *127*(1), 3.

Zacks, J. M., Tversky, B., & Iyer, G. (2001). Perceiving, remembering, and communicating structure in events. *Journal of Experimental Psychology: General*, *130*(1), 29.

Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007). Event perception: a mind-brain perspective. *Psychological bulletin*, *133*(2), 273.

Zhou, P., Crain, S., & Zhan, L. (2014). Grammatical aspect and event recognition in children's online sentence comprehension. *Cognition*, *133*(1), 262-276.

Appendix A

Experimental Stimuli (Perfective Aspect) *

Sentence	**Instrument Image**	**Patient Image**
"She had dried the flatware"	Tea towel	Cutlery
"The man had sliced the vegetables"	Knife	Carrot
"The woman had chopped the wood"	Axe	Log
"She had shaved herself"	Razor	Legs
"He had written the reply"	Pen	Letter
"The man had weighed the ingredients"	Scale	Flour
"The woman had knit the garment"	Needles & Yarn	Scarf
"She had sewn the clothes"	Sewing Machine	Dress
"She had stirred the liquid"	Spoon	Soup
"She had poured the beverage"	Teapot	Tea
"He had hit the ball"	Bat	Baseball
"He had shot the animal"	Gun	Deer
"The man had built the furniture"	Hammer	Chair
"She had pruned the shrub"	Garden Shears	Tree
"The woman had wiped the surface"	Cloth	Table
"The woman had trimmed the hair"	Scissors	Hair
"The woman had swept the room"	Broom	Floor
"The man had assembled the toy"	Screwdriver	Rocking Horse
"He had washed the vehicle"	Sponge	Car
"She had painted the house"	Paintbrush	Wall
"The woman had dusted the shelf"	Duster	Cabinet
"The man had hunted the beast"	Bow & Arrow	Bison
"She had wrapped the leftovers"	Tinfoil	Pizza
"The woman had groomed the pet"	Brush	Dog
"The woman had vaccinated the person"	Syringe	Arm
"He had roasted the meat"	Barbeque	Roast
"The woman had baked the dessert"	Oven	Cupcake
"The man had photographed the scene"	Camera	Landscape
"She had drained the pasta"	Strainer	Spaghetti
"He had caught the insect"	Net	Butterfly
"He had drawn the picture"	Crayon	Picture
"The man had unlocked the entrance"	Key	Door

* Note: Each sentence was changed from 'had verb+ed' to 'was verb+ing' for the Imperfective Condition.

Appendix B

Filler Items

Sentence

"The cat chased the mouse"
“The boy wants to eat candy”
“Linda likes apples and ice cream”
“The man with the hat is my teacher”
“Breakfast is Nicole’s favorite meal of the day”
“My nephew will turn four next week”
“The red bicycle was found near the cabin”
“We’re going to make a fire on the campground”
“The bird caught the worm”
“Rachel went to see the movie”
“My aunt works as a nurse”
“There is a lot of snow in winter here”
“Kids like getting presents on Christmas”
“The eagle saw the bee”
“The boat trip took two hours”
“The pilot saw the train”
“The racoon searched the garbage”
“My mother used her boot to kill the fly”
“The baby kept trying to crawl out of the crib”
“Michael loved hunting for bears”
“She was shopping and found a new bag”
“The boys liked traveling best using a skateboard”
“My little sister found a ladybug in the mailbox”
“Karen likes gardening with the wheelbarrow”
“The baby would throw fruit in the highchair”
“My grandpa loves to carve pumpkins on Halloween”
“My friend had the coolest t-shirts”
“The businessman wears a tie”

Practice Items

“The bus driver didn’t see the traffic sign”
“My little sister likes swimming in the lake”
“The child fed the pigs”
“We would always sit around playing the banjo”

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Spalding, T.L., Gagné, C.L. & **Nisbet, K.A.** (2017). If Birds Have Sesamoid Bones, do Blackbirds Have Sesamoid Bones? The Modification Effect With Known Compound Words. *Journal of Experimental Psychology: Learning, Memory, and Cognition.* Submitted.

Nguyen, P., Roberts, A., Orange, JB., Jog, M., **Nisbet, K.A.**, McRae, K. (2016). Differential Impairments of Upper and Lower Limb Movements Influence Action Verb Processing in Parkinsons Disease. *Cortex.* Manuscript in preparation.

Presentations:

Nisbet, K.A., Chamberlain, C.L., Gagné, C.L., & Spalding, T.L. (November 2015). *An examination of the modification effect in compound words.* Presented at the Psychonomic Society's 56th Annual Meeting, Chicago, USA.

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Gagné, C.L., Spalding, T.L., ***Nisbet, K.A.**, & Armstrong, C. (November 2014). *Opaque and Pseudo- compounds: Effects of (Pseudo) Morphemic Structure.* Presented at the Psychonomic Society's 55th Annual Meeting, Long Beach, California, USA.

Gagné, C.L., Spalding, T.L., ***Nisbet, K.A.**, & Armstrong, C. (October 2014). *Effects of Masked (pseudo)Morpheme Repetition Priming using opaque and pseudo-compounds*. Presented at the 9th International Conference on the Mental Lexicon, Niagara-On-The-Lake, ON, Canada.

Spalding, T.L., Gagné, C.L., **Nisbet, K.A**., & Park, J.R. (October 2014). *Inter-letter typing speed as an index of morphological processing.* Presented at the 9th International Conference on the Mental Lexicon, Niagara-On-The-Lake, ON, Canada.

Nisbet, K.A., Gagné, C.L., & Spalding, T.L. (July 2014). *Processing of (pseudo)constituents in English opaque and pseudo-compounds: Effects of morphemic structure.* Presented at the Canadian Society for Brain, Behaviour, and Cognition Science's 34th Annual Meeting, Toronto, Ontario.

Nisbet, K.A., Gagné, C.L., & Spalding, T.L. (March 2014). *A comparison of Various Measures of Transparency in English Compounds.* Presented at the 28th Annual Joseph R. Royce Research Conference, Edmonton, Alberta, Canada.

Robertson, K., Gore, S., **Nisbet, K.A.**, Gagné, C.L., & Spalding, T.L. (March 2014). *Studying Morphological processing of English compounds using typing time.* Presented at the 28th Annual Joseph R. Royce Research Conference, Edmonton, Alberta, Canada.

Nisbet, K.A., Cheung, S., Gagné, C.L., & Spalding, T.L. (November 2013). *A comparative analysis of three measures of semantic transparency.* Presented at the 3rd Annual Undergraduate Research Symposium, Edmonton, Alberta, Canada.

Nisbet, K.A., Robertson, K., Fox, W., Gagné, C.L., & Spalding, T.L. (November 2013). *Written Production of English compound words: Typing time as an index of morphological processing.* Presented at the 3rd Annual Undergraduate Research Symposium, Edmonton, Alberta, Canada.

Gagné, C.L., **Nisbet, K.A.**, Spalding, T.L., (November 2013). *Typing English Compounds:Effects of Semantic Transparency and Semantic Priming.* Poster presented at the 54th Annual Meeting of the Psychonomic Society, Toronto, ON.

Nisbet, K.A., Cheung, S., Gagné, C.L., & Spalding, T.L. (March 2013). *A comparison of measures of semantic transparency in English Compounds.* Presented at the 27th Annual Joseph R. Royce Research Conference, Edmonton, Alberta, Canada.