EFFECTS OF SYNTACTIC CUES ON EYE MOVEMENTS DURING SENTENCE COMPREHENSION IN YOUNG ADULTS

by

Mary Mitkish

Communication Science and Disorders, University of Pittsburgh, 2015

Submitted to the Graduate Faculty of

The University of Pittsburgh in partial fulfillment

of the requirements for the degree of

Bachelor of Philosophy

University of Pittsburgh

2015

UNIVERSITY OF PITTSBURGH

SCHOOL OF HEALTH AND REHABILITATION SCIENCES

This thesis was presented

by

Mary Mitkish

It was defended on

April 3, 2015

and approved by

Dirk den Ouden, Ph.D., Communication Sciences & Disorders, University of South Carolina

Christopher Brown, Ph.D., Communication Science & Disorders, University of Pittsburgh

Erin Lundblom, Ph.D., Departmental Communication Science & Disorders, University of Pittsburgh

Thesis Director: Michael Walsh Dickey, Ph.D., Communication Science & Disorders, Psychology, University of Pittsburgh

EFFECTS OF SYNTACTIC CUES ON EYE MOVEMENTS DURING SENTENCE COMPREHENSION IN YOUNG ADULTS

Mary Mitkish

University of Pittsburgh, 2015

Purpose: To use the eyetracking paradigm to explore how young healthy adults take advantage of semantic information provided by a verb cue versus syntactic information associated with WH- cues. The goal is to determine how predictive processing works in a young normal population.

Method: 27 college-aged participants listened to audio content while simultaneously looking at a related visual display. Their eyes were tracked for the duration of the study in order to determine where they fixated during critical parts of each trial. Recordings of their eye movements were then statistically analyzed and interpreted.

Results: The WH- cue has a much stronger and quicker effect on predictive tendencies than the verb cue alone. In WH- conditions, subjects fixated on the direct object both faster and more consistently than in the Y/N conditions. These results show that the verb cue alone has a weaker and slower effect on predictive tendencies than the WH- cue.

Conclusion: For young unimpaired individuals, the WH- conditions allowed for faster prediction. These findings provide a basis for future studies which will help determine treatment for aphasia. Performing the same experiment on aphasic individuals will allow us to determine how to scaffold treatment efforts based on which cue is stronger and weaker for this population.

TABLE OF CONTENTS

PREFACE ..... **IX**

1.0 INTRODUCTION **1**

1.1 THE VISUAL WORD PARADIGM AND PREDICTION **6**

1.1.1 Kamide (2008) **6**

1.2 SYNTACTIC CUES TO PREDICTION: VERB TRANSITIVITY BIAS AND WH- QUESTION STRUCTURE **9**

1.2.1 Sussman and Sedivy (2003) **9**

1.2.2 Pickering and Traxler (2003) **14**

2.0 THE PRESENT STUDY **20**

2.1 PURPOSE **21**

2.2 DESIGN **21**

2.3 HYPOTHESIS **23**

3.0 METHODS **25**

3.1 PARTICIPANTS **25**

3.2 MATERIALS **25**

3.3 PROCEDURE **26**

3.3.1 Screening Tasks **27**

3.3.2 Experimental Tasks **28**

4.0 RESULTS 30

5.0 DISCUSSION 42

6.0 CONCLUSION 45

APPENDIX A 47

APPENDIX B 54

BIBLIOGRAPHY 63

LIST OF TABLES

Table 1: Pickering & Traxler (2003), Experiment 1 summary of results 17

Table 2. Mean durations across conditions. 26

Table 3. Significant effects of target looks for each bin 33

Table 4. Significant effects of object looks by bin 37

LIST OF FIGURES

Figure 1. Target clicks across conditions..... 30

Figure 2. Images clicked for condition c 32

Figure 3. Looks to the target across conditions by number of milliseconds after the verb 33

Figure 4. Looks to direct object across conditions by number of milliseconds after the verb 36

PREFACE

I would like to sincerely thank many people who contributed endless time, effort, and support throughout this whole process.

My committee has provided valuable input and generosity, making this project and defense of this thesis possible:

- Dr. Michael Walsh Dickey, my thesis advisor and guiding hand. I cannot describe how grateful I am to have had Dr. Dickey as my mentor and colleague in this. His enthusiasm for research and his unparalleled knowledge have truly inspired me. None of this would have been possible without him.
- Dr. Erin Lundblom for her eagerness to participate as a member of my committee, as well as for her always-uplifting words as my Communication Science and Disorders advisor.
- Dr. Christopher Brown for his willingness to serve on my committee before I had even fully wrapped my head around my own project, despite having his own BPhil candidate to worry about.
- Dr. Dirk den Ouden, my external examiner, for his contributions and expertise in the field. I am appreciative that despite not having met Dirk in person, his valuable time will be spent traveling to Pittsburgh and participating in this defense.

The University Honors College, which offers this special degree and makes this undergraduate research experience possible.

Members of the Language and Brain Lab thank you for your endless time and moral support, I will never forget your small and large kindnesses. Special thanks to Rebecca Hayes, who always took time out of her extremely busy schedule to work patiently with me while I learned. Without her, I would be forever lost in a world of statistics and Excel.

Finally, my friends and family, especially Nicholas Dryslewski, for listening to my complaints and offering limitless support and encouragement. If it were not for all of you, I would have been overwhelmed and alone.

1.0 INTRODUCTION

Verbs have been an integral topic in studies investigating language processing (Altmann & Kamide, 1999; Garnsey, Pearlmutter, Myers & Lotocky, 1997), and they play an important role in many communication disorders (like aphasia) which are central to speech-language pathology research and clinical practice (Bastiaanse & Jonkers, 1998). Listeners use verbs to rapidly understand sentences, predicting the likely next word or phrase based on both semantic and syntactic information associated with verbs. The present study will again look to verbs, to determine the ways in which listeners predict upcoming parts of sentences. Specifically, Wh-questions will be compared to yes/no questions to determine which cues associated with these two question types – syntactic cues for Wh- questions versus verb-based semantic cues for yes/no questions – has a greater influence on sentence prediction. The overall goal is to better understand which of these two types of cues or information can be more helpful in guiding listeners in understanding words and sentences.

Being able to predict or "fill in" the next word of a phrase or sentence is often used clinically for individuals suffering from aphasia, in standardized aphasia test such as the Western Aphasia Battery (WAB) and in semantic cuing treatments (like in Wambaugh, 2003). For example, an item in the WAB asks patients to complete the following sentence: "Roses are red, violets are____" (Kertesz, 1982, 2006). Unimpaired individuals will have no problem predicting the word "blue," and even people with relatively severe aphasia will often be able to complete

this phrase. The ability to use the information in a strongly constraining phrase like “Roses are red, violets are __” to choose the right word is also often used in semantic cueing treatments for aphasia. If a person with aphasia cannot find the word “fork,” a speech-language pathologist may provide a semantically constraining sentence like “She ate her dinner with a knife and __” to help the person say “fork” (Love & Webb, 1977; Wambaugh, 2003). Using prediction clinically helps patients diagnosed with aphasia to utilize the inherent quality of predictive tendencies to improve their language processing abilities.

Prior research has shown that verbs, and the syntactic and semantic information they provide, are extremely important to language processing (Kamide 2008, Pickering and Traxler 2003, Sussman and Sedivy 2003, Clifton, et al. 1984). People can use syntactic information or semantic information from verbs to make predictions about upcoming words in a sentence. *Verb transitivity bias* is an example of syntactic verb-related information. It is defined as the likelihood of a verb to take a direct object (highly transitive verbs like *lick* are extremely likely to take a direct object, and intransitive verbs like *dance* are extremely unlikely to be followed by a direct object). Clifton, et al’s (1984) study provides evidence that verb transitivity helps unimpaired adults to predict the next word of a sentence. In their study, they had people read sentences one word at a time. People were interrupted at various points in the sentences, and they also had to make a decision about whether an unrelated string of letters was a word or not. The sentences contained verbs which were highly transitive, like *read*, meaning that when people see this verb, they tend to expect or predict that it will be followed by a direct object, like “the book.” Readers were extremely fast when they encountered transitive verbs being used transitively, for example in the partial verb phrase “read the” in the sentence “The babysitter read the ...” They were also very fast to make the decision about the letter string after seeing “read

the." But when they encountered transitive verbs being used intransitively (i.e. "read to" in "The babysitter read to"), reading times slowed significantly (Clifton et. al 1984). They were also much slower to make the decision about the letter string. The slower sentence reading times and decision times when the sentence structure was in conflict with the verb's transitivity bias indicates that verb transitivity is extremely important to how people understand sentences. It also indicates that people make predictions about the words coming next in sentences based on verb transitivity information. Verb transitivity has been well studied by other researchers such as Trueswell, Tanenhaus & Kello (1993), Garnsey et al. (1997), Arai and Keller (2012), and many more. DeDe (2013) has shown that verb transitivity can also affect how people with aphasia make predictions about what is coming next in a sentence.

A verb's semantic information can also help listeners predict what is coming next. A 1999 study by Altmann and Kamide gives a prime example of how semantic information from a verb like "eat" guides people to expect a direct object. Altmann and Kamide (1999) had people (college-aged students) do a visual world experiment. They found that when given a sentence like "The boy will eat the cake" while looking at a visual display with cake being the only edible object, participants were very quick to look at the cake after hearing the verb "eat." They looked at the image of the cake even before hearing "cake." However, they did not look at the cake until after hearing the word "cake" in a sentence like "The boy will move the cake." This is because "eat" requires an edible direct object, while "move" does not. Kamide, Altmann and Haywood (2003), Kamide (2008), and many others have also studies how a verb's semantic information can guide people to predict what words or phrases are coming next in a sentence.

However, another type of information which helps people make predictions is Wh-question words and structures. This type of information is also syntactic and will also be

explored in the current study. Wh- question words like “who” or “what” are always associated with a verb (like “read” or “eat”) or a preposition (like “to” or “from,” in “read to” or “eat with”). The verb or preposition that the Wh- word goes with indicates what the question is asking about. There is evidence that Wh- words can play a part in sentence prediction in a more top-down manner. When people hear or read a Wh- word, they may predict that a verb or preposition is coming, that the Wh- word is associated with. Many studies have shown that people do predict an upcoming verb or preposition when they hear or read a Wh- word, and that they want to associate the Wh- word with the first verb or preposition they hear (Traxler & Pickering, 1996, Stowe, 1986). For example, in a 2003 visual-world study with young people, Sussman and Sedivy compared sentences like “Did Jody squash the spider with her shoe?” versus “What did Jody squash the spider with?” comparing the differences in processing yes/no questions and Wh- questions. Only the Wh- question has a Wh- word, which should make people predict that a verb or preposition is coming. They found that participants do, in fact, process these two types of sentences differently. Participants expected that “what” was associated with “squash,” and that the question was asking about what Jody was squashing (instead of asking about what Jody was squashing a spider with). This evidence, and additional research, will be discussed further later on.

Overall, these two kinds of cues can both help people make predictions about what words or phrases are coming next in a sentence. They may be able to work together to help people make strong predictions, or they may work in conflict with each other. This is the question that the present study sets out to answer. We will explore if eye movements and target-selection data differ between Wh- and yes/no questions in young adults completing a visual-world study similar to Sussman and Sedivy’s 2003 study. We will also explore the same question in regards

to direct-object-fixation data. Yes/no questions only have verb-based syntactic and semantic information to guide people's predictions about what words are coming next. In the current study, verbs will primarily contribute semantic information regarding what is likely coming next. Wh- questions have not just verb-based information but the additional Wh- word syntactic cues to prediction. Comparing these two types of sentences will allow us to find out which cue, if either, is more important than the other in sentence processing. If participants are focused on the verbs alone, we will not see a difference between Wh- and yes/no questions, since they both have verb-based cues. However, if there is a difference between test conditions (Wh- versus Y/N conditions), then it is likely that the Wh- word is having a significant effect on people's predictions about how the sentence is going to continue, independent of verb-based information (Altmann & Kamide, 1999; Kamide, 2008).

In summary, the goal of the present study is to hone in on the effects that verbs versus other types of information offer towards prediction, using verbs that may provide semantic verb-based information but are neither strongly transitive nor intransitive. Does the verb alone offer our strongest cue for what is coming next in the sentence, or do Wh- questions offer a stronger cue for the same goal? This will create situations of conflict, with sentences that lead listeners to predict one thing and then surprise them with another. Seeing how people resolve this conflict will reveal which cue (the Wh- structure or the verb) is leading listeners towards one prediction over another.

Since this question has not been explored directly so far in research, my BPhil project focuses on providing a strong foundation for normal processing, so that future research can explore these affects in disordered individuals. I tested a younger unimpaired population, targeting mostly college-age individuals. The visual world paradigm is employed for this study

in order to use a very sensitive on-line means of collecting data. By using eye tracking, we can see direct, immediate, and unconscious results that are not offered by other tasks such as self-paced reading. Studies using eye-tracking (and the visual-world paradigm) have also provided strong evidence that people use verb-based information to make predictions about words and phrases coming next in a sentence (Kamide, 2008).

It is my hope that by conducting this initial research, further research can be built upon it to apply to individuals with impairments. Verb processing plays an extremely important role in our ability to understand conversation and verb-processing is often extremely difficult for people with aphasia, especially. Prior research has already hinted at the possibility that people with aphasia are able to predict and comprehend a sentence as it is being presented, but lose track of it when asked to respond to the sentence (Dickey, Choy & Thompson, 2007). Prior research has also shown that people with aphasia are very sensitive to verb-based information, especially verb transitivity information (DeDe, 2013). If I can build a base to better understanding of verb processing and which cues allow people to use predictive processing to understand sentences, it is possible that this can be applied to treatment methods.

1.1 THE VISUAL WORD PARADIGM AND PREDICTION

1.1.1 Kamide (2008)

In a 2008 systematic review done by Yuki Kamide, evidence in favor of the use of the visual-world paradigm to show predictive language skills is presented. The visual-world

paradigm is an experimental method where people listen to words or sentences while looking at images that go with the words and sentences they are hearing. It is based on the finding that people automatically look at a picture that goes with a word, within 200 milliseconds of hearing the word (Cooper, 1974). How quickly someone looks at a picture that goes with a word shows how quickly and accurately they have understood the word.

Kamide suggests that the language processing system should function as an anticipatory system as long as the benefits of anticipation outweigh the costs (Kamide 2008). For example, if predicting what will come next in a sentence will allow for a quicker conclusion and saved time, the listener or reader will likely try to anticipate what comes next. If a garden-path sentence is presented, where people are led to expect one continuation but then hear words that don't fit with their expectations, the cost of prediction outweighs the benefits. A listener must backtrack to the beginning of the sentence and disambiguate what they heard. However, as Kamide points out, much evidence shows that the language processing system does not wait to hear the end of a sentence, but rather starts to predict upcoming information before it is offered. With this in mind, the current study aims to disambiguate which factors contribute to the predictions participants will make based on the lexical information presented to them.

Kamide notes one of the first visual-world paradigms which looked at anticipatory responses performed by Altmann and Kamide in 1999. In this experiment, the researchers looked to see when predictions occurred in a sentence, based on information associated with a verb. They presented people with sentences like "The child will eat/move the cake," and measured how quickly people gazed at an image of the verb's object (a picture of a cake on a computer screen). They found, in support of their hypothesis, that participants tended to look at the target object (the picture of the cake) while still hearing the verb, prior to any information about the

object. However, they only looked at the object when the meaning of the verb allowed them to predict what was coming next: they looked at the cake when they heard “eat” but not “move.” This finding suggests that people may use the meaning of a verb (a semantic cue) to predict the next word or phrase in a sentence. Another visual-world study by Kamide, Altmann and Haywood (2003) also found that people used the meaning of verbs and subjects to predict what was coming next in a sentence. In that study, people heard sentences like “The girl/man will ride the carousel.” They were faster and more likely to look at a picture of the carousel for “The girl will ride the carousel” than for “The man will ride the carousel,” because girls are more likely to ride carousels than men are.

The results of these experiments hint at the idea that the level of verb transitivity may also play a role in the anticipatory process. Kamide notes that “the integration takes place rapidly enough to make anticipation of a semantic domain of a forthcoming object possible” (2008). Evidence from Altmann and Kamide (1999) and Kamide et al. (2003) also supports the possibility of transitivity bias having an effect on the number of looks and quickness to look at the target objects. Verbs like “eat” and “ride” are often followed by an object in general, and they were always followed by an object in these experiments. Because of this, people may have expected that the verbs they were hearing would always be followed by an object, and the transitive structure may have had a strong influence on the results of this particular experiment.

Kamide mentions other visual-world studies such as Boland (2005) which offer more support that the anticipatory process takes place at the onset of the verb in a given sentence, further indicating a preference to make predictions based on the verb. However, neither Wh-questions nor the direct influence of verb transitivity were taken into consideration which leaves some room for further experimentation and interpretation. It must be noted that while Kamide

offers up evidence in favor of predictions, she does not provide any insight as to how or whether syntactic information helps people to make these anticipatory guesses; this is the focus of the current study.

1.2 SYNTACTIC CUES TO PREDICTION: VERB TRANSITIVITY BIAS AND WH-QUESTION STRUCTURE

1.2.1 Sussman and Sedivy (2003)

In a 2003 study by Sussman and Sedivy, syntactic cues to prediction were brought into play. Sussman and Sedivy examined two types of syntactic cues, wh- question structure and verb transitivity. Verb transitivity is defined as the likelihood of a verb to take an object. A transitive verb is a verb that is very likely to take a direct object, for example, a verb like "lick." An intransitive verb is highly unlikely to take a direct object (i.e., "swim"). Sussman and Sedivy focused on whether listeners expect an object following a strongly transitive verb, and if this expectation is affected by a Wh- question. Wh- questions provide another kind of syntactic cue that may help people make predictions about the upcoming structure of the sentence. As described above, when people hear or read a Wh- word, they can predict that a verb or preposition is coming, which the Wh- word is associated with. Other studies not using the visual-world paradigm have shown that people do predict an upcoming verb or preposition when they hear or read a Wh- word, and that they want to associate the Wh- word with the first verb or preposition they hear (Traxler & Pickering, 1996, Stowe, 1986). Sussman and Sedivy tested

whether having a Wh- word cue caused people to have stronger predictions about what was coming next than just a strongly transitive verb did.

In the experiment, participants were presented with auditory and visual information simultaneously while their eye movements were tracked. Much like the current study, Sussman and Sedivy's experiment consisted of a story followed by one of two types of sentences: Wh-questions or yes/no formatted questions. For example, after hearing a story, the participant would be asked either "What did Jody squash the spider with?" or "Did Jody squash the spider with her shoe?" (2003). The purpose of these questions is to see whether the presentation of a Wh-question caused listeners to search for a possible gap site above all else, which would prove it to be a more significant linguistic cue as opposed to verb-based cues, including verb transitivity. The Wh- questions contain a Wh-word cue for predicting an upcoming object, plus a verb-based cue from the strongly transitive verb "squash." Sussman and Sedivy cited Altmann and Kamide (1999) in favor of verb-based cues, who showed that verbs such as "eat" evoke looks to the only edible object presented, whereas verbs such as "move," which can be applied to any object, did not elicit an anticipatory eye movement to any specific object.

The hypotheses made by Sussman and Sedivy include a hypothesis favoring Wh-questions as an inducer of an active search for an object gap by the participants (Frazier & Flores d'Arcais, 1987). Since Wh- questions beg to be resolved early on, it seems likely that participants will start to search for that resolution as soon as the Wh- word is presented. This should make them expect a verb as soon as possible, so that they can associate the Wh- word with that verb and answer the Wh- question. This should make them look to the object of the verb "squash," because they have understood the Wh- question as asking "What did Jody squash?" On the other hand, when a yes/no question is presented, it is unlikely that an active

search will be triggered because these types of questions do not contain overt fillers or gap sites, meaning there is no indication for the listener that they should expect a verb or an upcoming object until they hear the verb itself. One major difference to note between this study and the current study is that Sussman and Sedivy only included verbs with a strong transitivity bias, whereas the present study included verbs are neither strongly transitive nor strongly intransitive. However, despite this difference, the results shown by Sussman and Sedivy are in line with the initial expected outcome of the current study (see Hypotheses and Predictions below).

To illustrate the format design of the experiment, Sussman and Sedivy provide the following stimulus example:

"Jody was eating breakfast one morning when she saw a big hairy spider creeping across the table towards her. Jody, whose terrible arachnophobia had caused her to seek therapy a few years ago, drew on the techniques of relaxation and anxiety management that her psychologist had taught her. Instead of screaming or freaking out, she calmly took off her shoe and slammed it down on top of the spider. She ate the rest of her Froot Loops in peace."

Did Jody squash the spider with her shoe?/ What did Jody squash the spider with?

Eye movements were recorded from the onset of "did" to the offset of the preposition. The graphical data is presented below in Figures 1 and 2 for clarification of Sussman and Sedivy's results:

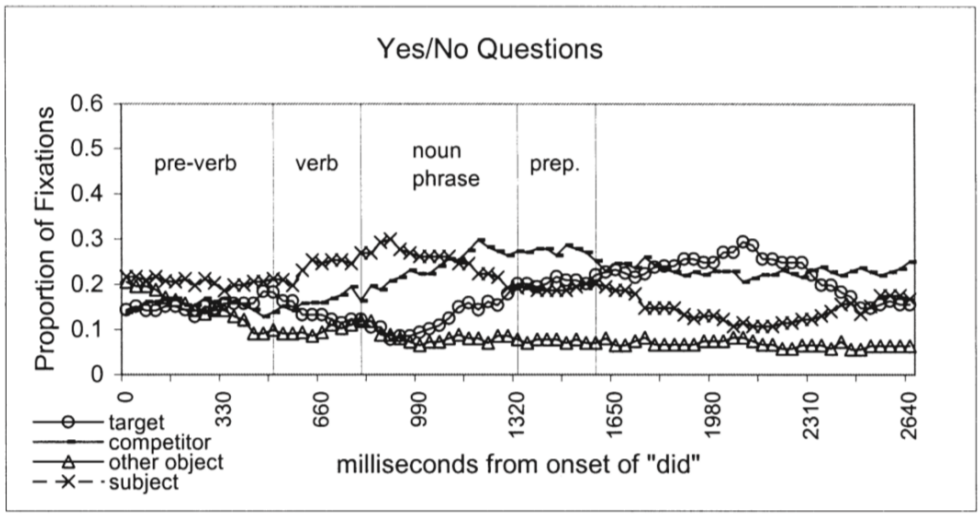

Figure 1. Sussman and Sedivy 2003 time-course of processing syntactic dependencies for Y/N condition

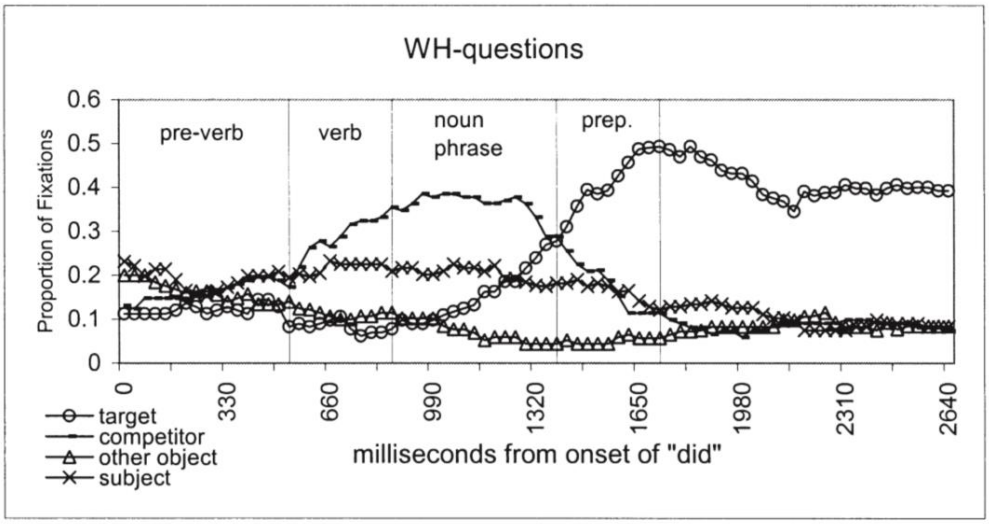

Figure 2. Sussman and Sedivy 2003 time-course of processing syntactic dependencies for WH- condition

In the figures presented above, subjects' gazes at the subject of the sentence, the direct object (competitor), the oblique object (target), or the "other" related image are plotted over time. Sussman and Sedivy found that yes/no questions elicited fixations that were consistent with participants' gazes simply following the words in the presented sentence. For example, looks to the subject spike around 400ms after the onset of the subject. More interestingly, when presented

with Wh- questions, participants showed a pattern of prediction rather than simply reaction to the sentence. “Looks to the competitor (direct object referent) begin to rise approximately 50 ms after the onset of the verb, and peak at about 150 ms after the offset of the verb. This peak is higher than that observed in the yes/no condition” (Sussman & Sedivy, 2003: 152). When participants realize that the competitor cannot be the correct response, looks to the competitor drop off immediately and looks to the target response rise quickly in the Wh- question condition. These results tell us that the Wh- question cue gave a boost to predictions about the upcoming words in a sentence, beyond any predictions that were based on the strongly transitive verb “squash.” These results directly support Sussman and Sedivy’s hypothesis, which is again tested in the current study.

In the current study, the question of whether the influence of verb information in guiding prediction is greater or less than the influence of a Wh- word cue is the main focus. Sussman and Sedivy suggested that participants anticipated the direct object more strongly in the Wh- question condition than in the Y/N question condition. This result suggests that people are more strongly guided in their predictions by that syntactic cue than by the syntactic and semantic cues associated with the verb. However, by using all highly transitive verbs like “squash,” Sussman and Sedivy steer the listeners in a particular direction more quickly than if listeners heard a variety of verbs, both strongly transitive and strongly intransitive. This is the approach taken by Pickering and Traxler (2003), described below. By using more neutral verbs, the goal of the present study is to inspect the influence of the Wh- word’s syntactic cues and the verb’s semantic cues in both the Y/N form and the WH- form. Using verbs that are neither strongly transitive nor strongly intransitive means that the verb is not providing a strong syntactic cue about whether to predict an object. Instead, the verb will provide primarily semantic cues, like in Altmann and

Kamide (1999) and Kamide, Altmann & Haywood (2003). We predict that Wh- questions will elicit a predictive-type response: people will gaze at the direct object earlier than in the Y/N questions, where the verb's transitivity bias is neutralized.

1.2.2 Pickering and Traxler (2003)

As previous mentioned, Sussman and Sedivy (2003) used all transitively-biased verbs in their study, while Altmann and Kamide (1999) and Kamide, et al (2003) both used all transitive sentences (where the verb was always followed by an object) in their studies. These choices may have caused listeners to be strongly influenced by a verb's transitivity, and more strongly predict that a verb would be followed by a direct object. Pickering and Traxler (2003) used both transitive and intransitive verbs in their study, in order to test whether verb-based syntactic cues (like transitivity) or wh- word syntactic cues have a stronger effect on prediction. Pickering and Traxler conducted a series of three experiments which looked at verbs that are more inclined to take a Noun Phrase (NP) or a Prepositional Phrase (PP). This verb information is a type of verb transitivity bias: does a verb prefer to be followed by a noun phrase (NP bias, i.e., transitive bias) or does it prefer to be followed by a prepositional phrase (PP bias, i.e., intransitive bias)? The first two of these experiments utilized a self-paced reading task to observe the effects of the different types of verbs. In this type of task, slower reading is indicative of an unexpected word or phrase, and a 'fast' response leads to the conclusion that a reader is reading exactly what they expect; this is strictly an indirect measure. This method differs from the current study which, using eyetracking, allows for a more immediate and possibly more direct view of the on-line processing involved with sentence comprehension. The present study also allows for a look into what exactly participants are expecting to come next, and where possible confusion occurs.

As in the Sussman and Sedivy (2003) study, the sentences used in the current study also involve a hidden Wh- word. Participants tend to search for a gap for the Wh- word as soon as possible, which will influence their fixations on the presented images. Pickering and Traxler employ a similar underlying structure to Sussman and Sedivy (as well as the present study). Take the following examples from Pickering and Traxler:

1.

    a. That's the cat that the dog worried compulsively about after going to the vet because of an injury. (PP-preference, plausible)
    b. That's the car that the dog worried compulsively about after going to the vet because of an injury. (PP-preference, implausible)

2.

    a. That's the general that the soldier killed enthusiastically for during the war in Korea. (NP-preference, plausible)
    b. That's the country that the soldier killed enthusiastically for during the war in Korea. (NP-preference, implausible)

These sentences have a hidden Wh- structure cue. The relative clause in (1a), "that the dog worried compulsively about," connects the NP "the cat" and the preposition "about" using the same structure as in Wh- questions like "Who did the dog worry compulsively about?" This relative clause structure is sometimes not hidden: relative clauses can also have Wh- words like "who" instead of "that." For example, it is fine to say "That's the general <u>who</u> the soldier killed enthusiastically for" for (2a). This wh- structure cue should also cause people to predict an upcoming verb or preposition, which the NP goes with.

As indicated in the above examples, the verbs (1a) and (2a) likely take a PP and NP, respectively. They are labelled 'plausible' because the NPs *the cat* and *the general* are a plausible direct object for the verbs *worried* and *killed.* If people are predicting an upcoming verb based on the hidden wh- structure cue, they should try to connect the NP with the verb. This means that (1a) and (2a) will be regarded as plausible when people read the verbs *worried* and *killed*. (1b) and (2b) are the implausible counterparts of (1a) and (2a). So, while each of the above sentences is plausible by the time participants reach their conclusion, the difference between plausible and implausible occurs at the verb, which represents the "garden-path" portion of sentences (1b) and (1a). For example, if (1b) ended after the word "compulsively," the sentence would not make sense: a car is not a plausible object of the verb *worried*. On the other hand, if (1a) ended at the same word, the sentence would still be plausible: a cat is a very plausible object of this verb. Slower reading times at the verb *worried* and the following word *compulsively* in (1b) compared to (1a) would be evidence that readers had been "led down the garden path," and decided that *car* was the object of *worried*. This reading-time slowdown would be evidence that readers predicted a verb, based on the wh- structure cue, and associated the NP with it. The same should occur for (2a) and (2b) at the word "enthusiastically."

The implausible versions are expected to slow reading times, which is exactly what Pickering and Traxler found (as described below).

Table 1: Pickering & Traxler (2003), Experiment 1 summary of results

Verb Preference	Region 1	Region 2	Region 3	Region 4	Region 5	Proportion Correct
PP-Preference plausible	984 (972)	890 (878)	1012 (1045)	1309 (1392	971 (893)	0.87
PP-Preference implausible	945 (880)	893 (948)	1113 (1157)	1228 (1326)	873 (867)	0.88
NP-Preference plausible	853	958	1045	1392	883	0.85
NP-Preference implausible	880	948	1157	1326	869	0.86

The above (Table 1) illustrates the mean reading times for different regions of the sentence in Pickering and Traxler's Experiment 1. The most important region is Region 3, which has the verb and the word following it. Pickering and Traxler found that "for PP-preference verbs, sentences with implausible object analyses produced longer reading times in the ambiguous region than sentences with plausible object analyses, F1(1, 37) = 5.06, p 5 .04; F2(1, 13) = 6.57, p 5 .03." (Pickering and Traxler, 2003: 486). The interesting part about this is that NP-preference sentences acted in a very similar way. We can observe this in the word-by-word reading times in Table 3. Regions 1 and 2 have similar reading times for the plausible and implausible conditions, but at region 3 (the ambiguous region), reading times slow significantly in both implausible conditions (both PP-preference and NP-preference) compared to the plausible conditions. These results suggest that NP-preference verbs seem to be processed in the same way as PP-preference verbs. This finding suggests that the verb-based syntactic cue, verb transitivity, did not guide predictions as strongly as the wh- structure syntactic cue. Reading a PP-preference verb (strongly intransitive) did not make them less likely to connect the NP and verb than reading an NP-preference (strongly transitive) verb. In other words, verb transitivity did not affect people's predictions strongly, while the wh- structure cue did. This pattern goes in the opposite direction after the ambiguous region. At region 4 (the disambiguating region, which has a preposition), people were slower in the plausible conditions than in the implausible

conditions. This is because people originally thought that the noun (*car* or *cat*) was the object of the verb in region 3: they had been led down the garden path, and they stuck with that choice in the plausible sentence. People then had to revise that decision at the following region, when they realized that the noun went with the preposition instead, which made them slow-down in their reading. Like for region 3, there was no difference between the NP-preference and PP-preference sentences: for both verb types, people were slower for the plausible sentences. These results also suggest that NP- and PP-preference verbs are processed in the same way.

These patterns tell us that people expected that the verb would be followed by a gap in Pickering and Traxler's sentences, much as people expected (and looked at) an object once they heard the verb in the Wh- questions in Sussman and Sedivy's study. They also expected that there would be a gap after the verb in both NP-preference (transitive bias) and PP-preference (intransitive bias) sentences. Because of these patterns, Pickering and Traxler concluded that verb transitivity bias is a weaker cue than the structure of a sentence when it comes to affecting predictions.

Pickering and Traxler's study used sentences with a false gap to test whether verb-based syntactic cues (verb transitivity) or wh- structure syntactic cues had a stronger effect on predictions. Readers were "led down the garden path," briefly believing that the verb and NP were connected, and then revising that conclusion when they read the preposition. The current study also employs a false gap structure for sentence stimuli, where a neutral verb which could be followed by an object actually has a preposition after it. The preposition is the actual gap site, meaning that the verb is a tempting but false gap site. We anticipate that participants will search for an object to the verb as soon as they hear it, prior to hearing the full sentence. This pattern would be similar to what Sussman and Sedivy (2003) found. That is, if given the stimulus "Tell

me what the boy wrote for his grandmother in at school" in the current study, participants are likely to look to a picture of a poem (something that can be written) upon hearing the verb "wrote," but will then shift to fixate on a picture of a notebook (something that can be written in) upon hearing the preposition "in." This pattern is very similar to examples like (1a) and (2a) from Pickering and Traxler's studies.

2.0 THE PRESENT STUDY

Research in the field of speech language pathology has often looked to verbs for explanations of what is hard and what is easy in language processing. Verbs are often very challenging for people learning a language (either children or adults learning a second language) and are frequently impaired among people with developmental or acquired language disorders, such as aphasia. In particular, I am interested in looking at peoples' tendencies to think predictively when they are understanding sentences, and where these predictive processing tendencies have their basis. In the current study, I will be looking specifically at predictive processing for Wh- formatted questions versus yes/no formatted questions. These two types of sentences are different in their cues for predictive processing: the wh- questions provide a syntactic cue for prediction (Sussman & Sedivy, 2003; Pickering & Traxler, 2003), while the yes/no questions provide a verb-based semantic cue (Altmann & Kamide, 1999; Kamide, 2008). The goal of this research is to better understand which of these two types of sentences offers us more information and influences our ability to predict what is coming next in the sentence. To achieve this goal, participants will participate in an eyetracking study which will monitor their fixations in response to auditory sentence stimuli, allowing for insight as to where participants look during which aspect of the sentence.

2.1 PURPOSE

We know from the above mentioned research that prediction plays a huge role in processing and can be extremely useful in treatment of impaired individuals. The current study examines how young unimpaired adults can take advantage of syntactic wh- cues and semantic verb-based cues in making predictions when understanding sentences. The results will indicate which of these two types of cues young healthy listeners use more quickly for prediction. We may find that these results differ in people who have aphasia; this study aims to provide a pathway to improving current treatments and adding to the existing research.

2.2 DESIGN

This study uses a between-subjects bivalent design in which we focused on young adults. The main goal of this study was to determine if different types of sentence conditions are processed differently. There are two independent variables, each with two levels: Preposition (preposition vs. no preposition) and question type (wh- question vs. yes-no question) which were actively manipulated. These two independent variables were crossed to create four conditions: Wh- question, no preposition (WH- no prep), yes/no question, no preposition (Y/N no prep), Wh- question, preposition (WH- prep), and yes/no question, preposition (Y/N prep). An example is found below:

3. Context Story: At school one day, a boy wrote a poem for his grandmother. He wrote it in his notebook. His grandmother loved the poem.

3a: Tell me what the boy wrote for his grandmother at school.

(WH- no prep)

3b: Tell me whether the boy wrote for his grandmother at school.

(Y/N- no prep)

3c: Tell me what the boy wrote for his grandmother in at school.

(WH- prep)

3d: Tell me whether the boy wrote for his grandmother in the notebook at school.

(Y/N prep)

Visual display pictures: boy, grandmother, notebook, poem, yes button, no button

Participants heard only one of the questions (3a-d) and respond by either clicking on the pictures or the yes/no buttons. The target for (3a) is poem, for (3b) is yes, for (3c) is notebook (this is an example of an especially challenging sentence, similar to Traxler & Pickering's false-gap sentences), and for (3d) is yes. In (3a) and (3c), the Wh- word *what* tells people that they should expect that there is an object coming in the sentence, the thing being asked about. A previous study using the visual world paradigm by Sussman and Sedivy (2003) found that people looked at a picture of the object (poem for 3a) as soon as they heard the verb (*wrote*). Participants received the stimuli in a randomized order to decrease the likelihood of sequencing effects on outcome measures.

The dependent variables that we measured were eye movements during critical periods of the sentences and mouse click data for each trial. We tested for main effects of preposition and sentence type as well as their interaction for both of these dependent variables. By tracking people's eye movements as they listen to the sentence, we will be able to discover which aspect of the sentence led to fixations on different parts of the display, and compare how quickly people fixated across the four conditions. By comparing mouse clicks across conditions, we can discover how accurately people comprehended the sentences, and how that was affected by the different sentence structures they heard.

2.3 HYPOTHESIS

My hypothesis is that we will find that the Wh- question word will be a strong cue for predictions. That is, hearing a Wh- word like *what* will cause listeners to look for a target as soon as they hear a verb, like in Sussman and Sedivy's (2003) visual-world study. This means there should be a main effect of question type, with more looks at the direct object image for Wh-question conditions (WH- prep, WH- no prep) than for yes-no question conditions (Y/N prep, Y/N no prep). Since listeners gazed at the target within 150 milliseconds of the verb's offset in Sussman and Sedivy's (2003) study, I anticipate that this main effect of question type will appear soon after the end of the verb. On the other hand, if the verb semantic cue is as strong a cue for predictions as the Wh- word, we should not see a main effect of question type.

The early preference to look at the direct object image will not only be true for easy questions (like 3a), where I expect that people will look at the poem as soon they hear *wrote*, but

also more challenging questions (such as 3c). When listening to (3c), I expect that people will first look toward the direct-object distractor (i.e., the poem), but upon hearing the prepositional phrase, will moves their eyes to find the target (i.e., the notebook). This would be similar to what Sussman and Sedivy found, and also to what Pickering and Traxler found. Pickering and Traxler found that people first tried to connect an NP with a verb, based on the hidden wh- structure cue, but then had to revise their interpretation when they read a preposition. This means that there should be an interaction of question type and preposition later in the sentence. People should look at the direct object image more for both Wh- question conditions compared to the yes-no question conditions, but they should look at the direct object (the poem) less for the WH- prep condition than for the WH- no prep condition. In the WH- prep condition, they should shift to look at the prepositional object image (the notebook) later in the sentence.

Sussman and Sedivy's results suggest that the yes/no question types (3b and 3d) will produce less predictive tendencies: people should be less likely to look at poem after hearing *wrote* in (3b) and (3d) than after hearing *wrote* in (3a) and (3c). However, we do know that people are more likely to look at images which fit with a verb's meaning, like a cake after hearing *eat* (Altmann & Kamide, 1999; Kamide, 2008). We might find that people are likely to look at the direct object (poem) more as time goes by even in the yes/no question conditions. This effect may be smaller or may appear later for yes-no questions than predictions in the Wh-question conditions. However, it would tell us that peoples' predictions are affected by verb semantic cues, even if the Wh- word cue has a stronger effect.

3.0 METHODS

3.1 PARTICIPANTS

The present study included 27 participants, all of whom were right-handed native English speakers. The participants were all University of Pittsburgh students ranging from 18 years old to 25 years old with no history of neurological or other damage that could have resulted in a speech or language impairment. The average age of the participants tested was about 21 years old. Participants were recruited via announcements in their classes and offered a bonus point to their final grade for participation. The mean years of education of the participants came to about 15 years, including their current year in college. Participants were given no information about the experiment prior to coming in for experimentation.

3.2 MATERIALS

Participants listened to 43 experimental stories like the one in (3) above. In addition, they listened to 19 filler stories, with many different types of structures. Effort was made to ensure consistency across each of the differing conditions. This was done in a number of different ways, including using very specific criteria for nouns across conditions as well as ensuring that duration data across conditions was as consistent as possible to ensure uniformity. Specifically,

every trial had pictures on the screen which corresponded to the agent of the action (i.e., Boy), theme of the action (i.e., the direct object, Poem), the object of the preposition (i.e., Notebook), and the distractor (i.e., Grandmother). Three of the pictures were always inanimate objects and one was always an animate object. They were all imageable (able to be pictured in an image) high-frequency names. In addition, none of them overlapped in their initial segments; the visual world paradigm is extremely sensitive to phonological overlap among picture names so we were very cautious in making sure that phonological cues did not overlap. Pictured in Table 2 below is the timing and duration information across conditions.

	Subject onset	Subject offset	Verb onset	Verb offset	Prep onset	Sentence offset
a: Wh no prep	1299.001857	1900.054571	2008.795548	2416.724048		4314.843262
b: Y/N no prep	1407.545762	2037.263571	2162.207762	2545.09469		4429.666
c: Wh prep	1317.254286	1960.537905	2101.481929	2486.95731	3320.384429	4791.350143
d: Y/N prep	1414.24319	2090.516476	2250.394167	2629.971405	3486.457833	5535.619976
Mean across Conditions	1359.511274	1997.093131	2130.719851	2519.686863	3403.421131	4767.869845

Table 2. Mean durations across conditions.

3.3 PROCEDURE

Participants first read and completed a consent form written for younger normal participants describing their involvement in the experiment, risks, use of their data, etc. This form was signed and dated by both the experimenter and the participant. One copy of the consent form was kept for records and the other copy was given to the participant. Each participant was assigned an arbitrary number which appears on their forms as well as in their experimental

results. Next, the participants were asked to fill out a demographic form which included things like their name, date of birth, years of education, and racial background. They then completed the medical history form which is kept on file for reference if necessary. Following completion of these forms, participants proceeded to the screening tasks, which include Raven's Colored Progressive Matrices and a hearing screening. They then completed the experimental tasks, first a mouse and acuity task, followed by the main visual world experiment.

3.3.1 Screening Tasks

Raven's Colored Progressive Matrices was used to analyze non-verbal cognition of each participant. In this task, participants were instructed to choose one of the pictures numbered 1-6 that best completed the picture/pattern above, which was missing a piece. Participants must have passed this screening task with a score of at least 26 correct answers in order to proceed with the experiment.

Next, participants completed a pass/fail hearing screening. Participants were asked to indicate that they've heard the beep (which was presented in a pulsing fashion) by either saying "yes" or raising their hand. Frequencies of 500, 1000, 2000, and 4000 hertz were tested bilaterally at 40dB. Participants must pass the hearing screening in order to qualify for experimental testing.

3.3.2 Experimental Tasks

The first task of the experimental procedure is a practice test titled Mouse and Acuity. The sole purpose of this task is to ensure that the participant is able to properly work the mouse as well as to adjust volume needs. All participants were tested using external speakers at a comfortable volume. In this task, participants were asked to click on a black cross in the center of the screen, then to listen to a spoken word and click on the picture that corresponded to the word. Participants were given feedback after each click on the cross (whether they clicked it or not) as well as on the pictures they chose (whether they clicked the target or not). No data was taken from this initial task.

Next, participants were instructed that the experimental procedure would begin and given a description of the instructions which appear in print on the monitor. The experimenter continued by explaining the need to calibrate the machine, measuring the distance of the participant from the camera lens (which was to be between 50-60cm), and placing a target sticker on their forehead. For the calibration procedure, participants were instructed to look at the dots that appeared on the screen without moving their head. A 13-point calibration was used for this experiment. After completing the calibration, validation took place where the participants were given the same instructions. An acceptable error must have been below 1.5 degrees of visual arc in order to proceed with the experiment.

After successful calibration, participants were given a more detailed reminder of the instructions for the experiment. The experimenter instructed the participants to look at the dot in the center of the screen and then click on the cross before each trial. The experimenter then told the participants that they will see a new screen appear with four pictures (in each corner), a yes button, and a no button, all of which are clickable. They were told that they would hear a story

followed by a beep and then a question about the story followed by another beep; participants were told to click on their answer to the question following the last beep. There were 62 trials in each list and the participants were tested on one of lists 1, 2, 3, or 4. They were not told any details of the experiment or the eyetracking equipment.

The total time for the entire procedure averaged around 45 minutes to an hour. The time to complete all 62 experimental trials took around 20-30 minutes.

4.0 RESULTS

The two dependent variables, mouse clicks and fixations provide information about two different types of processing. The gaze data can tell us which cue was stronger and faster in guiding predictions: wh- word cues or verb semantic cues. The mouse click data can tell us how successful people were in understanding the sentences, especially in the difficult WH- prep condition ("Tell me what the boy write for his grandmother in at school"). I analyzed the two dependent variables separately.

The accuracy data for mouse clicks is picture below in Figure 3.

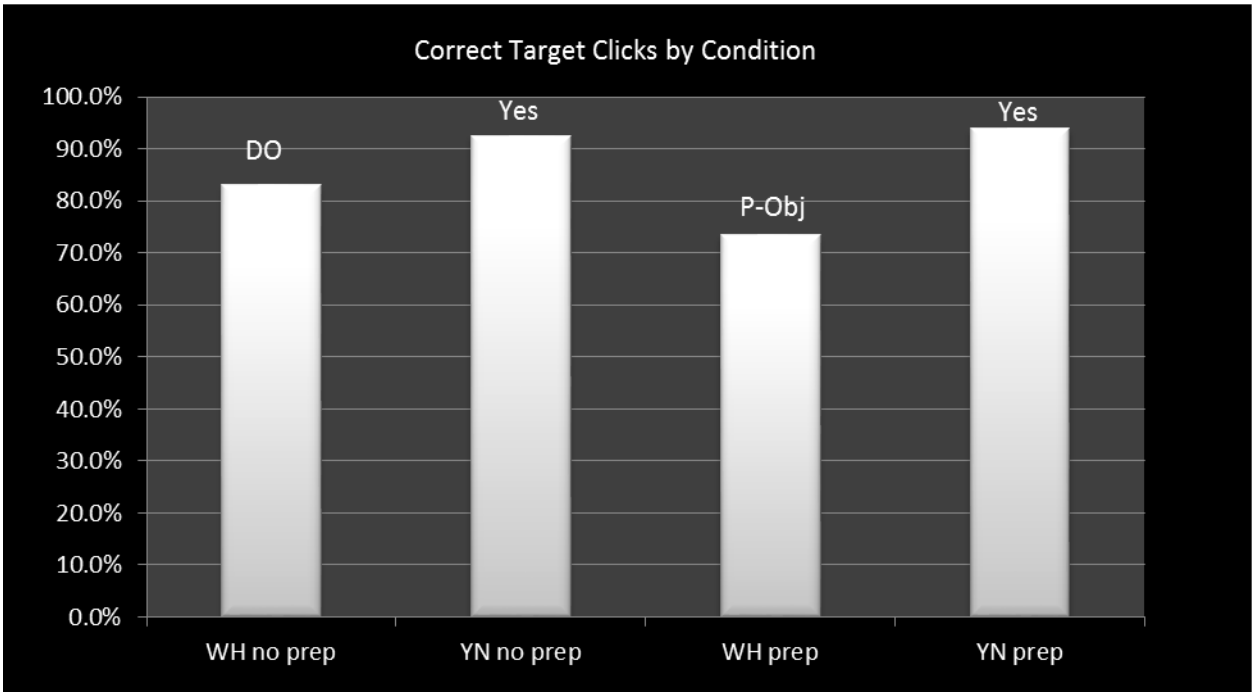

Figure 3. Target clicks across conditions

An analysis of variance (ANOVA) was done on the mouse click data, comparing how often people clicked on the target across the four conditions. There was a significant main effect of question type ($F[1,26]=22.25$, $p<0.001$), meaning that people clicked on the target more often for yes/no questions (where the target was the 'YES' response) than for the Wh- questions (where the target was either the direct object or the prepositional object). There was a nearly significant main effect of preposition ($F[1,26]=4.07$, $p<0.06$), with people clicking on the correct target more often in the no-preposition conditions than the preposition conditions. There was also an interaction of question type and preposition ($F[1,26]=5.61$, $p<0.05$), with a larger difference between the preposition and no-preposition conditions for the Wh- questions. People were the least accurate in clicking on the target in condition (c), the WH prep condition. A paired sample t-test showed that people clicked on the target less often in the WH prep condition than in the WH no-prep condition ($t[26]=2.32$, $p<0.05$). I expected that this condition would be the most difficult for people to understand, since they would be "led down the garden path" by the false gap and look first at the direct object and then change to look at the target (the prepositional object).

Because people had the least target mouse clicks in the WH prep condition, I decided to examine which picture they clicked on when they did not click on the target. The actual images they clicked on in condition (c) are shown in Figure 4.

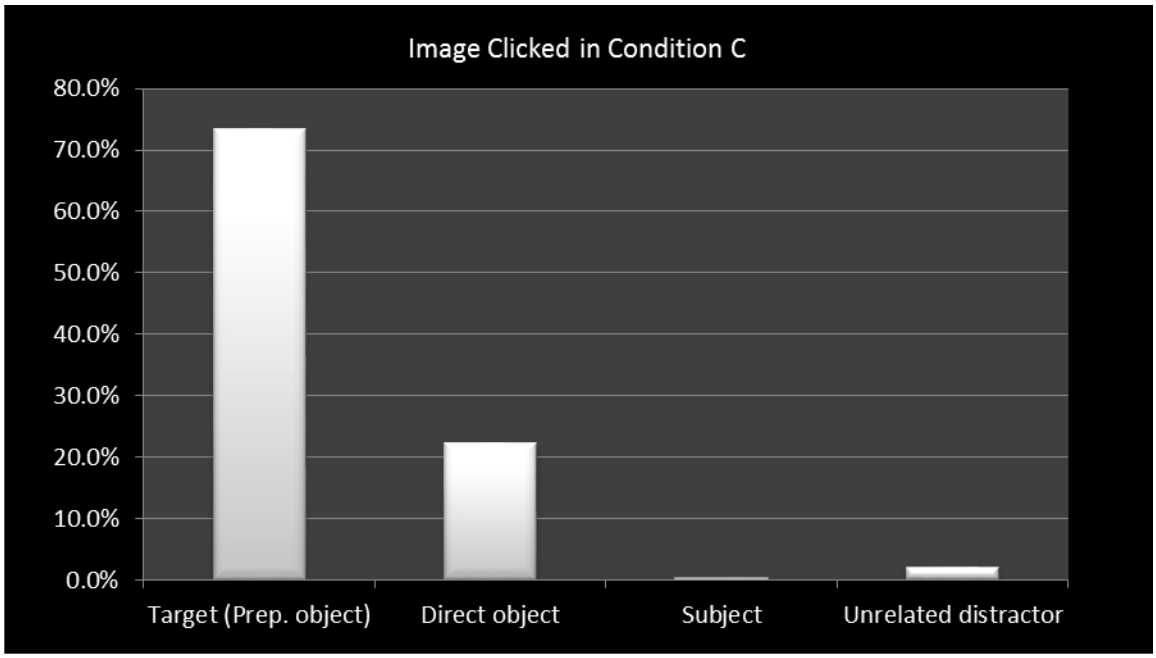

Figure 4. Images clicked for condition c

When they did not click on the target, they clicked most often on the direct object. This makes sense, because I expected that people would first assume that the direct object was the answer to the Wh- question in this condition, and then have to change that assumption when they heard the preposition. The mouse click data provides evidence for the internal validity of the current study, because it suggests that people understood the sentences (most of the time) and overwhelmingly clicked on the correct, target picture.

Next, I looked at peoples' eye movement patterns. I analyzed these eye movements in two steps. First, I calculated how often people fixated on the target every 100 milliseconds, starting at the onset of the verb. The verb onset is the first point at which people could predict an object in any of the conditions, and it is also where Sussman and Sedivy (2003) found more looks for the Wh- questions than yes/no questions in their study. The proportion of trials where people looked at the target in the different conditions, starting at the verb onset, is shown in Figure 5.

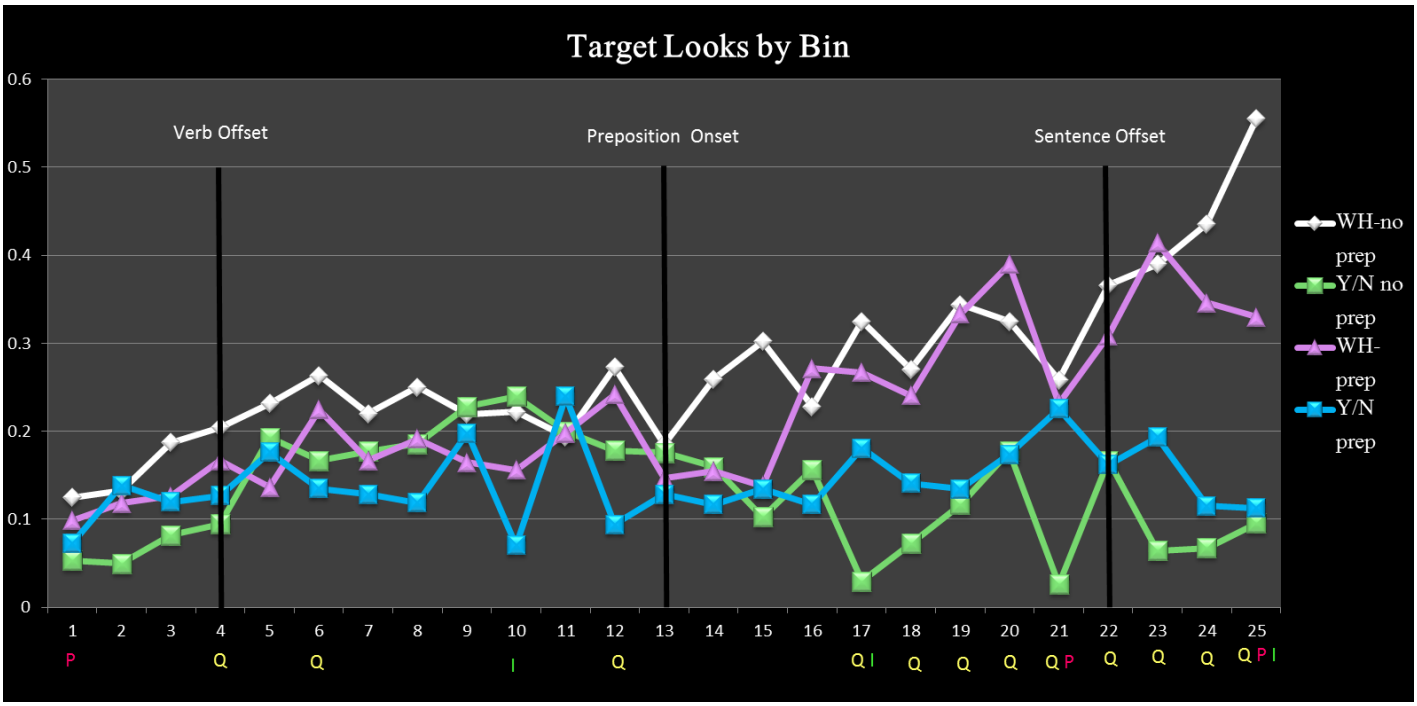

Figure 5. Looks to the target across conditions by number of milliseconds after the verb

I ran an ANOVA on the proportions of target fixations for each 100-millisecond bin, across the four conditions. The bins where there were significant effects of question type are marked with a "Q" on Figure 5, the bins where there were significant effects of preposition are marked with a "P," and the bins where there was a significant interaction of question type and preposition are marked with an "I." The pattern of significant effects is also presented in Table 3:

Table 3. Significant effects of target looks for each bin

Bin #	Question Type	Preposition	Interaction
Bin0: 0-100ms	no	no	no
Bin1: 100-200ms	no	yes F= 6.035 p= .022	no
Bin2: 200-300ms	no	no	no

Bin3: 300-400ms	no	no	no
Bin4: 400-500ms	yes F= 4.374 p= .048	no	no
Bin5: 500-600ms	no	no	no
Bin6: 600-700ms	yes F= 5.080 p= .035	no	no
Bin7: 700-800ms	no	no	no
Bin8: 800-900ms	no	no	no
Bin9: 900-1000ms	no	no	no
Bin10: 1000-1100ms	no	no	yes F= 9.857 p= .005
Bin11: 1100-1200ms	no	no	no
Bin12: 1200-1300ms	yes F= 5.455 p= .029	no	no
Bin13: 1300-1400ms	no	no	no
Bin14: 1400-1500ms	no	no	no
Bin15: 1500-1600ms	no	no	no
Bin16: 1600-1700ms	no	no	no
Bin17: 1700-1800ms	yes	no	yes

	F= 24.241 p= .000		F = 5.682 p= .026
Bin18: 1800-1900ms	yes F= 4.535 p= .046	no	no
Bin19: 1900-2000ms	yes F= 11.209 p= .003	no	no
Bin20: 2000-2100ms	yes F= 13.601 p= .001	no	no
Bin21: 2100-2200ms	yes F= 8.043 p= .010	yes F= 5.197 p= .033	no
Bin22: 2200-2300ms	yes F= 12.226 p= .002	no	no
Bin23: 2300-2400ms	yes F= 21.159 p= .000	no	no
Bin24: 2400-2500ms	yes F= 34.703 p= .000	no	no

Bin25: 2500-2400ms	yes F= 33.855 p= .000	yes F= 5.907 p= .024	yes F= 4.417 p= .048

The patterns in Figure 5 give us an indication that by the end of the question, participants were, in fact, looking at the target picture as they were getting ready to click on it. These patterns provide additional internal reliability because they show that the participants eventually reached the correct answers after hearing the complete question.

Next, I calculated how often people fixated on the direct object every 100 milliseconds, starting at the onset of the verb. I also did the same ANOVA analysis as for the target looks above. The direct object looks are in Figure 6, with significant main effects of question type and preposition and significant interactions marked. The significant main effects and interactions for each 100-millisecond bin are also summarized in Table 3.

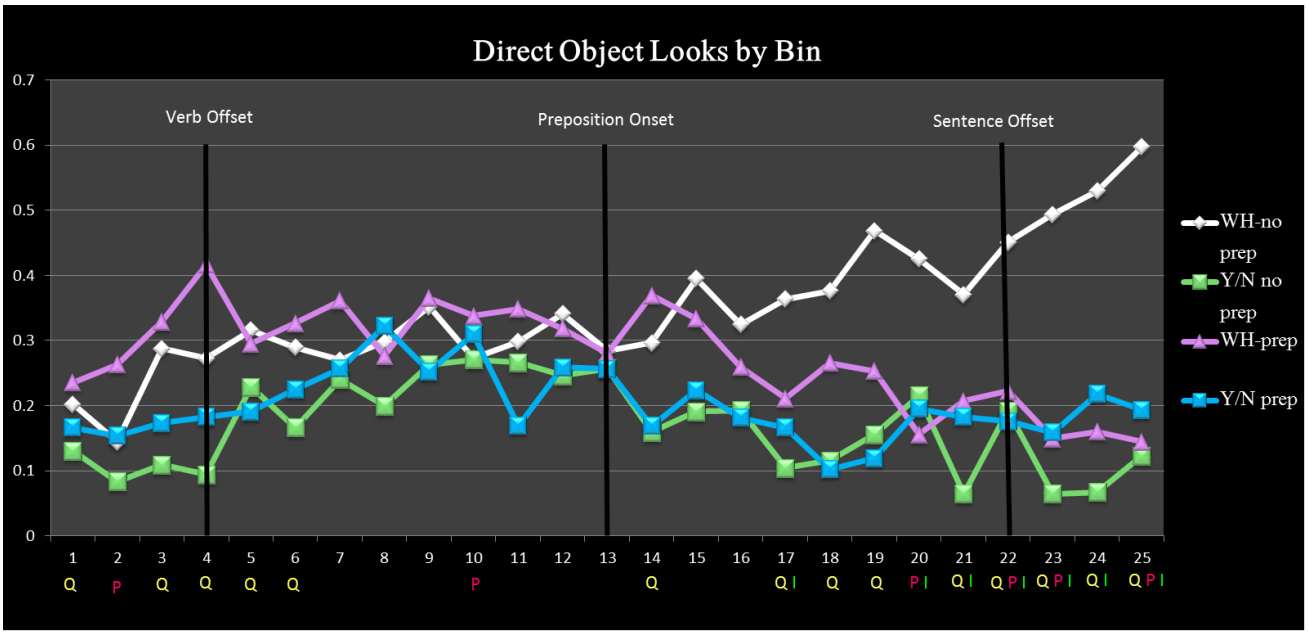

Figure 6. Looks to direct object across conditions by number of milliseconds after the verb

Table 4. Significant effects of object looks by bin

Bin #	Question Type	Preposition	Interaction
Bin0: 0-100ms	yes F= 10.402 p= .004	no	no
Bin1: 100-200ms	no	no	no
Bin2: 200-300ms	no	yes F= 6.831 p= .017	no
Bin3: 300-400ms	yes F= 11.981 p= .002	no	no
Bin4: 400-500ms	yes F= 21.490 p= .000	no	no
Bin5: 500-600ms	yes F= 5.260 p= .032	no	no
Bin6: 600-700ms	yes F= 5.454 p= .029	no	no
Bin7: 700-800ms	no	no	no
Bin8: 800-900ms	no	no	no

Bin9: 900-1000ms	no	no	no
Bin10: 1000-1100ms	no	yes F= 4.528 p= 045	no
Bin11: 1100-1200ms	no	no	no
Bin12: 1200-1300ms	no	no	no
Bin13: 1300-1400ms	no	no	no
Bin14: 1400-1500ms	yes F= 13.099 p= .002	no	no
Bin15: 1500-1600ms	no	no	no
Bin16: 1600-1700ms	no	no	no
Bin17: 1700-1800ms	yes F= 18.132 p= .000	no	yes F= 9.605 p= .005
Bin18: 1800-1900ms	yes F= 12.060 p= .002	no	no
Bin19: 1900-2000ms	yes F= 9.322 p= .006	no	no
Bin20: 2000-2100ms	no	yes F= 14.017	yes F= 10.326

		p= .001	p= .004
Bin21: 2100-2200ms	yes F= 0.849 p= .005	no	yes F= 8.901 p= .007
Bin22: 2200-2300ms	yes F= 13.227 p= .001	yes F= 7.505 p= .012	yes F= 8.232 p= .009
Bin23: 2300-2400ms	yes F= 16.750 p= .001	yes F= 6.050 p= .023	yes F= 21.003 p= .000
Bin24: 2400-2500ms	yes F= 19.960 p= .000	no	yes F= 29.953 p= .000
Bin25: 2500-2600ms	yes F= 11.936 p= .002	yes F= 7.248 p= .014	yes F= 14.006 p= .001

This is where we can directly decipher the effects of the Wh- cue and the verb cue independently. It is this analysis that shows the stronger and faster-acting effect of the Wh- cue. Starting at the verb onset itself and peaking approximately 400ms after the onset of the verb, there is a clear spike in the looks to the direct object for the WH- prep and WH- no prep conditions. As evidence of this, there were significant effects of question type, with more direct-object looks in the Wh- question conditions than the yes/no question conditions in Bins 1, 3, 4, 5,

and 6 (from 0 to 700 milliseconds after the verb onset). This is what I expected, based on Sussman and Sedivy (2003) and the hypothesis that the Wh- cue would be a stronger cue for predicting the upcoming object. Therefore, for the WH- prep condition and WH- no prep condition, this increase in looks to the direct object occurs on average approximately 87ms and 17ms, respectively. This is before participants have even heard the complete verb. This is incredibly fast and incredibly consistent across participants, which indicates a strong cue for prediction provided by WH- question words. For example, consider our earlier example, "At school one day, a boy wrote a poem for his grandmother. He wrote it in his notebook. His grandmother loved the poem," and being prompted with the question, "Tell me what the boy wrote for his grandmother in at school" (WH- prep) or "Tell me what the boy wrote for his grandmother at school" (WH- no prep). Before participants have even finished hearing the verb *wrote*, they are already overwhelmingly looking for a direct object (poem) to answer the question, in both cases, although more prominently in the WH- prep condition. This indicates that the WH- question is prompting subjects to look for an answer to the "what" question as soon as possible. It is not until they receive the prepositional phrase in the WH- prep condition (at Bin 13) that looks to the direct object (poem) rapidly drop off and looks to the target (notebook) rapidly increase. This is shown by the significant interaction of question type and preposition at Bin 17.

Note also that the Y/N prep and Y/N no prep direct-object looks increase later on in the sentence presentation, peaking approximately 800-1,000ms after verb onset. This slower increase in direct-object looks for the yes/no questions makes the earlier significant effects of question type go away in these bins. While there were significantly more looks to the direct object in the Wh- question conditions in Bins 1, 3, 4, 5, and 6, this significant difference goes away at Bin 7

and does not reappear until Bin 14. This pattern suggests that people were affected by the verb-based semantic cues in the yes/no condition, like participants in Altmann and Kamide's (1999) study. They looked at the direct-object picture (the poem), even though it was not mentioned in the sentence and they did not have to click on it in the yes/no questions. However, their looks to the direct object appear later for the yes/no condition, meaning that the verb-based semantic cue was not as strong in guiding predictions as the Wh- cue was.

5.0 DISCUSSION

Because we see a difference between the WH- conditions and the Y/N conditions, we can deduce that the WH- cue and the verb cue are having different effects. This is because the WH- conditions offer a WH- cue along with a verb that is neither strongly transitive or intransitive (meaning, it is neither likely or unlikely to take a direct object), but the Y/N conditions offer the verb cue alone (again, neither strongly or weakly transitive, thus providing only a semantic cue). Because the WH- and Y/N pairs of conditions only differ by presence of the Wh- question word *what*, it is easy to conclude that the presence of the WH- cue is what caused the differences in the eye movements. If the verb semantic cue was having the strongest effect on prediction, the looks to the direct object would have been uniform across all conditions because all else remained constant aside from the WH- cue. However, because the WH- conditions show a stronger and quicker predictive cue, it is clear that the WH- cue and verb cue have very different effects, as described above.

This finding is similar to Sussman and Sedivy's 2003 finding, which also showed that young unimpaired adults had very fast and strong predictions for Wh- cues. However, Sussman and Sedivy used strongly transitive verbs and all transitive sentence structures, so the verbs in their study may also have provided syntactic verb cues for predictions, in terms of strong transitivity. The current study used verbs that were neither strongly transitive nor strongly intransitive, so the verb cues were only semantic. The current study's findings are also similar to

the studies summarized in Kamide (2008), in that the current study also found that people looked at the direct object following a verb in the yes/no questions, when there was only a verb-based semantic cue. (This preference emerged later for yes/no questions than for Wh- questions.) However, the previous studies (like Altmann and Kamide 1999) always used transitive structures, with a direct object after the verb, and did not choose neutral verbs. These studies may therefore have unintentionally given people verb transitivity cues, which could have guided their predictions. The current study deliberately used neutral verbs and never mentioned a direct object following the verb, meaning that the looks to the direct object after hearing the verb can only be due to the verb's semantic cue.

However, it is worth mentioning that because of this verb-neutrality in the current study, the verb cue was put at a purposeful disadvantage. The verb cue was made as weak as possible in order to observe the effects of the Wh- cues. It is extremely difficult to see the effect of this Wh-cue exclusively because of the nature of language; essentially, we need to have a verb in sentences in order for them to make sense, so in reality, the effects of the Wh- cue are really the additive effects of the Wh- cue and a weak verb cue. In order to further parse out the true effects of the two differing cues, a follow-up study could be conducted wherein both highly transitive and highly intransitive verbs are used both alone (in a Y/N condition) and in conjunction with the Wh- cue (in another Wh- condition). By doing this, the effects of the combined and singular cues could better inform us of exactly how robustly the individual cues are causing predictions.

Also worth noting is the early significant difference of preposition presence shown in Figure 6. The strange appearance of a significant difference of preposition before the preposition has been heard could be due to a few different factors. First, it is possible that prosodic or duration information in the acoustic signal in the Wh- prep condition led listeners to expect a

preposition. While this is possible, it is unlikely after looking closely at the duration measurements listed in the methods section above. On the other hand, maybe more fine-grained analysis of the sentence prosody would reveal more information. Another contributing factor could be the small sample size used in the current study. This difference of preposition type early on occurs for exactly one bin, and then disappears. It could be that only a small number of participants' gazes are having a large effect on the results; essentially, the gazes of a handful of people may be what causes the preposition conditions to be in line with each other, but significantly different than the no preposition conditions. The results could have been fairly skewed by one or two outliers.

6.0 CONCLUSION

The major goal of this study was to determine which cue has a stronger effect on predictive tendencies in a young, unimpaired population. Without a doubt, the WH- cue outperformed the verb's semantic cue alone. This conclusion is clear from the patterns and the statistical analyses of the results. However, it will be beneficial to replicate these results before moving on to a different population.

The next step in this process will be to perform the same experiment on older unimpaired individuals and characteristically-matched individuals with aphasia. It is very possible that these three populations may show very different results. For example, people with aphasia may show more reliance on the verb-based semantic cue than the syntactic Wh- cue. However, it is also possible that they will follow the same trend. However, in order to take action on these findings, it must be determined how these different populations process the previously described verb and syntactic information. Without exploring the processing abilities of impaired populations, it will be impossible to improve available treatment options.

Presently, there is no single reliable, evidence-supported, and consistent treatment protocol for individuals suffering from aphasia. If we are able to determine which cue is stronger for the aphasic population, treatments focused on difficult Wh- structures may become more uniform and productive. For example, by separating out which cues are strong and which are weak in the processing system of people with aphasia, clinicians can scaffold on the strong cue

to improve the weak cue. It is well-established in the literature that aphasic individuals struggle with answering questions like the WH- no prep condition (Dickey, et al., 2007). If it turns out that, unlike the population in this experiment, the aphasic population is highly sensitive to verb cues, then a focus can be placed on using highly transitive and semantically-related verb cues to improve the ability to answer and pose WH- questions.

APPENDIX A

STIMULI: CONTEXT STORIES

1. At school one day, a boy wrote a poem for his grandmother. He wrote it in his notebook. His grandmother loved the poem.

2. At school one day, a boy wrote a poem for his grandmother. He wrote it in his notebook. His grandmother loved the poem.

3. One morning, a thief was riding the subway. He quickly and quietly reached into a student's backpack and stole the student's wallet.

4. One cloudy day, an athlete ran a marathon. He ran the marathon with a broken arm. He ran at a relaxed pace the entire day. A policeman cheered for him as he crossed the finish line.

5. At rush hour, a musician was standing near a cathedral. He was playing a saxophone with great passion. A priest listened.

6. One Saturday, a mother was shopping at an open-air market. She bought an apple and cleaned it slowly and carefully with a scarf. The apple farmer smiled at her.

7. One autumn day, a lumberjack needed firewood. He went behind a shack and spent several hours chopping some wood with an axe. His wife was pleased.

8. At a tournament, a man was throwing darts near a pool table. He was very skillful and hit the bulls eye many times. His wife was very proud of him.

9. Last Sunday night, a nerd was studying his physics textbook very intently. He had a big exam the next day. His neighbor, who was a jock, made fun of him.

10. One hot afternoon, a boy was really thirsty. He came inside and drank water straight from the faucet for several minutes. His father laughed at him.

12. One morning, a construction worker arrived at a work site late. He hurriedly put on his hard hat and started to build a brick wall. He used a tool called a trowel to help him build the wall.

13. One Friday night, the President needed a babysitter to watch his daughter. A lady came to the White House. She babysat her for the president for five hours. The President paid the babysitter very well.

14. On the Fourth of July, a chef was cooking in preparation for a banquet. He had to make lots of hot dogs. He worked continuously for many hours without a break. He was in a bad mood, so the waitresses tried to avoid him.

15. After lunch one day, a dentist was in the bathroom. He had to brush his teeth thoroughly because he had just eaten some corn. He used a new toothbrush to get his teeth clean.

16. One Sunday afternoon, a grandfather was sitting in his favorite armchair. He looked through his stamp collection which was held in a special book of stamps. Then he meticulously added a new stamp to the collection. His wife smiled at him lovingly.

17. Before nap time, an old woman was reading to some children. The woman read Goldilocks and the Three Bears from a book of children's stories. Her eyesight wasn't too good, so she used her new glasses while she was reading. The children loved the story.

18. At a talent show, a woman was on a stage in front of some judges. The woman sang the musical notes off of some sheet music. It was a beautiful song. The judges were very impressed.

19. Early in the morning, a professor was lecturing some students. The professor was lecturing about Napoleon, his favorite historical figure. He went on for hours, and the students fell asleep on their desks.

20. One Saturday night, a woman was drinking punch at a party. She was a terrible lush, and she was drinking with a straw right out of the punchbowl. Everyone was embarrassed for her.

21. One winter day, a skater was at the ice rink. She was bravely practicing her flips, so she could do well in the Olympics. Her coach encouraged her.

22. Last Tuesday, a hairdresser was working at a salon. A man came in with really long hair and the hairdresser cut it with his scissors. The hairdresser was a very lively man and cut the man's hair vigorously. The man was happy and thanked the hairdresser for the haircut.

23. After school, a teenager drove downtown. He was in a hurry to park the car, but didn't have any change for the parking meter. He stopped at a store and bought a pack of gum. He got some change back and impatiently paid the meter with it. He only had enough for one hour.

24. During the power outage, there was an angry crowd in the street. A policeman pushed them back forcefully with his shield. This made the crowd even angrier.

25. Last week, an old woman was hiking along a trail. She came across a dead bear, and it frightened her. To make sure that the bear was dead, she probed the carcass timidly with a stick.

26. Two days ago, a man wrote a letter. He used his grandfather's fountain pen to rapidly write the letter. After he finished writing the last word, the pen broke. Ink spilled all over his desk.

27. Last month, a boy stole bread from a grocery store. He continued to surreptitiously steal bread from that store for a month. He was just caught by police.

28. At the concert, a drummer played his snare furiously with some drumsticks. He broke the drum. His manager yelled at him.

29. Three weeks ago, children hungrily ate spaghetti from their plates. They used their hands to eat. Their mother did not give them dessert.

30. One spring day, a bird built a nest on the highest branch of a tree. The next morning, the nest was gone. The bird was very sad because it had laid an egg in the nest.

31. One evening, some soldiers played cards boisterously in their tents. The captain won the last game with a royal flush. The soldiers bought him a beer.

32. One morning a businessman presented a graph showing company sales for each month. He awkwardly used his fancy new laptop to show some company executives the graph. They were unimpressed and he was fired.

33. Yesterday, a cook squeezed lemon onto the chicken he was cooking. The customers in the restaurant thought the chicken was delicious. He energetically squeezed lemon onto the rest of the chicken.

34. Last night, a mom read Peter Rabbit to her daughter. The mom sat next to her daughter on her daughter's bed for nearly an hour. Her daughter loved to hear about Peter's adventures.

35. At the ranch, a cowboy used a cane to prod the cattle through the gate. He was pretty rough on the cattle. His unnecessary roughness caused a stampede.

36. Last Friday afternoon, a carpenter used a shiny new hand saw to cut a plank of wood in half. He sawed very hastily. The wood fell on his foot and it hurt.

37. Last Saturday, a mother put her kids in the new minivan and drove to the zoo. The mother was excited to drive to the zoo because there was a new lion exhibit there. At the zoo, they saw the lion being fed.

38. Last fall, a teenager wrote a letter to the editorial department of the local newspaper. His letter exuberantly described how great his French class at the high school was. He wanted everyone to know that his public school had the best French program.

39. Last summer, an actor pantomimed being a robot outside a museum. The actor approached all the museum patrons for money as they left the museum. They were annoyed by him.

40. One afternoon, some children played baseball very loudly in the new park. They got in a fight, and two girls went home to help their mother make some cookies instead.

41. One morning, an aunt baked a pie for her niece's birthday with a new pie pan. She made a special pie containing lots of walnuts. The niece was very happy.

42. Late last night, some thoughtless gang members destroyed a window with a shovel. An alarm went off, and they ran out of the building with some paintings and jewelry.

43. At the last competition, an aggressive ice-skater attacked her opponent's car with a hammer. Her plan was discovered and she was disqualified. Her husband tried to help her recover her good name.

APPENDIX B

STIMULI: POSSIBLE CONDITIONS

1a Tell me what the boy wrote for his grandmother at school.

1b Tell me whether the boy wrote for his grandmother at school.

1c Tell me what the boy wrote for his grandmother in at school.

1d Tell me whether the boy wrote for his grandmother in the notebook at school.

2a Tell me what the thief stole quickly and quietly that morning.

2b Tell me whether the thief stole quickly and quietly that morning.

2c Tell me what the thief stole quickly and quietly from that morning.

2d Tell me whether the thief stole quickly and quietly from the backpack that morning.

3a Tell me what the athlete ran at a relaxed pace that day.

3b Tell me whether the athlete ran at a relaxed pace that day.

3c Tell me what the athlete ran at a relaxed pace with that day.

3d Tell me whether the athlete ran at a relaxed pace with a broken arm that day.

4a Tell me what the musician was playing with great passion that evening.

4b Tell me whether the musician was playing with great passion that evening.

4c Tell me what the musician was playing with great passion near that evening.

4d Tell me whether the musician was playing with great passion near the cathedral that evening.

5a Tell me what the mother cleaned slowly and carefully that Saturday.

5b Tell me whether the mother cleaned slowly and carefully that Saturday.

5c Tell me what the mother cleaned slowly and carefully with that Saturday.

5d Tell me whether the mother cleaned slowly and carefully with a scarf that Saturday.

6a Tell me what the lumberjack was chopping for several hours that autumn day.

6b Tell me whether the lumberjack was chopping for several hours that autumn day.

6c Tell me what the lumberjack was chopping for several hours with that autumn day.

6d Tell me whether the lumberjack was chopping for several hours with an axe that autumn day.

7a Tell me what the man threw very skillfully that day.

7b Tell me whether the man threw very skillfully that day.

7c Tell me what the man threw very skillfully near that day.

7d Tell me whether the man threw very skillfully near a pool table that day.

8a Tell me what the nerd was studying very intently last Sunday night.

8b Tell me whether the nerd was studying very intently last Sunday night.

8c Tell me what the nerd was studying very intently for last Sunday night.

8d Tell me whether the nerd was studying very intently for a big exam last Sunday night.

9a Tell me what the boy drank for several minutes that afternoon.

9b Tell me whether the boy drank for several minutes that afternoon.

9c Tell me what the boy drank for several minutes from that afternoon.

9d Tell me whether the boy drank for several minutes from the faucet that afternoon.

10a Tell me what the kids were sculpting for their father that summer day.

10b Tell me whether the kids were sculpting for their father that summer day.

10c Tell me what the kids were sculpting for their father with that summer day.

10d Tell me whether the kids were sculpting for their father with a plastic shovel that summer day.

12a Tell me what the construction worker was building hurriedly that morning.

12b Tell me whether the construction worker was building hurriedly that morning.

12c Tell me what the construction worker was building hurriedly with that morning.

12d Tell me whether the construction worker was building hurriedly with a trowel that morning.

13a Tell me who the lady was babysitting for five hours that Friday night.

13b Tell me whether the lady was babysitting for five hours that Friday night.

13c Tell me who the lady was babysitting for five hours for that Friday night.

13d Tell me whether the lady was babysitting for five hours for the president that Friday night.

14a Tell me what the chef cooked continuously that Fourth of July.

14b Tell me whether the chef cooked continuously that Fourth of July.

14c Tell me what the chef cooked continuously for that Fourth of July.

14d Tell me whether the chef cooked continuously for hours that Fourth of July.

15a Tell me what the dentist was brushing thoroughly after lunch.

15b Tell me whether the dentist was brushing thoroughly after lunch.

15c Tell me what the dentist was brushing thoroughly with after lunch.

15d Tell me whether the dentist was brushing thoroughly with a new toothbrush after lunch.

16a Tell me what the grandfather added meticulously that Sunday.

16b Tell me whether grandfather added meticulously that Sunday.

16c Tell me what the grandfather added meticulously to that Sunday.

16d Tell me whether the grandfather added meticulously to his book of stamps that Sunday.

17a Tell me what the grandmother read to the children before nap time.

17b Tell me whether the grandmother read to the children before nap time.

17c Tell me what the grandmother read to the children with before nap time.

17d Tell me whether the grandmother read to the children with her new glasses before nap time.

18a Tell me what the woman sang to the judges at the talent show.

18b Tell me whether the woman sang to the judges at the talent show.

18c Tell me what the woman sang to the judges on at the talent show.

18d Tell me whether the woman sang to the judges on a stage at the talent show.

19a Tell me who the professor lectured for hours early in the morning.

19b Tell me whether the professor lectured for hours early in the morning.

19c Tell me who the professor lectured for hours about early in the morning.

19d Tell me whether the professor lectured for hours about Napoleon early in the morning.

20a Tell me what the woman drank with a straw Saturday night.

20b Tell me whether the woman drank with a straw Saturday night.

20c Tell me what the woman drank with a straw from Saturday night.

20d Tell me whether the woman drank with a straw from the punchbowl Saturday night.

21a Tell me what the skater was practicing bravely that winter day.

21b Tell me whether the skater was practicing bravely that winter day.

21c Tell me what the skater was practicing bravely for that winter day.

21d Tell me whether the skater was practicing bravely for the Olympics that winter day.

22a Tell me what the hairdresser cut vigorously last Tuesday.

22b Tell me whether the hairdresser cut vigorously last Tuesday.

22c Tell me what the hairdresser cut vigorously with last Tuesday.

22d Tell me whether the hairdresser cut vigorously with his scissors last Tuesday.

23a Tell me what the teenager paid impatiently after school.

23b Tell me whether the teenager paid impatiently after school.

23c Tell me what the teenager paid impatiently with after school.

23d Tell me whether the teenager paid impatiently with some change after school.

24a Tell me what the policeman pushed forcefully during the outage.

24b Tell me whether the policeman pushed forcefully during the outage.

24c Tell me what the policeman pushed forcefully with during the outage.

24d Tell me whether the policeman pushed forcefully with his shield during the outage.

25a Tell me what the woman probed timidly last week.

25b Tell me whether the woman probed timidly last week.

25c Tell me what the woman probed timidly with last week.

25d Tell me whether the woman probed timidly with a stick last week.

26a Tell me what the man wrote very rapidly two days ago.

26b Tell me whether the man wrote very rapidly two days ago.

26c Tell me what the man wrote very rapidly with two days ago.

26d Tell me whether the man wrote very rapidly with a fountain pen two days ago.

27a Tell me what the boy stole surreptitiously last month.

27b Tell me whether the boy stole surreptitiously last month.

27c Tell me what the boy stole surreptitiously from last month.

27d Tell me whether the boy stole surreptitiously from the grocery store last month.

28a Tell me what the drummer played furiously at the concert.

28b Tell me whether the drummer played furiously at the concert.

28c Tell me what the drummer played furiously with at the concert.

28d Tell me whether the drummer played furiously with drumsticks at the concert.

29a Tell me what the children ate hungrily three weeks ago.

29b Tell me whether the children ate hungrily three weeks ago.

29c Tell me what the children ate hungrily from three weeks ago.

29d Tell me whether the children ate hungrily from three weeks ago.

30a Tell me what the bird built on the highest branch that summer day.

30b Tell me whether the bird built on the highest branch that summer day.

30c Tell me what the bird built on the highest branch of that summer day.

30d Tell me whether the bird built on the highest branch of a tree that summer day.

31a Tell me what the soldiers played boisterously that evening.

31b Tell me whether the soldiers played boisterously that evening.

31c Tell me what the soldiers played boisterously in that evening.

31d Tell me whether the soldiers played boisterously in their tents that evening.

32a Tell me what the businessman presented awkwardly that morning.

32b Tell me whether the businessman presented awkwardly that morning.

32c Tell me what the business man presented awkwardly with that morning.

32d Tell me whether the businessman presented awkwardly with his fancy new laptop that morning.

33a Tell me what the cook squeezed energetically yesterday.

33b Tell me whether the cook squeezed energetically yesterday.

33c Tell me what the cook squeezed energetically onto yesterday.

33d Tell me whether the cook squeezed energetically onto the chicken yesterday.

34a Tell me what the mom read for nearly an hour last night.

34b Tell me whether the mom read for nearly an hour last night.

34c Tell me what the mom read for nearly an hour on last night.

34d Tell me whether the mom read for nearly an hour on the bed last night.

35a Tell me what the cowboy prodded very roughly at the ranch.

35b Tell me whether the cowboy prodded very roughly at the ranch.

35c Tell me what the cowboy prodded very roughly with at the ranch.

35d Tell me whether the cowboy prodded very roughly with a pole at the ranch.

36a Tell me what the carpenter sawed very hastily last Friday afternoon.

36b Tell me whether the carpenter sawed very hastily last Friday afternoon.

36c Tell me what the carpenter sawed very hastily with last Friday afternoon.

36d Tell me whether the carpenter sawed very hastily with a shiny saw last Friday afternoon.

37a Tell me what the mother drove excitedly last Saturday.

37b Tell me whether the mother drove excitedly last Saturday.

37c Tell me what the mother drove excitedly to last Saturday.

37d Tell me whether the mother drove excitedly to the zoo last Saturday.

38a Tell me what the teenager wrote exuberantly last fall.

38b Tell me whether the teenager wrote exuberantly last fall.

38c Tell me what the teenager wrote exuberantly about last fall.

38d Tell me whether the teenager wrote exuberantly about his French class last fall.

39a Tell me what the actor pantomimed for money last summer.

39b Tell me whether the actor pantomimed for money last summer.

39c Tell me what the actor pantomimed for money outside last summer.

39d Tell me whether the actor pantomimed for money outside the museum last summer.

40a Tell me what the children played very loudly that afternoon.

40b Tell me whether the children played very loudly that afternoon.

40c Tell me what the children played very loudly in that afternoon.

40d Tell me whether the children played very loudly in their new uniforms that afternoon.

41a Tell me what the aunt baked lovingly for the niece's birthday.

41b Tell me whether the aunt baked lovingly for the niece's birthday.

41c Tell me what the aunt baked lovingly with for the niece's birthday.

41d Tell me whether the aunt baked lovingly with walnuts for the niece's birthday.

42a Tell me what the gang members destroyed thoughtlessly last night.

42b Tell me whether the gang members destroyed thoughtlessly last night.

42c Tell me what the gang members destroyed thoughtlessly with last night.

42d Tell me whether the gang members destroyed thoughtlessly with a shovel last night.

43a Tell me what the ice-skater attacked aggressively at the last competition.

43b Tell me whether the ice-skater attacked aggressively at the last competition.

43c Tell me what the ice-skater attacked aggressively with at the last competition.

43d Tell me whether the ice-skater attacked aggressively with a hammer at the last competition.

BIBLIOGRAPHY

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

Arai, M., & Keller, F. (2013). The use of verb-specific information for prediction in sentence processing. *Language and Cognitive Processes, 28*(4), 525–560.

Bastiaanse, R., & Jonkers, R. (1998). Verb retrieval in action naming and spontaneous speech in agrammatic and anomic aphasia. *Aphasiology, 12*(11), 951–969.

Boland, J. E. (2005). Visual arguments. *Cognition, 95*(3), 237–274.

Clifton, C., Frazier, L., & Connine, C. (1984). Lexical expectations in sentence comprehension. *Journal of Verbal Learning and Verbal Behavior, 23*(6), 696–708.

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive Psychology, 6*(1), 84–107.

DeDe, G. (2013). Verb transitivity bias affects on-line sentence reading in people with aphasia. *Aphasiology, 27*(3), 326–343.

Dickey, M. W., Choy, J. J., & Thompson, C. K. (2007). Real-time comprehension of wh-movement in aphasia: Evidence from eyetracking while listening. *Brain and Language, 100*(1), 1–22.

Frazier, L., & d' Arcais, G. B. F. (1989). Filler driven parsing: A study of gap filling in Dutch. *Journal of Memory and Language, 28*(3), 331–344.

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.

Kamide, Y. (2008). Anticipatory processes in sentence processing. *Language and Linguistics Compass, 2*(4), 647–670.

Kamide, Y., Altmann, G., & Haywood, 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.

Kertesz, A. (1982). *Western aphasia battery test manual*. Psychological Corp.

Kertesz, A. (2006). *Western Aphasia Battery - Revised*. Toronto: Pearson Assessment.

Love, R. J., & Webb, W. G. (1977). The efficacy of cueing techniques in Broca's aphasia. *Journal of Speech and Hearing Disorders*, *42*(2), 170–178.

Pickering, M. J., & Traxler, M. J. (2003). Evidence against the use of subcategorisation frequency in the processing of unbounded dependencies. *Language and Cognitive Processes*, *18*(4), 469–503.

Stowe, L. A. (1986). Parsing WH-constructions: Evidence for on-line gap location. *Language and Cognitive Processes*, *1*(3), 227–245.

Sussman, R. S., & Sedivy, J. (2003). The time-course of processing syntactic dependencies: Evidence from eye movements. *Language and Cognitive Processes*, *18*(2), 143–163.

Traxler, M. J., & Pickering, M. J. (1996). Plausibility and the processing of unbounded dependencies: An eye-tracking study. *Journal of Memory and Language*, *35*(3), 454–475.

Trueswell, J. C., Tanenhaus, M. K., & Kello, C. (1993). Verb-specific constraints in sentence processing: separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(3), 528.

Wambaugh, J. (2003). A comparison of the relative effects of phonologic and semantic cueing treatments. *Aphasiology*, *17*(5), 433–441.