LEXICAL AND SYNTACTIC PREDICTION WITHIN A NOISY CHANNEL MODEL OF LANGUAGE COMPREHENSION

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The present paper explored adaptation of prediction within a noisy channel framework of language comprehension. Three experiments examined whether adaptation of reliance on lexical and/or syntactic predictive cues occurs across contexts in which there is a change in the informativity of these cues. Within a single experimental session (Exp. 1, n=44) and across experiments (Exp. 2, n= 45; Exp. 3, n= 92), there was no evidence that participants adapted their reliance on a lexical cue, as subjects predicted specific words within highly-constraining sentences at an equal rate across contexts which supported and violated this expectation. Furthermore, it was found that participants only adapted and relied less on a syntactic cue in the violating context within Experiment 3, in which a stronger violating cue was used for the expectation of an *either…or* sentence structure than the violating cue used in the first two experiments. Results suggest that the combination of a strong predictive cue and a strong violation of that cue is necessary to elicit adaptation. Further research is needed to investigate how and when readers adapt their prediction during language comprehension.

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PREFACE

I would like to thank my advisor, Dr. Tessa Warren, and my committee members, Dr. Michael Dickey and Dr. Scott Fraundorf, for all their help and support. I would also like to thank my parents, my brother, and my husband, to whom I dedicate this document.

1.0 INTRODUCTION

Everyday language is imperfect. Language comprehension occurs over a noisy channel, because environmental noise, like background conversations simultaneously occurring at a party, and producer/receiver errors can distort the language signal. How are we able to correctly comprehend language when there are numerous ways in which the signal could be distorted?

Gibson, Bergen, and Piantadosi (2013) proposed a model of noisy channel language comprehension (see Equation 1), according to which the probability of a receiver comprehending an intended sentence (s_i) given a perceived sentence (s_p) is proportional to the baseline probability of the producer intending s_i multiplied by the probability that s_i would be distorted to s_p in the noisy channel.

$$P(s_i|s_p) \propto P(s_i)\, P(s_i \rightarrow s_p)$$

Eq 1. Communication across a noisy channel

The likelihood of the producer intending s_i is the prior probability (or prior likelihood term), and represents the default setting of expectation for a sentence to occur. In everyday language, comprehenders expect that producers will generate utterances that are likely to be said and conform to the rules of our language. One important source of evidence in determining a sentence's prior probability is its plausibility. Producers are more likely to produce sentences that make sense. Gibson and colleagues studied the effect of an expectation of plausibility as one experimental manipulation within their studies.

The probability that s_i would have been distorted to s_p is the noise term, and represents the likelihood of potential corruption during communication of the language signal. Gibson and colleagues found evidence that comprehenders follow a string-edit-distance theory when computing the noise term. Comprehenders assumed that fewer distortions (only one insertion or deletion of a word between the intended and perceived sentences) were more likely than greater distortions (two insertions or deletions). Furthermore, comprehenders followed a Bayesian size principle and assumed a distortion of the language signal involving a deletion was more likely to occur than a distortion involving an insertion. For example, Gibson et al. revealed that, at baseline, the noise term guides comprehenders to assume that a prepositional object (PO) sentence structure was more often intended than a double object (DO) sentence construction. Alternation between a DO sentence and a PO sentence involves a single preposition (e.g. the word *to*). The size principle states that it is more likely for comprehenders to assume that a deletion of a *specific* word from a sentence has occurred (e.g. perceive a DO as a PO by assuming *to* was accidentally deleted from the sentence) than it is for comprehenders to assume that an insertion of *any* word from producers' vocabulary set accidentally occurred (e.g. perceive a PO as a DO).

Gibson and colleagues also provide evidence that the prior probability and noise term in their model of language comprehension are adaptive depending on the context in which language occurs. They showed that participants relied less on their default prediction of plausibility to derive meaning from sentences when more implausible sentences were included in the experiment. In a separate study where filler sentences contained more typos and word deletions, participants relied less on their default noise term for comprehension and assumed a greater likelihood of sentence distortion. These two studies by Gibson et al., as well as others (e.g.

Warren, Dickey, & Liburd, 2017), provide evidence that, although we have baseline probabilities for what we predict will occur, adaption of our prior probability and noise term can take place within environments that do not reflect these default likelihoods. In other words, when context violates or is not supportive of our baseline predictions, we update our expectations to new ones to inform our prior probability and noise term.

Gibson et al. (2013) utilized plausibility to manipulate the prior probability term. But, there are additional factors that are known to affect language comprehension and should influence the prior term within the noisy channel model. Two such factors include lexical and syntactic predictions. There are numerous studies examining expectations for words and showing that predictable words are processed faster than unpredictable words (for instance, see Fischler & Bloom, 1979; Kleiman, 1980; Kutas & Hillyard, 1980). One example is an experiment from Federmeier and colleagues. Using electroencephalography, Federmeier, Wlotko, Ochoa-Dewalk, and Kutas (2007) found that participants predict specific words within highly constraining sentences, or sentences that contain a high cloze probability for a specific word due to the restrictive nature of the sentence (i.e. *Cats loved to be scratched behind the ears*.). Participants exhibited greater processing costs, revealed through larger N400 responses, when the highly constraining sentences were completed with unexpected versus expected words. If these results are viewed within a noisy channel account of language comprehension, then the likelihood of a particular word to occur could be an additional factor influencing prior probability.

People are also sensitive to expectations of syntax during language comprehension. Levy (2008) found that reading times are proportional to syntactic surprisal. A word is more difficult to process, resulting in a longer reading time, when it is less expected in the context of its

sentence structure. This relationship between reading time and syntactic surprisal is evidence that comprehenders have predictions for upcoming sentence constructions. Expectation for certain sentence structures is known to occur in healthy individuals (Staub & Clifton, 2006) and people with aphasia (Warren, Dickey, & Lei, 2016). Staub and Clifton presented sentences with disjunctions to participants, where some sentences contained the word *either* earlier in the sentence while others did not. Placement of the word *either* differed across two types of experimental sentences: a sentence-coordination type (i.e. *Either Linda bought the red car or her husband leased the green one.*) and a noun-phrase-coordination type (i.e. *The maid stole either a necklace or a bracelet at the end of each day.*) When both types of experimental sentences included *either*, participants read *or* and the following words more quickly than the same sentences when *either* was absent. Staub and Clifton also observed that participants experienced garden-path effects in the sentence-coordination sentences missing *either*: in these sentences, the following disjunct after *or* was ambiguous, and participants misanalysed this sentence region as another noun phrase of a direct object instead of a separate clause. Also using the *either…or* sentence construction (noun-phrase-coordination type), Warren, Dickey, and Lei found that individuals with aphasia are faster to process the word *or* and its disjunct when the word *either* appears earlier in the sentence than when *either* is absent.

This evidence suggests that comprehenders make lexical and syntactic predictions during language comprehension. Although plausibility is one cue that comprehenders use to inform their prior probability, it is possible that lexical and syntactic cues can also be factors that affect the prior term. Gibson framed prior probability as the likelihood of the overall message at the sentence level. For this paper, we view prediction as a process with hierarchical structure, in which prediction occurs at many levels of comprehension (Kuperberg & Jaeger, 2016). A lexical

cue would influence prior probability at the word level, or the likelihood of a particular word occurring next in the sentence. A syntactic cue would influence prior probability at the structural level, or the likelihood of a particular sentence structure occurring. If lexical and syntactic cues behave like plausibility within a noisy channel framework, adaptation of reliance on these cues should be observed. Comprehenders should update their lexical and syntactic expectations according to the context in which language is processed.

The goal of the following experiments was to investigate adaptation of reliance on lexical and syntactic cues during comprehension across contexts in which the informativity of these cues changes. Gibson and colleagues' evidence for adaptation of reliance on a plausibility cue to inform prior probability leads one to question whether this behavior generalizes to other predictive linguistic cues that guide and shape comprehension. The question we hoped to address is: can we in a sense "break" reliance on expectations for certain words and the *either…or* sentence structure? In the following experiments, participants read sentences that included predictable and unpredictable words. For example, participants read 1a-1b below (in 1a, the word *leash* is more predictable in the sentence than *diet* in 1b):

1a. George must keep his pet on a <u>leash</u> for a month.
1b. George must keep his pet on a <u>diet</u> for a month.

Participants also read sentences with a predictable *either…or* sentence structure or sentences where the word *either* was absent. For example, participants read 2a-2b below (in 2a, the word *or* and its disjunct are more predictable than in 2b):

2a. June donated *either* a box of books <u>or a load of clothes</u> to the local shelter.
2b. June donated a box of books <u>or a load of clothes</u> to the local shelter.

We measured how long it took participants to read critical words and phrases in these sentences within a context in which lexical and syntactic cues supported default lexical and syntactic predictions and an environment in which these cues violated default predictions. It was hypothesized that participants would rely on their default lexical and syntactic expectations when reading in the supportive lexical and syntactic cue environment. This would be demonstrated by lexical and syntactic predictability effects. If a lexical cue, a syntactic cue, or both types of cues influence prior probability and behave like plausibility in Gibson's experiments, we would expect that participants would adapt and rely less on these cues when reading in the violating lexical and syntactic cue environment. This "breaking" of reliance on lexical and syntactic cues would be evidenced by diminished lexical and syntactic predictability effects.

2.0 EXPERIMENT 1

The first experiment examined whether adaptation of reliance on lexical and syntactic cues occurs within a single experimental session (Fine, Jaeger, Farmer, & Qian, 2013). By testing adaptation within one experiment, we could observe whether participants updated their likelihoods of reading a certain word or sentence structure as they received input across the experimental environment that the informativity of the lexical and syntactic cues has changed. We manipulated the informativity of lexical and syntactic cues by creating different sets of filler sentences for lexical and syntactic experimental items across blocks of the experiment. For example, in the violating cue context, Block 1, participants read sentences like 3a-3b:

Violating Filler Sentences

3a. Lexical Fillers

On the top of her head she wore a bowl with stripes.

3b. Syntactic Fillers

Deb carried either laundry or the blue folded pool cover into the yard.

The lexical filler sentences were constructed so that upcoming words within the sentences were unpredictable (in the example, the word *bowl*). The syntactic fillers were constructed so that the two disjuncts in the sentences were not parallel in structure (in the example, the disjuncts *laundry* and *blue folded pool cover*). Research from the *either…or* structure literature (Staub & Clifton, 2006; Warren & Dickey, 2011) suggest that comprehenders may have an expectation for

parallelism between noun phrase disjuncts. In a norming sentence completion task, Warren and Dickey showed that participants completed *either…or* constructions that included an initial noun phrase disjunct structure (i.e. *Jim thinks that Ally admired either Karen or…*) 86% of the time with another noun phrase (i.e. *Rita*) compared to 16% of completions including a clause or verb phrase (i.e. *Rita had greatly admired Betsy*) and vice versa when the construction included an initial clause phrase. Thus, manipulating the context so that there is a greater presence of non-parallelism violates this expectation.

Within the supporting lexical and syntactic cue environment, or Block 2, participants read sentences like 4a-4b:

Supporting Filler Sentences

4a. Lexical Fillers

The girl scout troop sold cookies at a stand outside the event.

4b. Syntactic Fillers

Jason caught either an angry raccoon or a small fox in his cage by the pond.

The lexical fillers sentences in Block 2 were constructed to be typical fillers, or sentences in which prediction of upcoming words was possible (*cookies*). The syntactic fillers were constructed so that the two disjuncts in the sentences were parallel in structure (*angry raccoon* and *small fox*).

If comprehenders adapt and "break" their reliance on lexical and syntactic cues within an experimental context that violates default lexical and syntactic expectations, then we should see an interaction of predictability and block at the critical word/phrase region, such that in Block 1, there should be smaller main effects of lexical and syntactic predictability than those observed in Block 2 of the experiment, or a context in which these cues are supportive of default predictions.

2.1 MATERIALS AND METHOD

2.1.1 Participants

Fifty native English-speaking (learned English before the age of 5) undergraduate students (M= 18.7 years, 32 female) from the University of Pittsburgh with normal or corrected normal vision participated in the study. Participants were recruited through the University undergraduate subject pool's SONA system. The protocol has been approved by the University of Pittsburgh Ethics committee. Participants were compensated one credit of research through SONA for their participation.

2.1.2 Materials

Participants read 52 experimental sentences and 80 filler sentences across two experimental blocks. Critical experimental sentences were drawn from two sub-experiments. Lexical predictability items included highly constraining sentences with high cloze probability and low cloze probability (from Federmeier et al., 2007). These experimental sentences thus appeared in one of two conditions:

Lexical Predictability

1a. High cloze, high constraint

George | must keep | his pet | on a | <u>leash</u> | for a | month.

1b. Low cloze, high constraint

George | must keep | his pet | on a | <u>diet</u> | for a | month.

Federmeier and colleagues established the difference between high and low cloze probability conditions via cloze norming, with high-predictability words being provided in at minimum 67% of completions and low-predictability words being provided in at maximum 47% of completions. We chose a subset of 32 highly-constraining sentences from the Federmeier stimuli that were matched on critical natural log word frequency ($M_{predictable}$= 9.778, $M_{unpredictable}$= 9.386, p=0.385) (HAL corpus, Balota et al., 2007) and critical word length ($M_{predictable}$= 4.938, $M_{unpredictable}$= 5.531, p= 0.142) across conditions. Short clause endings were added to the Federmeier sentences, thus creating post-critical regions for the lexical items to ensure that any potential predictability effect would be observed in the task.

Disjunction predictability items included sentences with an *either…or* syntactic structure or sentences with only the word *or* (sentences were adapted from Warren, Dickey, & Lei, 2016). These experimental sentences thus appeared in one of two conditions:

Disjunction Predictability

2a. Either…or

June donated either | a box of books | <u>or a load of clothes</u> | to the local shelter.

2b. …Or

June donated | a box of books | <u>or a load of clothes</u> | to the local shelter.

The presentation segments for self-paced reading are marked with a pipe (|) above; the critical word or phrase region is underlined. Full lists of lexical and disjunction predictability stimuli can be found in Appendices A and B. Filler sentences were constructed for the lexical and syntactic items for each type of filler context. Block 1 contained filler sentences in which lexical and syntactic cues violated default expectations and were uninformative for prior probability. These included unpredictable sentences like Example 3a and sentences with non-

parallel disjuncts like Example 3b (see Appendices C-D for full lists of violating filler stimuli). Block 2 contained typical filler sentences, or sentences in which lexical and syntactic cues supported default predictions and were informative for prior probability. These included predictable sentences like Example 4a and sentences with structurally-parallel disjuncts like Example 4b (see Appendices E-F for full lists of supporting filler stimuli).

There were 26 experimental sentences (16 lexical predictability items, 10 disjunction predictability items) and 40 filler sentences (30 filler items for lexical predictability, 10 filler items for disjunction predictability) presented in each of the two blocks. Yes/no comprehension questions followed half of the lexical and syntactic experimental items and eight filler sentences within each block. Experimental items were counterbalanced across blocks according to a Latin square design. Sentences were pseudo-randomized within blocks, so that there was no more than two of the same kind of sentence in sequential order. In addition, sentences were carefully segmented for the self-paced reading task in an attempt to prevent participants from using the sentence fragment divisions themselves as predictive cues. This was done by dividing the word *either* in its own segmentation for half of the trials, and for the other half of trials implementing a division after the word *either*, where *either* was included in the first segmentation with previous words in the sentence.

2.1.3 Procedure

Participants were tested in the behavioral laboratory in the Learning, Research, and Development Center at the University of Pittsburgh. Participants read sentences in a self-paced reading moving window format, presented using E-prime version 2.0 (Schneider, Eschman, & Zuccolotto, 2002). Periodically, yes/no comprehension questions pertaining to the sentences were asked to ensure

participants were paying attention. Participants completed the task on a desktop monitor and were encouraged to take breaks throughout the study. Participants were aware when one block of the experiment ended and another began because each block was a different experiment in E-prime (the researcher came into the testing room and opened the next block file). The reading task took between 15-25 minutes to complete. Upon completion, participants were asked to fill out a demographic form and were debriefed.

2.1.4 Measures

The time that it took to read each word or phrase region in the experimental sentences was measured. Reading time was calculated as the duration between keyboard presses during self-paced reading. Accuracy on the comprehension questions was also measured.

2.2 RESULTS

2.2.1 Accuracy

Mean accuracy scores by lexical and syntactic experimental items can be found in Table 1. Mean participant accuracy on the comprehension questions was used as a check to make sure that participants were successfully reading and comprehending sentences within the task.

Table 1. Mean Accuracy Scores by Experimental Item

Table 1

Mean Accuracy Scores by Experimental Item

Items	Count	Proportion Correct
Overall	1584	0.95
Lexical	396	0.90
Syntactic	396	0.98

Note: Filler comprehension questions are included in Overall

2.2.2 Reading Time

Reading-time data were analyzed using linear mixed effects models within the lme4 package of R (Bates & Sarkar, 2005). Reading times for the critical and post-critical words and phrase regions in the lexical predictability items and the disjunction predictability items were analyzed separately (see previous examples below–underlined is critical word/region), with post-critical analyses conducted to examine any possible spill-over effects with the self-paced reading paradigm.

1. George | must keep | his pet | on a | <u>leash/diet</u> | for a | month.
2. June donated | (*either*) | a box of books | <u>or a load of clothes</u> | to the local shelter.

Reading-time data for forty-five participants were included in the analyses, with five participants' data dropped due to failure to follow instructions and for having low accuracy scores (more than two standard deviations below the mean accuracy on comprehension questions across all participants).

Within each sub-experiment–lexical predictability items and disjunction predictability items–models included the following fixed effects: condition (predictable vs. unpredictable), block (block 1, violating filler cue context vs. block 2, supporting filler cue context), the

interaction of condition and block, and trial number. Categorical fixed effects of condition and block were contrast-coded as the following: predictable = -0.5, unpredictable = 0.5, and block 1 = 0.5, block 2 = -0.5, to reflect our predictions that more predictable sentences will be read faster at these regions and that all sentences will be read faster overall in a more typical language environment (supporting cue context). The continuous measure of trial number was centered. Random intercepts of participant and item and random slopes of condition and block were included to reach maximally converging models. Reading times were natural log transformed within each model.

2.2.3 Lexical Predictability

2.2.3.1 Critical Region

Figure 1 shows mean reading times by condition for each block at the critical region (leash/diet in Example 1) of our lexical items. Overall, participants were faster reading predictable words (leash) than less predictable words (diet). This predictability effect of condition was significant, estimated Beta= 0.06, p= 0.01. There was no main effect of block, estimated Beta< 0.01, p= 0.92. There was no interaction between condition and block, estimated Beta= 0.01, p= 0.75. Participants were similarly fast reading the critical word in predictable sentences across blocks of the experiment. To further explore if there was any indication of adaptation across the experiment (i.e. if a block design inadvertently masked an adaptation effect), we also ran a model where we used a continuous measure of number of violating lexical occurrences encountered before a given trial instead of the categorical block fixed effect. There was a predictability effect of condition, estimated Beta= 0.06, p= 0.01, and no interaction between condition and number of violating lexical occurrences, estimated Beta= -0.01, p= 0.50.

2.2.3.2 Post-Critical Region

Figure 2 displays mean reading time results at the post-critical region of our lexical items. Participants were again faster overall reading sentences with predictable words than sentences with less predictable words, estimated Beta= 0.10, p< 0.01. There was no effect of block, estimated Beta= 0.001, p= 0.87, and no interaction between condition and block, estimated Beta= -0.04, p= 0.14.

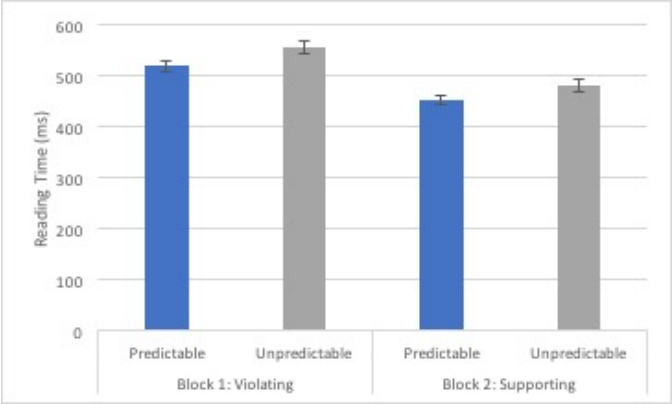

Figure 1. Critical Region Lexical Mean Reading Times by Block

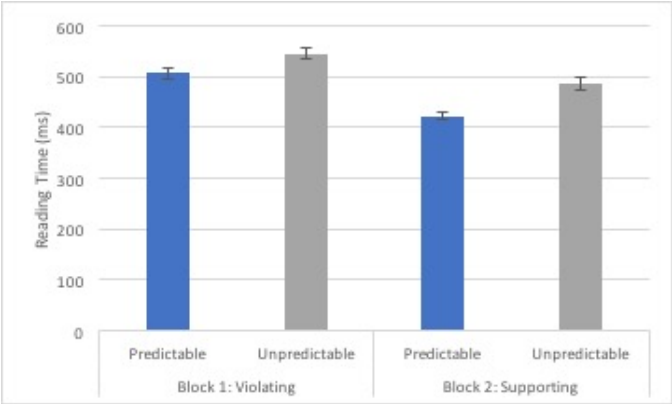

Figure 2. Post-Critical Lexical Mean Reading Times by Block

2.2.4 Disjunction Predictability

2.2.4.1 Critical Region

Figure 3 shows mean reading times by condition for each block at the critical region of our syntactic items (*or a load of clothes* for examples 2a and 2b). Overall, participants were faster to read *or* and its disjunct in sentences with the *either…or* syntactic structure than sentences that did not include the word *either*, estimated Beta= 0.07, p= 0.01. There was no effect of block, estimated Beta= -0.04, p= 0.46, and no interaction between condition and block, estimated Beta= 0.07, p= 0.21.

2.2.4.2 Post-Critical Region

Figure 4 displays mean reading times at the post-critical region of our syntactic items. We did not see a difference in participant reading time between sentences with the predictable *either…or* structure and sentences where *or* was absent, estimated Beta= 0.03, p= 0.32. There was a main effect of block, estimated Beta= 0.14, p= 0.02, and there was no interaction between condition and block, estimated Beta= -0.05, p= 0.30.

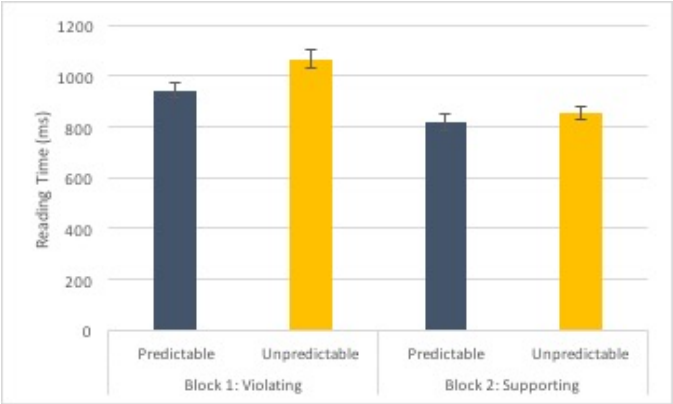

Figure 3. Critical Disjunction Mean Reading Times by Block

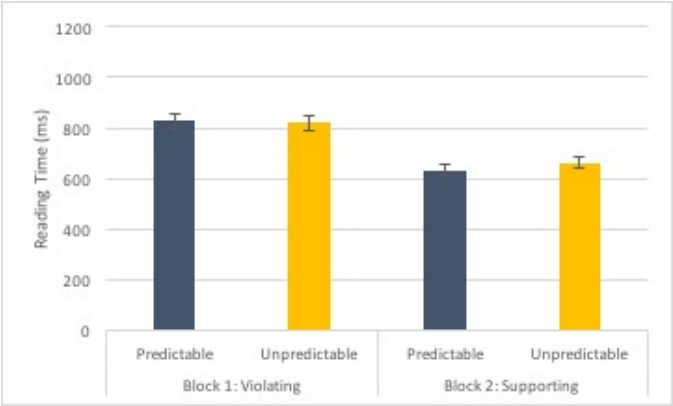

Figure 4. Post-Critical Disjunction Mean Reading Times by Block

2.3 DISCUSSION

In Experiment 1 we investigated reliance on lexical and syntactic cues across a single experimental session that changed the utility of these cues for prior probability. Results revealed that participants consistently predicted upcoming words and the *either…or* sentence construction. Although these lexical and disjunction predictability effects were robust, we did not see any change in the size of these effects across the experiment. Participants did not seem to adapt their reliance on lexical and syntactic cues. Other than the post-critical region for the disjunction item sentences, where there was a possible speed-up effect during reading, we did not see an effect of block, indicating that participants did not treat sentences across blocks differently during comprehension. This suggests that comprehenders were utilizing their default lexical and syntactic predictions to inform prior probability regardless of whether the environment in which they read violated (Block 1) or supported (Block 2) these predictions.

One possible reason for why we did not observe any adaptative behavior within a single experimental session could be due to the time course and nature of these lexical and syntactic

adaptation effects (Samuel, 2011). On the one hand, if comprehenders quickly adapt their reliance on these cues upon "entering" their initial reading environment (after reading the first few sentences of the experiment), and then maintain this behavior for the remainder of the experimental study, then we may have lacked the capability to observe faster adaptation effects within our experimental design. On the other hand, if adaptation of reliance on lexical and syntactic cues is a slower process, then a within-subjects experimental design may have lacked the power to detect these adaptation effects due to a smaller number of items within each filler context. Thus, we conducted a second study to investigate the question of whether adaptation of reliance on lexical and syntactic cues occurs *across* experiments. This experimental design follows Gibson's plausibility experiment.

3.0 EXPERIMENT 2

The second experiment examined whether adaptation of reliance on lexical and syntactic cues occurs across experiments in which participants are exposed to either a context in which cues support default predictions or a context in which cues violate these expectations. It was again predicted that comprehenders can adapt and "break" their reliance on lexical and syntactic cues. This would be revealed by an interaction of condition and filler type, where participants reading within the violating filler cue context would have smaller lexical and disjunction predictability effects than subjects reading within the supporting filler cue context.

3.1 MATERIALS AND METHOD

3.1.1 Participants

A different set of forty-eight undergraduate students (M= 19.2 years, 28 female) from the University of Pittsburgh participated in the study. Participants adhered to the same requirements, protocol, and compensation as those in Experiment 1.

3.1.2 Materials

The same lexical and syntactic experimental and filler materials were used as Experiment 1, but instead of a within-subjects design with two experimental blocks, Experiment 2 was a between-subjects design. The two versions of the experiment differed in their filler types, where participants were exposed to either a violating filler cue environment (refer to Example 3 sentences) or a supporting filler cue environment (refer to Example 4 sentences). Participants read 52 experimental sentences (32 lexical predictability items, 20 disjunction predictability items) and 40 filler sentences (30 filler items for lexical predictability, 10 filler items for disjunction predictability). Experimental items were counterbalanced and pseudo-randomized in the same way as Experiment 1.

3.1.3 Procedure

Participants were tested in the same location with the same self-paced reading format task as that of Experiment 1. Participants only completed one experiment within E-prime that took about 15-20 minutes to complete. Upon completion, participants were asked to fill out a demographic form and were debriefed.

3.1.4 Measures

The same measures were calculated as in Experiment 1.

3.2 RESULTS

3.2.1 Accuracy

Mean accuracy scores for lexical and syntactic items in Experiment 2 can be found in Table 2.

Table 2. Mean Accuracy Scores by Experimental Item

Table 2

Mean Accuracy Scores by Experimental Item

Items	Count	Proportion Correct
Overall	1146	0.94
Lexical	384	0.87
Syntactic	378	0.99

Note: Filler comprehension questions are included in Overall

3.2.2 Reading Time

Critical and post-critical reading-time data for forty-four participants were analyzed. Four participants were dropped from analyses for having low accuracy scores (more than two standard deviations below mean accuracy on comprehension questions across all participants) and long reading times (greater than two standard deviations above mean reading time across all regions of the sentences for all participants).

Linear mixed-effect models included the following fixed effects: condition (predictable vs. unpredictable), filler type (supporting cue context vs. violating cue context), the interaction of condition and filler type, and trial number. Categorical fixed effects of condition and filler type were contrast-coded as the following: predictable = -0.5, unpredictable = 0.5, and supporting = -0.5, violating = 0.5. The continuous fixed effect of trial number was centered. Random intercepts of participant and item and random slopes of condition and filler type were included in

the models to reach maximally converging models. Reading times were natural log transformed within each model.

3.2.3 Lexical Predictability

3.2.3.1 Critical Region

Figure 5 shows mean reading times by condition for each filler type at the critical region of the lexical items. Across all participants, there was a main effect of condition, estimated Beta= 0.06, p= 0.01. Participants read predictable words faster than unpredictable words. There was no effect of filler type, estimated Beta= 0.07, p= 0.20, and no interaction between condition and filler type, estimated Beta= 0.04, p= 0.31. Participants across filler contexts had similar predictability effect magnitudes. We also ran a model in which we included trial number in the interaction to explore whether there was any indication of adaptation occurring within the experimental environments. There was no three-way interaction between condition, filler type, and trial number, estimated Beta= 0.01, p= 0.76.

3.2.3.2 Post-Critical Region

Figure 6 displays mean reading times at the post-critical region of the lexical items. Participants were again significantly faster reading sentences with predictable words than sentences with less predictable words, estimated Beta= 0.09, p< 0.01. There was no effect of filler type, estimated Beta= 0.05, p= 0.32, and no interaction between condition and filler type, estimated Beta= -0.04, p= 0.30.

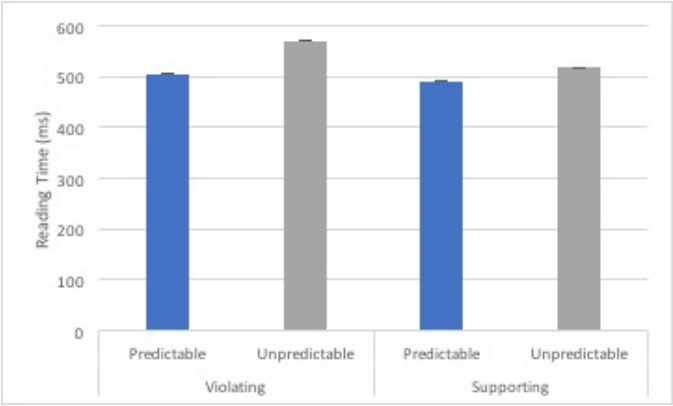

Figure 5. Critical Lexical Mean Reading Times by Filler Type

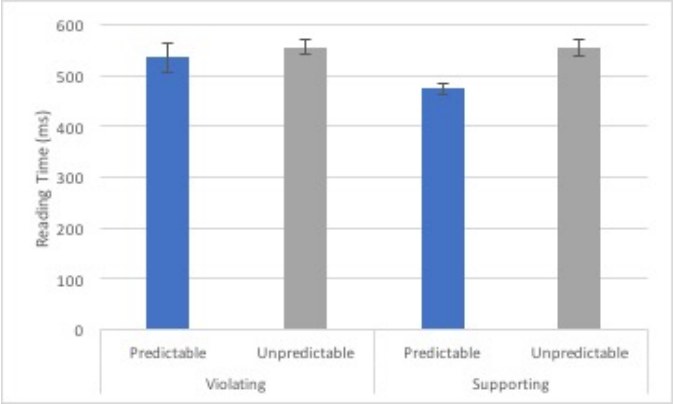

Figure 6. Post-Critical Lexical Mean Reading Times by Filler Type

3.2.4 Disjunction Predictability

3.2.4.1 Critical Region

Figure 7 shows mean reading times by condition for each filler type at the critical region of the syntactic items. There was a main effect of condition, estimated Beta= 0.14, $p< 0.01$, where participants read *or* and its disjuncts in predictable *either…or* sentences faster than *or* and disjuncts in sentences that did not include *either*. There was no effect of block, estimated Beta= 0.10, p= 0.13, and no interaction between condition and filler type, estimated Beta= -0.03, p= 0.53. Syntactic predictability effects were similar for participants reading within a supportive

syntactic cue context and participants reading within an environment in which a syntactic cue violated default predictions.

3.2.4.2 Post-Critical Region

Figure 8 displays mean reading times at the post-critical region of the syntactic items. We did not see a main effect of condition, estimated Beta= 0.04, p= 0.23, or block, estimated Beta= 0.01, p= 0.84, and there was no interaction between condition and filler type, estimated Beta= 0.06, p= 0.93.

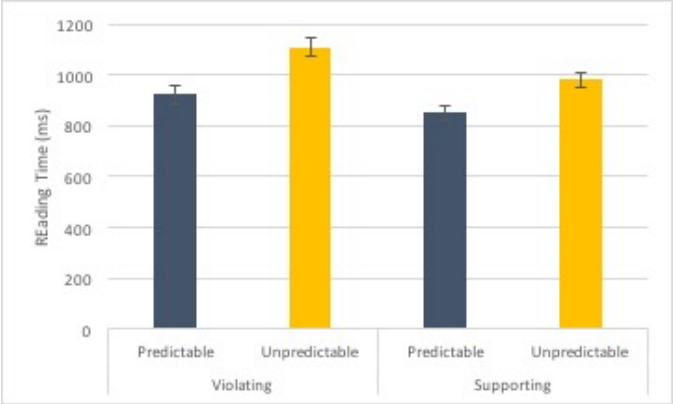

Figure 7. Critical Disjunction Mean Reading Times by Filler Type

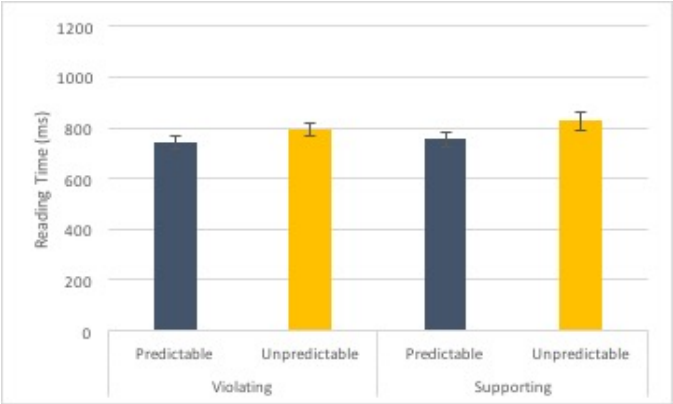

Figure 8. Post-Critical Disjunction Mean Reading Times by Filler Type

3.2.5 Additional Graphs

In case adaptation effects were too fast for us to observe in the overall analyses, graphical investigations of Experiments 2 were conducted to further examine reading times across and within experimental sessions for both lexical and syntactic items at the critical region. This was completed by breaking each set of predictable and unpredictable lexical and syntactic items into eight equal distribution groups across the experiments according to the presentation order of the items. As observed in Figure 9 for the violating filler experimental context and Figure 10 for the supporting filler experimental context, adaptation of reliance on lexical or syntactic cues is not depicted across a single experimental session or across experimental contexts.

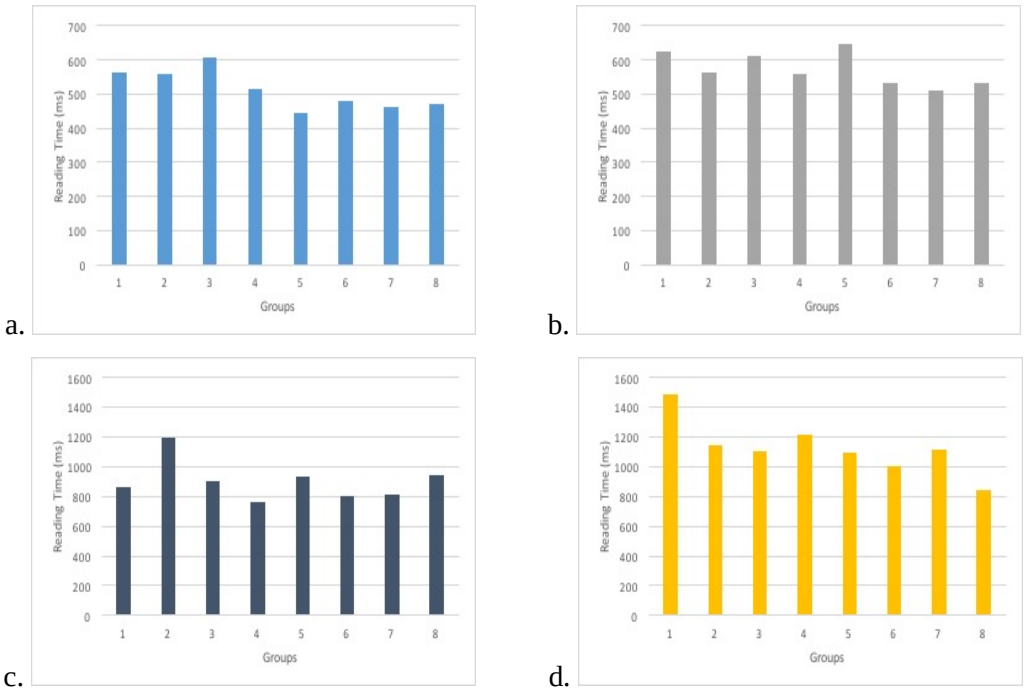

Figure 9. Critical Region Distribution Mean Reading Times Across the Violating Filler Experimental Context. Legend: a) predictable lexical items, b) unpredictable lexical items, c) predictable syntactic items, d) unpredictable syntactic items.

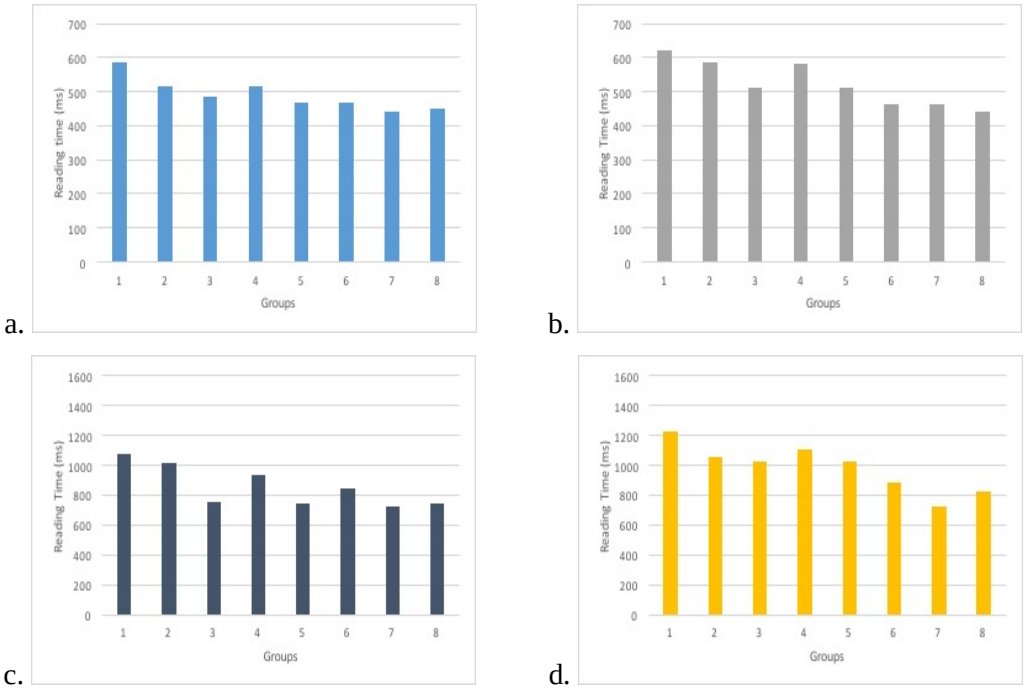

Figure 10. Critical Region Distribution Mean Reading Times Across the Supporting Filler Experimental Context. Legend: a) predictable lexical items, b) unpredictable lexical items, c) predictable syntactic items, d) unpredictable syntactic items.

3.3 DISCUSSION

Results from Experiment 2, in which reliance on lexical and syntactic cues was explored across experimental filler types, again revealed robust lexical and syntactic predictability effects. Comprehenders in both experimental contexts consistently read critical regions faster when predictable words and disjuncts were present than less predictable words and disjuncts. This result follows those found in Federmeier et al. (2007) and Staub and Clifton (2006), and confirms our condition manipulation, since we chose lexical and syntactic experimental items with strong and salient predictive cues. Lexical items were highly-constraining sentences that guided comprehenders to predict a specific word; very few words could also complete the

sentence and maintain semantic coherence. Syntactic items contained the strong one-word morphosyntactic cue *either* that indicated to comprehenders that an *or* and disjunct would follow in the sentence. In the English language, there are few–if only one–alternative syntactic structure(s) that also contain *either* (i.e. "either decision is fine with me"), and processing of these alternative structures is revised immediately at the first word (noun) after *either* when the sentence is misanalysed.

We again did not see any evidence for comprehenders adapting their reliance on lexical and syntactic cues when reading within the violating filler context. Participants continued to use their default predictions for upcoming words and the *either…or* sentence structure to inform prior probability, even when the cues violated these expectations. This result is interesting, given that with greater power to detect differences in lexical and disjunction predictability effects across experimental filler contexts in Experiment 2, we still found the same pattern of results as Experiment 1. It is possible that lexical and syntactic cues may not work the same as a plausibility cue within the noisy channel model. Everyday language communication intrinsically consists of plausible utterances, but typical language does not necessarily include predictable words or a specific sentence structure such as *either…or*. There likely exist differences between the extent to which a plausibility cue is relied upon to inform prior probability and the extent of lexical or syntactic cue reliance. Plausibility may be a more reliable cue when predicting upcoming information, and when broken, would lead to greater adaptation of reliance on the cue.

Another possibility is that the violating lexical and syntactic cues that we created for Experiments 1 and 2 were too subtle to drive any adaptation of reliance on these factors. Filler sentences for lexical items in the violating context contained unexpected words (*bowl*) that changed typical events (i.e. *On the top of her head she wore a <u>hat</u> with stripes*) to be

unpredictable and semantically implausible (i.e. *On the top of her head she wore a bowl with stripes*). While these sentences were constructed to inform comprehenders that expecting predictable words was not helpful for comprehension, it could have been that there was not enough of a processing cost associated with the cue in the language environment for comprehenders to change their reliance on word expectancy. Even if predicting upcoming words did not always result in reading those words, it may have still been better to predict than not.

Filler sentences for syntactic items in the violating filler context contained non-parallel disjuncts. This violating cue could also have been too subtle to drive adaptation if comprehenders did not relate structural parallelism to their expectation for the *either…or* sentence construction. Even when given an *either…or* structure that contained non-parallelism (i.e. *Deb carried either laundry or the blue folded pool cover into the yard*), participants may have continued predicting the *either…or* structure at the same rate as participants in the supporting cue context if the processing cost associated with a non-parallel disjunct cue was much smaller compared to the processing cost associated with *either*. Thus, if our violating syntactic cue context contained a strong default predictive cue for the *either…or* construction but a weaker violating cue relative to this expectation, it would explain why we observed a syntactic predictability effect in this environment but no adaptation of reliance on this cue.

In case our violating syntactic cue may have been too subtle in Experiments 1 and 2, Experiment 3 explored a syntactic cue that violated default syntactic prediction for *either…or* via a different approach. Instead of examining changes in the informativity of a syntactic cue by including fillers sentences with parallel and non-parallel disjuncts, Experiment 3 examined syntactic cue informativity by incorporating filler sentences that always successfully carried out

the *either…or* sentence structure or filler sentences in which the *either…or* syntactic construction was not carried out, with the *or* never appearing later in these sentences.

4.0 EXPERIMENT 3

The purpose of Experiment 3 was to investigate whether a stronger violating syntactic cue would drive adaptation of reliance on this cue when informing prior probability for comprehension. Filler sentences for syntactic items in the violating filler context of Experiment 3 always contained the word *either* and failed to carry out the *either…or* structure in a systematic way by 1) never having the word *or* appear later in the sentences and 2) making sure these sentences were still readable despite not coherent. For example, participants read sentences like Example 5:

5. Violating Syntactic Fillers
Deb carried either laundry to fold into piles in the backyard.

The same hypotheses for Experiment 2 were proposed for Experiment 3.

4.1 MATERIALS AND METHOD

4.1.1 Participants

A third and separate set of one hundred undergraduate students (M= 18.0 years, 64 female) from the University of Pittsburgh participated in the study. Participants adhered to the same requirements, protocol, and compensation as those in Experiments 1 and 2.

4.1.2 Materials

Experiment 3 was identical to Experiment 2 except for a new set of violating syntactic filler sentences. This included unsuccessful *either…or* constructions, designed so that *or* never followed in the sentence after given an *either* (see Appendix G for a full list of violating syntactic filler stimuli).

4.1.3 Procedure

The same procedure was followed as in Experiment 2.

4.1.4 Measures

The same measures were calculated as in Experiments 1 and 2.

4.2 RESULTS

4.2.1 Accuracy

Mean accuracy scores for lexical and syntactic items in Experiment 3 can be found in Table 3.

Table 3. Mean Accuracy Scores by Experimental Item

Table 3

Mean Accuracy Scores by Experimental Item

Items	Count	Proportion Correct
Overall	2363	0.95
Lexical	763	0.94
Syntactic	800	0.99

Note: Filler comprehension questions are included in Overall

4.2.2 Reading Time

Critical and post-critical reading-time data for ninety-two participants were analyzed. Eight participants were dropped from analyses for having low accuracy scores (more than two standard deviations below mean accuracy on the comprehension questions across all participants) and long reading times (greater than two standard deviations above mean reading time across all regions of the sentences for all participants). Linear mixed-effects models for Experiment 3 followed the reading time natural log transformation, same contrast-coding scheme, and same inclusion of random intercepts and random slopes specified in Experiment 2.

4.2.3 Lexical Predictability

4.2.3.1 Critical Region

Figure 11 shows mean reading times by condition for each filler type at the critical region of the lexical items. Participants were faster reading predictable words than less predictable words, estimated Beta= 0.05, p< 0.01. There was no effect of filler type, estimated Beta= 0.04, p= 0.23, and no interaction between condition and filler type, estimated Beta= 0.01, p= 0.66, suggesting that participants did not adapt their reliance on a lexical cue across filler contexts.

4.2.3.2 Post-Critical Region

Figure 12 displays mean reading times at the post-critical region of the lexical items. We observed the same reading patterns as those found in the critical region: a main effect of condition, estimated Beta= 0.09, p< 0.01, no effect of block, estimated Beta= -0.01, p= 0.62, and no interaction between condition and filler type, estimated Beta= -0.02, p= 0.51.

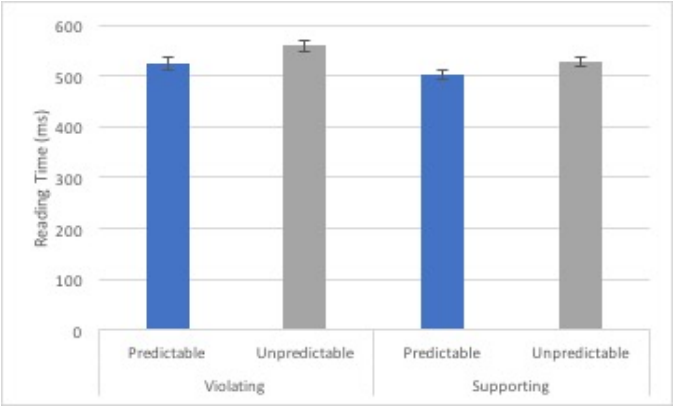

Figure 11. Critical Lexical Mean Reading Times by Filler Type

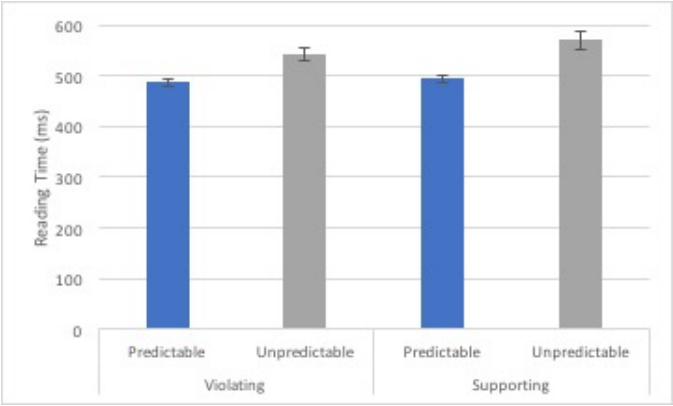

Figure 12. Post-Critical Lexical Mean Reading Times by Filler Type

4.2.4 Disjunction Predictability

4.2.4.1 Critical Region

Figure 13 shows mean reading times by condition for each filler type at the critical region of the syntactic items. There was a main effect of condition, estimated Beta= 0.14, p< 0.01, and no effect of filler type, estimated Beta= 0.01, p= 0.88. Overall, participants were faster reading *or* and the disjunct after *or* when *either* was included in the sentence than when *either* was absent. There was a significant interaction effect between condition and filler type, estimated Beta= -0.09, p= 0.05. Participants who read within the violating syntactic cue environment had a smaller syntactic predictability effect than participants who read within the supporting cue context.

4.2.4.2 Post-Critical Region

Figure 14 displays mean reading times at the post-critical region of the syntactic items. We again observed a main predictability effect of condition, estimated Beta= 0.06, p= 0.04 and no

effect of filler type, estimated Beta= -0.01, p= 0.82. There was no interaction between condition and filler type, estimated Beta= -0.03, p= 0.44.

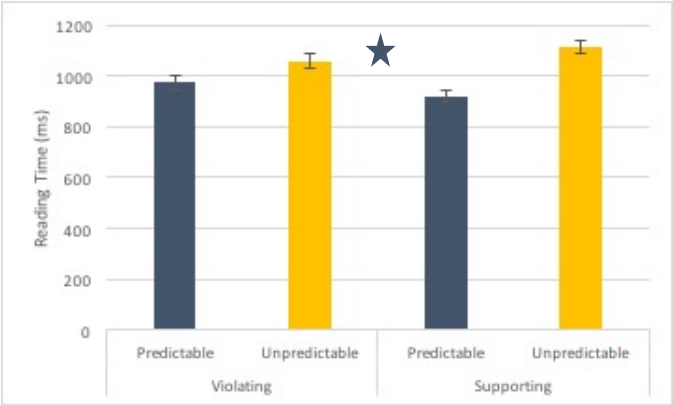

Figure 13. Critical Disjunction Mean Reading Times by Filler Type

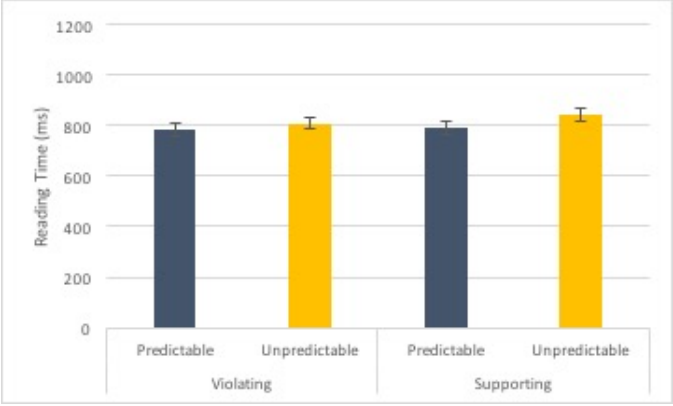

Figure 14. Post-Critical Disjunction Mean Reading Times by Filler Type

4.3 DISCUSSION

In Experiment 3, we were interested in whether participants would adapt their reliance on a syntactic cue to inform prior probability in a context in which there was a stronger violating cue. At the critical region of syntactic items across both versions of the experiments, participants were faster reading sentences that contained the word *either* than sentences that did not.

Additionally, there was an interaction effect of condition and filler type, in which the disjunction predictability effect was diminished in the violating filler cue context compared to the supporting filler cue context. This result suggests that participants "broke" their reliance on the *either* cue to inform prior probability when comprehending in a context in which the likelihood of reading an *either…or* sentence was low.

As we observed in Experiment 2, Experiment 3 also revealed that participants had a strong lexical predictability effect, but they did not show any adaptation of their reliance on a lexical cue across filler contexts.

5.0 GENERAL DISCUSSION

The purpose of the presented studies was to explore adaptation of reliance on lexical and syntactic cues within a noisy channel framework of language comprehension. We investigated this research question by measuring perceivers' expectations for 1) predictable words within highly constraining sentences and 2) the *either…or* syntactic structure, across contexts in which the informativity of lexical and syntactic cues for prior probability changed. In one experimental context–with typical filler sentences–lexical and syntactic cues were informative for prior probability since they supported baseline predictions. The other experimental context contained fillers where lexical and syntactic cues were not informative for prior probability. These cues violated default expectations.

Research from Federmeier et al. (2007) and Levy (2008) highlight prediction as a probabilistic mechanism. The prior probability term within Gibson's noisy channel model is the default setting of expectation for a sentence to occur, and it should be influenced by many linguistic probabilities. While Gibson and colleagues (2013) investigated plausibility as one factor that guides prior probability, the focus of this paper was on lexical and syntactic likelihoods. Gibson et al. showed that reliance on a default prediction of plausibility can decrease when there is overwhelming evidence in the environment that the probability of something being plausible is low. We created our experimental filler cue contexts by also following a probabilistic view of prediction. In the supporting cue context, lexical and syntactic

cues aligned with default expectations for upcoming words and structures, so that utilizing these default likelihoods to influence prior probability should aid sentence comprehension. The probability of reading an expected word or the *either…or* sentence structure remained high in this environment. In the violating cue context, filler sentences were created with lexical and syntactic cues that decreased the probability of reading predicted words and *either…or* sentences. Relying on default lexical and syntactic contributions to influence prior probability in this environment should not facilitate comprehension. We predicted that lexical and syntactic likelihoods would behave like plausibility within the noisy channel model. It was hypothesized that comprehenders would adapt and decrease their reliance on these factors when processing sentences within the violating cue context.

In all three experiments, we did not observe adaptation of reliance on a lexical cue to inform prior probability. Within a single experimental session and across experiments, participants maintained the same magnitude of expectation for predictable words when reading within a violating cue context and a supporting cue context. In other words, even when in an environment in which a lexical cue was informing them that the local likelihood of reading a predictable word was low, comprehenders did not update their expectation to new one and continued to use their default lexical predictions for comprehension. Experiments 1 and 2 also suggested that there was no adaptation of reliance on a syntactic cue for prior probability. Only when we utilized a stronger syntactic violating cue in Experiment 3 did we observe a change of reliance on a syntactic contribution to the prior probability term. When the syntactic cue clearly violated default predictions by never carrying out the *either…or* construction, participants had a larger structural predictability effect when comprehending syntactic items in the supporting cue filler context than the violating cue filler context (Figure 13). A study by Fine, Jaeger, Farmer,

and Qian (2013) also demonstrates that comprehenders can change their reliance on syntactic expectations. Within a single experimental session, Fine and colleagues found that comprehenders adapted their predictions for sentence structures when continually exposed to temporarily ambiguous reduced relative clauses (i.e. *The experienced soldiers warned about the dangers conducted the midnight raid).*

A common connection between Gibson et al. (2013), Fine et al. (2013) and our syntactic items in Experiment 3 is the salience of the violating cues relative to their default predictions. The experimental environment in Gibson's study contained many implausible fillers. Continually reading sentences that do not make sense is a clear indication to a comprehender that he/she should not expect plausible sentences in the future. In a similar manner, reading an ambiguous reduced relative clause syntactic structure elicits a garden-path effect, or a stark increase in reading time at the disambiguating region of the sentence (*conducted* in the example sentence). Continually being exposed to temporarily ambiguous reduced relative clauses can also be considered a strong cue to a comprehender that he/she should no longer rely on his/her expectation for *warned* as a main verb in the sentence, since the consequence of relying on this expectation is a pitfall for comprehension. In Experiment 3, comprehenders consistently read sentences that contained the word *either*, but these sentences never completed the *either…or* construction. Observing an adaptation effect for a syntactic cue in Experiment 3, but no such effect in Experiments 1 and 2, in which the violating syntactic filler context included non-parallel disjuncts, suggests that the combination of 1) a strong predictive cue and 2) a clear violation of this cue is what drives comprehenders to "break" their reliance on such a cue to inform prior probability.

Although we did not see adaptation of reliance on a lexical cue in any of the current experiments, a recent study by Brothers, Swaab, and Traxler (2017) did find adaptation of prediction for upcoming lexical items. In their experiment, Brothers and colleagues had 252 participants read sentences with highly predictable or unpredictable words, similar to Federmeier et al. (2007) sentences. Participants either read these sentences within a context with filler sentences that ended with an expected word (i.e. *The volleyball shot barely made it over the net*) or a context with fillers that ended in an unexpected word (i.e. *The volleyball shot barely made it over the car*). They found that reading time benefits (faster reading times for predictable words) disappeared for participants reading within the latter context, since this context invalidated the strategy of using predictive information for comprehension.

There are two possible reasons why we failed to show changes in reliance on a lexical cue but Brothers et al. (2017) showed this adaptation effect. The first reason again relates back to the saliency of the violating cues relative to their default predictions. Our violating lexical cue was created by including filler sentences with unpredictable words that changed the possibility of the sentences. While these did include unexpected words, the filler sentences in Brothers et al. better resemble the experimental sentences in Federmeier et al. (2007), or sentences with expected and unexpected words as both possible endings to the sentences, but where one word is more highly predicted than the other. It may be that an important characteristic of a clear violation of a predictive cue includes a close matching between violating sentences and predictive information.

A second possible reason could be due to the size of the adaptation effect for lexical information. The study by Brothers et al. (2017) had approximately 189 participants comprehending within filler contexts that included 50% or 87.5% unpredictable sentence

continuations (126 participants for the 50% violating context and 63 participants for the 87.5% violating context). The maximum number of participants in our violating filler cue context for the three experiments was 50 (with a range of 24-50). It may be that while it only takes about 50 participants to undo the predictive validity of the *either…or* sentence structure, any adaptation effect for changes in reliance on a lexical cue is small and only visible with a larger sample size.

Even with these differences between our study and Brothers et al., it still begs the question of what is a lexical predictability cue. Unlike a plausibility cue or a syntactic cue in which a prediction for a plausible utterance or a prediction for a certain structure need only occur once during sentence comprehension, lexical predictability can occur for every word in a sentence. Whether comprehenders calculate prior probabilities for each upcoming word is an open possibility, though our study and Federmeier et al. (2007) suggest that a strong lexical predictability cue exists in situations in which the next word is greatly constrained. Nevertheless, better understanding of what constitutes a lexical predictability cue would provide insight for when these cues are relied upon for comprehension.

Lexical and syntactic cues may play similar roles as a plausibility cue within a noisy channel framework, where various factors contribute to the prior probability of expecting a sentence to occur. Further experiments assessing the similarities and differences among types of linguistic contributions to prior probability is necessary (e.g. why some cues are more adaptive to context than other cues). Such research will allow us to better understand the process by which we sift through noise during language communication and will continue to shed light on the question previously presented: How are we able to correctly comprehend language when there are numerous ways in which the signal could be distorted?

APPENDIX A

LEXICAL PREDICTABILITY STIMULI

*Predictable sentence versions in **bold**

1) Cats | loved to be scratched | behind the | **ears**/collar | and on | the chin.

2) Bill jumped | in the lake | and made | a big | **splash**/commotion | this | afternoon.

3) George | must keep | his pet | on a | **leash**/diet | for a | month.

4) You | could tell | he | had grown up | in the | South | by his | **accent**/truck | and his | bumperstickers.

5) He bought her | a pearl necklace | for her | **birthday**/collection | last | year.

6) The rude waiter | was | not | given a | **tip**/tray | any time | tonight.

7) The ship disappeared | into | the thick | **fog**/smoke | and | left.

8) Steve | spilled | coffee | all over | his clean white | **shirt**/couch | and | pants.

9) Don't | touch | the wet | **paint**/clothes | over | there.

10) The groom | took the bride's hand | and placed | the ring on her | **finger**/dresser | very | gently.

11) He was | knocked off | his surfboard | by the first | **wave**/bully | to reach | him.

12) His boss | refused to | give him a | **raise**/drink | so he | was angry.

13) The squirrel stored | some nuts | in the | **tree**/basement | last | fall.

14) Paul | painted | the clown's suit | blue | and gave him | a big red | **nose**/balloon | before the | show.

15) Most | shark attacks | occur | very close to | **shore**/winter | in | Hawaii.

16) The prisoners | were planning | their | **escape**/party | extremely | carefully.

17) Father | carved | the turkey | with a | **knife**/smile | while mother | said grace.

18) Josie | found | she | could not | bend | the elbow | of her broken | **arm**/doll | yesterday | morning.

19) Tim threw | a rock | and broke the | **window**/camera | in the | corner.

20) I | added | my name | to the | **list**/basket | once | already.

21) There were | brightly colored pictures | on every | **wall**/card | in the | room.

22) The dispute | was settled by | a third | **party**/trial | after | a few months.

23) He was cold | most of the night | and finally | got up to get | another | **blanket**/log | at 4:00 AM.

24) Every morning | before school | his mother laid out | his clothes | and packed his | **lunch**/clarinet | before | sending him off.

25) Within minutes of arriving | at the office, | the detective | spilled his | thermos full of | **coffee**/scotch | on the | desk.

26) He knew | that he could call | Chris | even if it | was the | middle of | the | **night**/game | and late.

27) Will | played his | stereo | much too | **loud**/late | this | evening.

28) They | raised pigs | on their | **farm**/own | for | twenty years.

29) Joan fed | her baby | some warm | **milk**/peas | and soggy | Cheerios.

30) When the power | went out | the house became | **dark**/cold | and | quite scary.

31) He | decided to travel | in Iran | even though he knew | it could be | **dangerous**/expensive | and | time-consuming.

32) The children | went outside | to | **play**/look | with the | neighborhood kids..

APPENDIX B

DISJUNCTION PREDICTABILITY STIMULI

*Predictable sentence versions in **bold**

1) Olivia sent | **either** | a gift card | or a personal check | to her niece.
2) Janelle paid for | **either** | airbrush makeup | or wedding hair | for her bridesmaids.
3) The nurse looked in on | **either** | a stroke victim | or a cancer patient | before going home.
4) The barista made | **either** | a frozen smoothie | or a protein shake | for the customer.
5) The mailman delivered **either** | a rectangular box | or a large envelope | to the house.
6) Paulette offered **either** | a handshake | or a hug | to each of her guests.
7) Gregory signed **either** | a permission form | or a detention slip | for his son's school.
8) The worker drank **either** | a hot beverage | or some warm soup | from his thermos.
9) The coach assigned **either** | twenty free throws | or ten dribbling drills | to his players.
10) Emanuel renewed **either** | his driver's license | or his vehicle registration | before it expired.
11) Colin wore | **either** | an elaborate striped suit | or a classic black tuxedo | to the event.
12) Hilda noticed | **either |** some birds chirping | or the wind whistling | outside her window.
13) Benjamin interviewed **either** | a recent graduate | or a retired lieutenant | over her phone.
14) Stacey rented | **either** | a pony ride | or a bouncy house | for the party.
15) Haley decorated **either** | the fireplace mantle | or the staircase railing | with garland.
16) The dog followed **either** | the rabbit | or the squirrel | into the woods.
17) Heidi arranged **either** | a book club | or a support group | every Wednesday.
18) The author signed **either** | the front cover | or the dedication page | for the loyal fan.
19) The guy in the office is **either** | a research assistant | or a grad student | at the university.

20) The leader threatened **either** | another gang member | <u>or an undercover cop</u> | after the crime.

APPENDIX C

SUPPORTING LEXICAL FILLERS FOR EXPERIMENTS 1, 2, 3

1) Before it started, Laura bought popcorn to eat during the movie.
2) The limo driver took a wrong turn and missed the house.
3) Instead of ordering the fish, he chose the vegetarian option.
4) The lyrics that were played over the speaker made her cry.
5) While hiking, Zachary kept complaining about his heavy backpack.
6) The only chore the daughter had left was to take out the trash.
7) The wife caught her husband texting his mistress.
8) Georgia forgot her new watch in one of the lockers at the gym.
9) Scott earned his bachelor's degree by taking online classes.
10) The large flag on the pole moved back and forth in the wind.
11) Even though it looked like glass, the bottle was plastic and light to hold.
12) The deliveryman dropped the pizza on the way up the stairs.
13) The antique dealer inspected the family heirloom with great care.
14) They huddled in front of the fireplace after a day of skiing.
15) The lightbulb that was above the table burnt out.
16) It was Ray's car that was damaged in the accident.
17) The map was of no help to the lost tourists.
18) The girl scout troop sold cookies at a stand outside the event.
19) The skydiver landed in the grassy field with grace.
20) The toddler laughed at the cartoon as his mom picked up his toys.

21) The new tattoo hurt the first few days, but then healed neatly.

22) The mailman screamed as he was stung by the bee in the mailbox.

23) The phone contract ended so Jasmine drove to the store to renew it.

24) There was a long line at the grocery store and he was very hungry.

25) Swearing under his breath, the actor struggled with his lines.

26) By only a few inches, the replay showed the sprinter winning the race.

27) Nicole might be the first one at work every day but is also the first to leave.

28) The earthquake caused the frame to fall off the wall.

29) At the prom, Jessie spilled punch all over her beautiful dress.

30) When Jerry opened the door, he was surprised to see a cat on his porch.

APPENDIX D

VIOLATING LEXICAL FILLERS FOR EXPERIMENTS 1, 2, 3

1) Hidden in the cupboard was the elephant.
2) The mom rocked the baby to sleep in the space shuttle.
3) The cashier handed the man a chicken in change.
4) The car was cleaned in the washing machine in the basement.
5) Splashing in the puddle, the little girl found a submarine.
6) On the top of her head she wore a bowl with stripes.
7) The bus driver drove the bus right into the ant hole on the side of the road.
8) Nathan went to the beach to see the penguins.
9) Trevor was sick of the bed so he slept on the refrigerator.
10) Audrey cleaned the fish tank and added more alligators.
11) Medical school orientation was held at the amusement park in Ohio.
12) The prize in the cereal box was a coupon for bacon at Giant Eagle.
13) On Sunday, Sandy could not swim because the ocean froze over.
14) Meredith used the hose to fill up Lake Michigan.
15) The cyclist rode her bike on the edge of the Grand Canyon.
16) At Allison's house, the tacos were made with lettuce and peanut butter.
17) The daughter found buried treasure in her bathtub.
18) Larry turned on the air conditioner and snow blew out onto the floor.
19) Ben set up a picnic on the railroad tracks.
20) The teenager photoshopped herself to have a bigger nose.

21) Melanie grabbed the table salt to melt her driveway.

22) The model walked down the runway wearing a scuba diving outfit.

23) Tasha wanted to go on a walk so she put on her high heels.

24) Adam decorated his new apartment with newspaper from the recycling bin.

25) The children dug a hole in the ground and came out in Africa.

26) He proposed to his girlfriend and gave her a coffee.

27) The television did not turn off until the man sang to it.

28) The grandma made the blanket with plastic bags of many different colors.

29) Some people just need a high five in the face.

30) An apple a day keeps the young boy full.

APPENDIX E

SUPPORTING SYNTACTIC FILLERS FOR EXPERIMENTS 1, 2, 3

1) Katie drove by either an emptied pool or a skate park on her way to the movies.
2) The stewardess attended a nervous flyer or a quirky passenger upon take off.
3) Mary is either a staunch Republican or a conservative Liberal in the race this year.
4) George met a body builder or a steroid user at the gym yesterday.
5) Anna called either the doctor's office or dentist's office to schedule an appointment.
6) Maude offered a cucumber or a zucchini to the shopper at her farmer's market stand.
7) Jason caught either an angry raccoon or a small fox in his cage by the pond.
8) Trent spotted a shooting star or an airplane light in the night sky.
9) Martin took either a municipal bus or a crowded subway to get to work today.
10) The inspector visited a recently renovated bakery or a new pastry shop without warning.

APPENDIX F

VIOLATING SYNTACTIC FILLERS FOR EXPERIMENTS 1 AND 2

1) Karl is either a clown or interested in making people laugh.
2) The police stopped the petty thief or the man handing out flyers in the parking lot.
3) Evelyn requested either a back massage or someone to paint her nails at the salon.
4) Hillary ordered a new wood bedroom set or a chair for her apartment.
5) Penelope is either a liar or incredibly obnoxious when she pretends to be fainting.
6) The designer consulted her very eager young assistant or some lady on her latest design.
7) The musician played either the guitar or some loud modern music at the party.
8) The street cleaner picked up leaves or some crushed plastic bottles left in the road.
9) Deb carried either laundry or the blue folded pool cover into the yard.
10) Aidan entered the famous tattoo shop on the corner or his apartment this afternoon.

APPENDIX G

VIOLATING SYNTACTIC FILLERS FOR EXPERIMENT 3

1) Karl is either a clown and interested in making people laugh.
2) The police stopped the petty thief either after the man passed out the flyers.
3) Evelyn requested either a back massage at the beauty salon.
4) Hillary ordered either a new wood bedroom set and a chair for her apartment.
5) Penelope is either a liar when she pretends to be fainting.
6) The designer consulted either her eager young assistant with questions on her latest design.
7) The musician played either the guitar at the party with other musicians.
8) The street cleaner picked up leaves and some plastic bottles either left in the road.
9) Deb carried either laundry to fold into piles in the backyard.
10) Aidan entered the tattoo shop either on the corner toward his apartment this afternoon.

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