Identifying the *eel on the Table:

An Examination of Processes that Aid Spoken Word Ambiguity Resolution

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Abstract

Because ambiguous words frequently occur in running speech, the perceptual system must somehow resolve the ambiguities. If disambiguating context is present, it can aid resolution. When the disambiguation follows the ambiguity, the perceptual system delays resolution. Four Experiments investigated this delay. In Experiment 1, participants heard sentences containing a target word with a phoneme replaced by or intermixed with noise followed by disambiguating context close to or far from the target word (e.g., "The *ing had feathers." or "The *ing had an exquisite set of feathers."). In Experiments 2a and 2b duration between target word offset and disambiguation varied while syllable number remained constant. In Experiment 3 syllable number within this region varied while duration remained constant. Increasing syllable number caused early commitment. When the duration was also increased, early commitment was not observed. The findings suggest that sufficient processing time is necessary for the perceptual system to delay ambiguity resolution.
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Introduction

When noise such as cell phone interference masks a crucial portion of a word (i.e., the initial phoneme in the word "wing"), the word may be ambiguous. In order for accurate word identification to occur, the perceptual system must employ processes to help resolve the lexical ambiguity. Thus, an interest of psycholinguists is to understand how processes aiding word identification function when an ambiguous word is perceived.

One line of research has indicated that disambiguating context preceding a lexical ambiguity may help to resolve the spoken ambiguity (e.g., Borsky, Tuller, & Shapiro, 1998; Marslen-Wilson & Welsh, 1978; Samuel, 1981). Such findings suggest that when informative context is produced prior to the ambiguity, such context can aid word identification.

Although substantial research has confirmed that prior contextual information can help to resolve a lexical ambiguity, surprisingly little research has examined whether disambiguating context subsequent to an ambiguous word (e.g., "The *ing had feathers." where "**" represents noise) can also aid ambiguity resolution. If disambiguating context follows the ambiguous spoken word, in order for the context to aid ambiguity resolution, the perceptual system must delay resolution until the disambiguating context becomes available. Investigations using various methodologies have indicated that the perceptual system may delay ambiguity resolution until well after onset of the following word has
been produced (e.g., Bard, Shillcock, & Altmann, 1988; Grosjean, 1985; Luce, 1986; van Alphen & McQueen, 2001). One argued reason for this delay is that many spoken words in English, especially monosyllabic words, do not become unique until onset of the following word (e.g., Luce, 1986). If word identification occurs prematurely, inaccurate word identification will likely result. Thus, it would be advantageous for the perceptual system to incorporate processes which delay word identification to wait for disambiguating context.

Warren and Warren (1970) hypothesized that disambiguating information occurring subsequent to a lexical ambiguity could aid ambiguity resolution. They argued that if an ambiguous word is perceived, the perceptual system will delay commitment by storing perceived information (e.g., phonetic) from the lexical ambiguity until following context has been perceived. Then through synthesis of the disambiguating context, the appropriate phoneme will be restored. However, Warren and Warren (1970) reported no empirical findings supporting their hypothesis. Two subsequent empirical investigations have attempted to examine the processes involved in lexical ambiguity resolution when disambiguating context occurs subsequent to the ambiguity.

Connine, Blasko, and Hall (1991) constructed a voicing continuum from "dent" to "tent". Two clear word end-points and three ambiguous word mid-points on the continuum were then spliced into sentence frames containing subsequent contextual information that was biased toward one continuum end-point (e.g., "After the tent in the campgrounds collapsed, we went to a hotel."). To test whether there is a point at which the perceptual
system will commit regardless of whether disambiguating contextual information has been perceived, Connine et al. (1991) manipulated the distance between the ambiguous target word offset and following disambiguating context. For each sentence, the disambiguating context was provided either three (near condition) or six to eight (far condition) syllables after target word offset. Participants were required to make a judgment as to whether "dent" or "tent" had been spoken and whether the sentence was logical. Connine et al. (1991) predicted that if there was a limited period within which following context would help resolve an earlier occurring lexical ambiguity, such a prediction would be supported by a reduced number of biased responses (e.g., responding "tent" in the "tent biased sentences) in the far condition compared with the near condition.

Connine et al. (1991) obtained reliable findings suggesting that subsequent biasing context can help resolve a lexical ambiguity. In the near condition a 4.68% increase in "dent" responses was observed in the "dent" biased sentences while only a .01% biasing advantage was observed in the far condition. Furthermore, they reported a 10 msec reaction time increase in the near condition when disambiguating context was congruently related to the target word in comparison with the far condition. Given that the disambiguating information was presented within a mean of 1048 msec after lexical ambiguity onset, Connine et al. (1991) concluded that a temporal window of approximately one sec exists after which the perceptual system will commit to a lexical competitor regardless of whether the context has been perceived.
In an investigation using a modified phonemic restoration paradigm, Samuel (1990) further supported the findings from Connine et al. (1991). Samuel (1990) selected sets of minimal word pairs varying in place of articulation (e.g., "locket" and "rocket"). He then introduced a noise into the position containing the distinguishing phoneme (e.g., /l/ or /r/). The noise either replaced or was intermixed with the target phoneme; producing a lexical ambiguity. The ambiguous word was then placed into the middle of sentences biased toward one member of the word pair (e.g., "They saw the *ocket on her necklace."). Similar to Connine et al. (1991), Samuel (1990) also examined whether there is a point after which the perceptual system will commit to a lexical competitor regardless of whether subsequent disambiguating context has been presented. To accomplish this, he provided the biasing information either two to five (near condition) or seven to eleven (far condition) words subsequent to the ambiguous word. Participants were required to judge whether the phoneme was added to or replaced by the noise, and whether the word had been "locket" or "rocket". The modified technique thus allowed for measures of discriminability and bias to be obtained. In line with Connine et al. (1991), Samuel (1990) predicted that listeners would be more biased toward reporting the phoneme as having been present when identifying the word as congruent with the subsequent context. He further predicted that participants would produce more unbiased responses in the far condition compared with the near condition again suggesting that there is a limit to how long the perceptual system will delay before commitment to an identified word is made.
Samuel (1990) reported that in the near condition a greater added bias and increased discriminability were observed when the ambiguous word and following context were reported as being congruently related compared with when they were reported as being incongruently related. In the far condition, Samuel (1990) observed a reduction in the added bias and discriminability in the congruent condition. He thus concluded that his findings suggest that when a lexical ambiguity is present, an initial word is identified. To help maximize accurate word identification, the perceptual system then waits for approximately one sec for disambiguating context to be presented. If context is presented within the 1-sec window, the perceptual system invokes a decisional process that judges the congruency of the ambiguous word and disambiguating context. If the disambiguating context and identified word are congruent, discriminability improves as the word initially identified by the perceptual system is confirmed. This also increases the likelihood of the target phoneme being reported as "added". However, if disambiguating context is not perceived within approximately one sec, the perceptual system will commit to the initially identified word regardless of following disambiguating context.

One remaining question is what factor causes the decisional process to become less effective in helping resolve a lexical ambiguity when the disambiguating context occurs after approximately five syllables (e.g., "The *ing had an exquisite set of feathers."). There are two possible factors that may be hindering this process in the far condition. It is possible that either the duration or number of syllables present between ambiguous word offset and disambiguating context onset (intervening portion) could be leading to the
limitation placed on the process. If duration is the influential factor limiting the process's ability to enhance word identification in the far condition, then the conclusion drawn by Connine et al. (1991) and Samuel (1990) suggesting that a temporal window exists will be confirmed. If, in contrast, the number of syllables limits the process, it may suggest that other factors such as syntactic complexity may be limiting effectiveness of this process. Thus, the purpose of the following set of experiments was to identify what produces early commitment to occur when the disambiguating context follows the ambiguous word.
Experiment 1

Before exploring what factor causes early commitment to occur when the distance (e.g., number of syllables or duration) is increased, it was first necessary to ensure Connine et al. (1991) and Samuel's (1990) distance findings could be replicated. Thus, the purpose of Experiment 1 was to replicate Connine et al. (1991) and Samuel (1990). To accomplish this, the same four conditions used by Connine et al. (1991) and Samuel (1990) were used. Disambiguating context that was either congruent with the actual produced target word (congruent condition) or with a competitor of the produced word (incongruent condition) was used. Across congruency conditions, the distance between ambiguous word offset and disambiguating context onset was manipulated to investigate how distance influences the process involved in lexical ambiguity resolution when disambiguating context occurs subsequent to the ambiguity. To accomplish this, two distance conditions were constructed. The near condition was comprised of sentences having only one syllable presented in the intervening portion (e.g., "The *ing had feathers.") while the far condition contained six to eight syllables within the intervening portion (e.g., "The *ing had an exquisite set of feathers.").

In addition to the above purpose, Experiment 1 would also serve to more directly investigate the original hypothesis posed by Warren and Warren (1970). Although Samuel's (1990) investigation allowed for an exploration of the influence of subsequent disambiguating context on lexical ambiguity resolution using a method compatible with
Warren and Warren's (1970) discussion, his experiment used ambiguous bi-syllabic words while Warren and Warren (1970) discussed a case involving ambiguous monosyllabic words (e.g., "It was found that the *eel was on the table."). Thus, to accomplish this, the modified phonemic restoration method used by Samuel (1990) with monosyllabic words was used. As monosyllabic words are spoken most often in English (e.g., Pitt, Johnson, Hume, Kiesling, & Raymond, 2005), tend to have the greatest number of lexical competitors, and are the most likely to not become unique until after word offset (Luce, 1986), the invoking of processes within the perceptual system that aid resolution of a lexical ambiguity would likely be most frequently needed for identification of monosyllabic words.

Given the findings reported by Samuel (1990), across the near condition, an increase in $d'$ and an increased added bias were expected to be present in the congruent condition in comparison with the incongruent condition. Such a finding would suggest that when the lexical ambiguity and disambiguating context occur in close proximity an initial word identification is made based on information within the signal (e.g., phonemic). Once disambiguating context becomes available, a decisional process will be invoked which will help to confirm or modify the initial identification. In contrast, in the far condition, $d'$ and added bias in the congruent condition would decrease and begin to merge with the decreased $d'$ and neutral bias in the incongruent condition. This finding would indicate that again an initial word identification is made based on information within the signal, but if the disambiguating context occurs at a far enough distance after the ambiguous
word, the perceptual system will commit to a word competitor based solely on information obtained in the signal.

**Method**

*Stimuli.* Stimuli included 24 monosyllabic target words selected from an on-line dictionary containing phonetic pronunciations. Target words always had a consonant-vowel-consonant (CVC) or CVCC sequence. Target words also had at least one rhyme competitor (any monosyllabic word sharing the final phonetic VC or VCC sequence and only differing in word onset) such as "wing" and "ring". Any word containing a rhyme that was a real word was excluded. For example, the word "cat" was not a viable target word because it contains the word "at" as its rhyme.

Sentences were constructed that contained disambiguating contextual information which was either semantically congruent with the target word (congruent condition) such as "The wing had feathers.", or semantically congruent with a rhyme competitor of the target word (incongruent condition) such as in the sentence "The wing had diamonds.”

Given findings from Samuel (1981), actual spoken target words were limited to words containing liquid, nasal, or glide onset phonemes. Rhyme competitors of the target word however were not subjected to this restriction owing to the limited number of words in English which have a rhyme competitor that differs by one onset phoneme feature (e.g., "lock" and "rock").
Two versions of each of the two sentence types (congruent and incongruent) were constructed. The near condition contained sentences in which the disambiguating information occurred one syllable after target word offset as in the sentence "The wing had feathers." The far condition contained sentences in which the disambiguating information was presented six to eight syllables post-target word offset as in the sentence "The wing had an exquisite set of feathers."

Each of the 24 target words were therefore placed in four separate sentence types (a near congruent sentence type, a near incongruent sentence type, a far congruent sentence type, and a far incongruent sentence type) for a total of 96 items (24 target words times 4 sentence types). The Appendix includes a full set of the stimuli used in this and all subsequent experiments.

All sentences began with the word "the" followed by the target word and ending with the disambiguating context. For each sentence quad, the disambiguating context in the congruent and incongruent conditions always shared the same part of speech.

A minimum of four tokens of each sentence were spoken in a sound-dampened booth by a female native English speaker with a Mid-Western accent. Sentences were spoken in a slow clear voice. Stimuli were then down sampled to 22.5 kHz.

For each of the 24 sentence quads, one token maintaining clearly articulated speech up through the intervening portion offset was selected (e.g., "The wing had an exquisite set of", "The wing had"). The final word from this token (e.g., "feathers") was then spliced out of the sentence thus leaving the sentence without its original disambiguating
information. Once this process was complete, a second copy of the remaining portion of the sentence was made and stored as a separate sound file. For each of the remaining tokens, one of the tokens of each sentence type (e.g., short incongruent) was selected. The final word from each of the sentences was excised from the sentence and spliced onto one of the two sentence copies whose final word had been removed. The use of this cross-splicing technique ensured that both sentences in the near condition would be identical to one another until disambiguation onset and that both sentences in the far condition would be identical until this same point.

Once cross-splicing was accomplished, the target phoneme (e.g., /w/ in "wing") was located both visually and auditorily on a spectrogram. Added and replaced versions of the target phoneme were then constructed in the same manner as in Samuel (1990). To accomplish this, the target word was first located both auditorily and visually using a spectrogram. To ensure no evidence of the target phoneme was present outside of the noise-boundaries, onset and offset boundaries were selected which included no visual or auditory evidence of the target phoneme (e.g., formant shifts). This often required inclusion of a portion of the prior or following vowel within the noise boundary (e.g., the schwa in the word "the" was often partially included in the following target phoneme). This decision was made to ensure no evidence of the target phoneme was present in the clear portion of speech presented to listeners (i.e., Warren & Sherman, 1974). Once this criterion was met, a program was used which would calculate the root mean square amplitude of the target phoneme. The program would then randomly flip 66% of the
signal of the phoneme. To produce the noise plus phoneme case, this randomly flip signal was then added to the original signal. For the noise alone case, the entire phoneme signal was first set to 0 and then the newly generated signal was inserted. This process ensured that the amplitude envelope remained the same as the original signal (Samuel, 1987) and also ensured that no evidence of the acoustic features were present in the noise alone case. The result sounded something like cell phone interference. Each finalized stimulus sentence was then saved as a separate wave file.

Through pilot testing, it was found that the stimuli were produced at a speaking rate that was excessively slow. Thus speaking rate across all sound files was time-compressed to approximately 78.5% of the original rate. This amount of compression was selected in order to ensure that the duration within the intervening portion was closely related to the duration reported by Connine et al. (1991) since no duration was reported by Samuel (1990). The resulting speech sounded slightly sped up without losing intelligibility. To more heavily ensure that the target words were intelligible and were presented at a normal-sounding speaking rate, they were compressed to approximately 82% of their original rate. Table 1 provides a list of compressed mean target phoneme durations by phoneme class.

Participants. Participants included 32 undergraduates receiving course credit for an introductory psychology class. They had no reported hearing disorders or impairments and all were native English speakers.
Procedure. Upon arrival at the test session, participants were told that they would hear logical and nonsense sentences over headphones and would be required to make a judgment as to whether the initial phoneme of the second word in each sentence was present or absent and to identify the phoneme. Participants were tested in groups of one to four in sound attenuated booths. All stimuli were presented to participants over headphones.

Participants heard each of the 192 items; 24 target words times 4 sentences times 2 levels of target phoneme intactness (e.g., noise intermixed with the target phoneme features, noise alone). To provide the largest interval between repetitions of a given target word, stimuli were separated into eight blocks of 24 trials with each target word occurring in the same pseudo-randomized position in each block.

Because participants would hear two repetitions of each sentence, (e.g., an added and replaced version), Blocks 5-8 had the identical order to the first 4 blocks but contained the alternate member of the pair. For example, if the added version of "The *ing had feathers." was presented in the third position of Block 3, the replaced version of the same sentence would be presented in the third position in Block 7.

Each participant was seated in front of a button board containing two buttons labeled "added" and "replaced". For each trial, participants were told to press the "added" button with their left index finger if they believed the phoneme at the beginning of the second word was present, and to press the button labeled "replaced" with their right index finger
when they believed the phoneme was absent. Participants were given 2,000 msec to provide a response beginning at sentence offset. Once all participants had responded or 2,500 msec had elapsed, a number would appear on a computer screen situated in front of each participant. When the number appeared, participants were instructed to perform a secondary task. Each participant was provided with a numbered answer sheet and was required to identify the target phoneme regardless of whether the phoneme was present or absent. This task was used in place of the two-item forced-choice option reported by Samuel (1990) as it avoided limiting participants' responses. For example, if a participant was presented with "wing" and "ring" but believed "sing" had been spoken, there would be no way to accurately report what had been heard. Participants were given 4,000 msec to perform the secondary task. The computer would then move onto the next trial after 1,500 additional msec. A short break was offered to the participants after trial 96. Participants were provided with 24 practice trials to become comfortable with the two tasks and were asked if they had any questions before the experimental trials began. At the end of the experiment, participants were thanked for their time and debriefed. The entire experiment lasted approximately 50 minutes.

Results and Discussion

d' and beta scores were computed for each participant. d' scores close to 0 indicated poor discriminability while higher d' scores indicated improvements in discriminability. Beta scores below 1.0 indicated a bias to respond "added" while those above 1.0 indicated a
bias to respond "replaced". Two participants were removed from all analyses as a result of failure to follow instructions. A clear d' effect emerged across distance. The data indicated a decrease in d' in the far condition compared with the near condition (e.g., near condition = 1.41, far condition = 1.20). Turning to congruency, a large decrease in d' was present in the incongruent condition (.85) compared with the congruent condition (1.76). A two factor repeated measures Analysis of Variance (ANOVA) with distance and congruency as the two factors indicated both a reliable main effect of distance, F (1, 29) = 7.74, *p* < .01 and congruency, F (1, 29) = 31.79, *p* < .001. A reliable distance*congruency interaction, F (1, 29) = 4.72, *p* < .05 was also observed. Table 2 provides results from Experiment 1 for each of the four conditions. Across the two near conditions (e.g., "the wing had feathers/diamonds."), a substantial disadvantage emerged in the incongruent condition compared with the congruent condition. A comparison of the means showed the difference to be reliable, *t* (29) = 5.69, *p* < .001. In contrast, in the two far conditions (e.g., "The wing had an exquisite set of feathers/diamonds."), although a difference across congruency conditions was observed, the effect was smaller than the congruency effect observed in the near condition. A comparison of the means showed the effect to be reliable, *t* (29) = 4.99, *p* < .001. The difference across the two far conditions was reliably smaller than that of the two near conditions (e.g., mean d' difference = .21) as indicated by the distance main effect reported previously. The data suggested that although there
was an effect of congruency, it was reliably weaker in the far condition than in the near condition.

In the beta data, no distance effect was observed. A nearly identical added bias was observed in the near (.89) and far (.88) conditions. In contrast, a large congruency effect was observed with an added bias (.73) in the congruent condition and no bias (1.04) in the incongruent condition. In a two-factor repeated measures ANOVA, the main effect of congruency, \( F(1, 29) = 8.65, p < .01 \) and the interaction between distance and congruency, \( F(1, 29) = 8.45, p < .01 \) were reliable. The main effect of duration was unreliable, \( F < 1 \). Across the near conditions, a clear effect of congruency emerged as can be seen in the table. A strong added bias was observed in the congruent condition while a neutral bias was observed in the incongruent condition. The mean difference was reliable, \( t(29) = 3.48, p < .001 \). In contrast, a much smaller effect was found across the two far conditions. Although both the congruent and incongruent betas in the far condition showed an added bias, both were weak and approaching a neutral bias. The difference was unreliable, \( t < 2 \). In line with the d' data, the beta data indicated a reliable congruency effect that was weaker in the far condition.

Recall that a hit referred to an "added" response given to the added version of a target phoneme (e.g., /w/ in the word "wing") while a false alarm referred to an "added" response given to the replaced version of a target phoneme. Across the four conditions as can be seen in the final two columns of Table 2, the congruency effects were attributed to the hits rather than the false alarms. Because a false alarm indicated that an absent
phoneme was perceived as present, changes in this measure would have indicated that phonemic restoration had taken place (c.f., Warren & Warren, 1970). In contrast, the differences in hits across the congruency conditions suggest that a decisional process produced the observed effect given that a present phoneme would have to be dismissed when the resulting target word proved incongruent with the disambiguating context. Given this conclusion it is likely that the more traditional interpretation of $d'$ as a measure of sensitivity may not be appropriate in the present experiment. Rather, the congruency influence on the hit measure would suggest that the $d'$ data provide a reflection of bias. Overall, the weakened effects observed across congruency in the far condition replicated the findings reported by Connine et al. (1991) and Samuel (1990). Thus, the issue of whether duration or the number of syllables present in the intervening portion (e.g., "had an exquisite set of") produced the weakened congruency effect in the far condition can be explored. The subsequent experiments were therefore designed to compare the effects of the duration (experiments 2a and 2b) and the number of syllables (Experiment 3) within the intervening portion in order to identify the cause of the reduced influence of disambiguating information in aiding lexical ambiguity resolution.
In Experiment 1, the intervening portion of the near condition contained one syllable with a mean duration of 217 msec while the intervening portion of the far condition contained six to eight syllables with a mean duration of 1,113 msec. For Experiment 2a, the number of syllables in the intervening portion was held constant while the duration in this region was varied. To accomplish this, the intervening portion in the far condition was time-compressed. Participants were presented with two versions of "The wing had an exquisite set of feathers." once with an unaltered intervening portion (long condition) and once with a time-compressed intervening portion (short condition). In using this technique, the effects of two different durations could be compared without changing the number of syllables presented to the listener.

Two primary predictions were plausible. (1) In the short condition, an added bias would emerge in the congruent condition while a neutral bias would be observed in the incongruent condition. In the long condition, the added bias observed in the congruent condition would be weakened and would begin to merge with the incongruent neutral bias. The above findings would suggest that as Connine et al. (1991) and Samuel (1990) argued, there is a limited temporal window of approximately one sec within which subsequent disambiguating information can aid in the resolution of an ambiguous word. (2) An added bias would emerge in the congruent condition across both the short and long conditions. This finding could have two plausible explanations. (a) A temporal
window exists but it is wider than Connine et al. (1991) and Samuel (1990) conjectured. 
(b) The number of syllables rather than the duration caused the effect in the far condition 
to be weaker than that of the near condition.

Method

Stimuli. Stimuli included the same 48 added/replaced versions of the far congruent (e.g., 
"The wing had an exquisite set of feathers.") and 48 far incongruent (e.g., "The wing had 
an exquisite set of diamonds.") sentences used in Experiment 1. These sentences 
comprised the long condition for Experiment 2. 
Time-compressing the intervening portion so that it was equated with the intervening 
portion in the matched near condition sentence (e.g., "had") was impossible to 
accomplish while maintaining intelligibility as such a compression rate would have 
produced individual syllables with durations of approximately 25-35 msec within the 
intervening portion. Thus, to maintain intelligibility, a longer duration was selected for 
the intervening portion in the short condition. To accomplish this, a point falling 
approximately mid-way between the duration of the intervening portion of the near 
condition (e.g., "had") and 1,000 msec or the temporal window boundary posed by 
Connine et al. (1991) was selected as the duration of the compressed intervening portion. 
For example, if the word "had" in the sentence "The wing had feathers." had a duration of 
200 msec, the compressed intervening portion "had an exquisite set of", in the sentence 
"The wing had an exquisite set of feathers." would have an intervening portion duration
of 600 msec. This duration change required the duration within the intervening portion to be compressed by approximately 40-60% ($m = 55.90\%$). This adjustment in time-compression ensured that the short condition durations fell below one sec or the temporal window boundary posed by Connine et al. (1991). All other aspects of stimulus construction were identical to Experiment 1.

**Participants.** Twenty-three new participants from the same pool meeting the same criteria as those in Experiment 1 participated for course credit.

**Procedure.** The procedure with one exception was identical to Experiment 1. The written task was not performed in the present and all future experiments. The entire experiment lasted approximately 40 minutes.

**Results and Discussion**

d' and beta scores were computed in the same way as in Experiment 1. Given the conclusion in Experiment 1 that d' appeared to be a reflection of the beta data, only beta results will be reported. Two participants were removed from all analyses as a result of failure to follow instructions.

Across duration, similar added biases were observed in the short (.85) and long (.76) conditions. For congruency, a strong added bias emerged in the congruent condition (.62) while a neutral bias was observed in the incongruent condition (.99). According to a two-
factor repeated measures ANOVA with duration and congruency as the two factors, only the main effect of congruency was reliable, $F(1, 20) = 14.14, p = .001$. The main effect of duration and the interaction were both unreliable, $Fs < 2$. In the short condition, as can be seen in Table 3 which provides mean beta scores across conditions in all of the reported Experiments, a strong congruency effect emerged with a greater added bias observed in the congruent condition compared with the incongruent condition. A comparison of the difference was reliable, $t(20) = 2.39, p < .05$. In the far condition, a similar beta trend emerged with a strong added bias observed in the congruent condition compared with the incongruent condition. The mean difference was also reliable, $t(20) = 3.46, p < .001$. The beta findings suggested that there was a strong congruency effect that remained stable as duration increased.

Overall, the findings disconfirmed the prediction that duration caused the reduced effectiveness of disambiguating context on the resolution of a lexical ambiguity. Thus, the perceptual system's early commitment to a lexical candidate in the far condition observed in Experiment 1 does not appear to be dependent on duration and thus places doubt on the temporal window hypothesis posed by Connine et al. (1991). However, before duration can be completely ruled out, a further consideration must be addressed. It is possible that a temporal window that is wider than originally hypothesized exists. Given that the mean duration of the intervening portion in the long condition was 1,113 msec, it is plausible that the duration was simply not long enough to reach the outer boundary of the temporal window. If the window is wider than the
originally proposed one sec duration, than a null effect would be observed in Experiment 2a. Thus, before rejecting duration as the cause of the distance reduction observed in Experiment 1, it was first necessary to investigate whether a longer duration would produce the weakened influence of subsequent disambiguating information on the resolution of a prior lexical ambiguity. This was explored in Experiment 2b.
Experiment 2b

Because no theoretical guidelines were available that suggested a duration beyond one sec that could viably be the outer boundary of the temporal window, an arbitrary longer duration of 1900 msec (extra long condition) was compared with the short condition from Experiment 2a (e.g., time-compressed "The wing had an exquisite set of feathers."). For Experiment 2b, two predictions were plausible. (1) Across the short and extra long condition, an added bias would emerge in the congruent condition while a neutral bias would emerge in the incongruent condition. This finding would suggest that duration within the intervening portion did not cause the reduced distance effect observed in Experiment 1. Further, such a finding would suggest that a fixed temporal window of one sec (Connine et al., 1991; Samuel, 1990) does not exist. (2) Across the short condition an added bias would emerge in the congruent condition while a neutral bias would be observed in the incongruent condition. In the extra long condition, the added bias in the congruent condition would decrease and begin to merge with the incongruent condition. Such a finding would suggest that there is a temporal window within which the perceptual system waits for subsequent disambiguation before committing to a lexical competitor, yet that the window is wider than Connine et al. (1991) originally conjectured.
Method

Stimuli. The 48 congruent (e.g., "The wing had an exquisite set of feathers.") and 48 incongruent (e.g., "The wing had an exquisite set of diamonds.") stimuli from the short condition from Experiment 2a again made up the short condition in the current experiment. To create the extra long condition, the duration of the intervening portion of the long condition from Experiment 2a was time-expanded to a mean of 1900 msec. This was accomplished by first calculating the difference between 1900 msec and the original long condition intervening portion mean of 1,113 msec, difference = 787 msec. Once the difference was calculated, the intervening portion of the long condition from Experiment 2a was time-expanded so that it was 787 msec longer than the original long condition intervening portion. This process ensured that the distribution of the extra long condition matched the distribution of the far and long conditions from Experiments 1 and 2a respectively but was shifted upward. The resulting extra long condition sentences sounded as though the talker was somewhat uncertain of what she was saying.

Participants. Twenty-two new participants from the same pool meeting the same criteria as those in the prior Experiments participated for course credit.

Procedure. The procedure was identical to Experiment 2a.

The entire experiment lasted approximately 40 minutes.
Results and Discussion

d' and beta scores were computed in the same way as in Experiment 1. As with Experiment 2a, only the beta data are reported below. Four participants were removed for producing excessively large beta scores in at least one condition (e.g., a beta greater than 3.5).

An added bias emerged across duration. In the extra long condition the added bias (.79) was slightly larger than the added bias in the short condition (.87). Across congruency, an added bias was observed in the congruent condition (.62) and a neutral bias was observed in the incongruent condition (1.03). A two-factor repeated measures ANOVA with duration and congruency as the two factors showed only the main effect of congruency to be reliable, $F(1, 17) = 22.66, p < .001$. The main effect of duration and the interaction were both unreliable, $Fs < 2$. In the short condition as can be seen in the third row of Table 3, a strong congruency difference was observed with an added bias in the congruent condition and a slight replaced bias in the incongruent condition. The difference was reliable, $t(17) = 3.13, p < .01$. In the extra long condition, a similar added bias was observed in the congruent condition while a neutral bias was observed in the incongruent condition. The difference was also reliable, $t(17) = 6.45, p < .001$. The data suggested that the congruency effect remained stable across duration.

The findings from the present experiment combined with those from Experiment 2a suggest that duration was not the cause of the distance effects observed in Experiment 1 (e.g., the decreased added bias in the far condition compared with the near condition of
Experiment 1). The findings further disconfirm the temporal window hypothesis suggesting that neither the one sec duration posed by Connine et al. (1991) nor a longer duration of nearly two sec in the present experiment produced the distance effects observed in Experiment 1. Given such findings, the cause of the differences in Experiment 1 were most likely attributed to the number of syllables within the intervening portion.
Experiment 3

The purpose of Experiment 3 was to determine whether the number of syllables caused the decreased added bias observed in the far condition in Experiment 1. Thus, in Experiment 3, duration-matched intervening portions containing one (one syllable condition) or six to eight (multiple syllable condition) syllables were compared. It was predicted that in the one syllable condition, a greater added bias would emerge in the congruent condition compared with the incongruent condition. In the multiple syllable condition, the added bias in the congruent condition was predicted to reduce and merge with the incongruent condition. Such a finding would indicate that the reduced bias observed in Experiment 1 was caused by the number of syllables within the intervening portion.

Method

Stimuli. The 96 short condition sentences used in Experiments 2a and 2b (e.g., time-compressed intervening portion "had an exquisite set of") were used in Experiment 3. This stimulus set would comprise the multiple syllable condition. To create the one syllable condition, the 96 stimulus items from the near condition in Experiment 1 (e.g., "The wing had feathers.") were used. The intervening portion of each of the 96 one syllable condition sentences was time-expanded by approximately 200% (m = 199.94%).
This lengthened the duration of the intervening portion of the short condition by approximately half of the duration needed to be fully equated with the multiple syllable condition. However, when time-expanding beyond 200%, the stimuli took on a tinny quality and became less intelligible. To maintain intelligibility, to reduce the tinny quality, and to fully time-equate the stimuli, the difference between the duration of the intervening portion of the matched multiple syllable condition sentence and the time-expanded intervening portion of the one syllable condition sentence was calculated. A pause equal to this difference (m = 171 msec) was then placed at the onset of the intervening portion to time-equate the intervening portions of the one and multiple syllable conditions. For example, if the intervening portion "had an exquisite set of" was 600 msec and the expanded intervening portion "had" was 400 msec, a 200 msec pause would be inserted between "wing" and "had" Thus resulting in "The wing <200 msec pause> had feathers.". All other aspects of stimulus construction were identical to the previous experiments.

Participants. Twenty-two new participants from the same pool meeting the same criteria as those in the prior Experiments participated for course credit.

Procedure. The procedure was identical to Experiment 2b.
Results and Discussion

d' and beta scores were computed in the same way as in Experiment 1. As with Experiments 2a and 2b, only the beta data are reported below.

Across the number of syllables, a reduced added bias was observed as the number of syllables increased (e.g., one syllable condition = .75, multiple syllable condition = 1.01). The congruency effect was also again observed. In the incongruent condition, a neutral bias was observed (1.03) while in the congruent condition an added bias was observed (.73). A two-factor repeated measures ANOVA with number of syllables and congruency as the two factors showed both a reliable number of syllables main effect, F (1, 21) = 11.04, p < .005 as well as a reliable congruency main effect, F (21, 1) = 6.728, p < .05 but no interaction, F < 3. As can be seen in the final row of Table 3, across the one syllable condition, the added bias was reduced in the incongruent condition compared with the congruent condition. This finding was reliable, t (21) = 4.51, p < .001. In contrast, the congruency effect was nearly identical in the multiple syllable condition. The mean difference was not reliable, t < .3. The beta findings showed a reduced effect of congruency as the number of syllables was increased. Overall, the results of Experiment 3 suggest that as the number of syllables in the intervening portion is increased, the perceptual system is likely to commit to a lexical candidate regardless of whether disambiguating context has been presented.
General Discussion

Four experiments were conducted to investigate why the influence of subsequent disambiguating information on a lexical ambiguity is reduced when the disambiguating context occurs at a far distance (e.g., six to eight syllables) from the ambiguous word (c.f., Connine et al., 1991; Samuel, 1990). Across experiments as the number of syllables in the intervening portion was increased, participants proved less biased toward responding that the phoneme was present. This is most evident when examining the fairly similar results obtained across Experiments 1 and 3. Had increasing the number of syllables not proved to reduce this bias in responding, the far and multiple syllable conditions seen in the far congruent column in Table 3 would have been nearly identical to the near and one syllable conditions in the second Column respectively. However, although increasing the number of syllables within the intervening portion weakened the added bias, when the duration and number of syllables were increased simultaneously, the added bias was observed as can be seen in the long and extra long conditions of Experiments 2a and 2b respectively.

Increasing the duration within the intervening portion had two additional interesting effects. (a) When six to eight syllables were present in the intervening portion, the additional 787 msec intervening portion duration increase in the extra long condition in Experiment 2b did not further increase the added bias observed in the long condition in Experiment 2a as can be seen in Table 3. The mean beta difference (.04) between the
long and extra long conditions was not reliable, duration (long condition vs. extra long condition) t < 1. This suggests that when the duration of the intervening portion reached approximately one sec, no additional added bias advantage was gained by further increasing the duration within this region. (b) In contrast, no additional advantage was gained by increasing the duration of the intervening portion when it contained only one syllable. Recall that the one syllable and near conditions from Experiments 3 and 1 respectively contained only one syllable within the intervening portion. The one syllable condition had a mean intervening portion duration of 609 msec while the near condition had a mean intervening portion duration of 217 msec. Although a larger added bias was observed in the one syllable condition compared with the near condition (mean beta difference = .12), this finding was unreliable, t < 1.

Interestingly, the biasing effects produced by altering the duration and number of syllables within the intervening portion was restricted to the congruent conditions across experiments. In contrast, the incongruent conditions maintained means close to 1 suggesting neutral biases regardless of changes in duration or the number of syllables within the intervening portion. The difference in congruency across experiments suggests that when acoustic feature information was available in the signal, such information was perceived and able to aid in resolving the ambiguous word. Had participants not been able to perceive enough information to aid word identification, the congruent and incongruent conditions should have been identical given that the incongruent condition contained a disambiguating context that was congruent with a competitor of the target
word (e.g., "The ring had diamonds", where "wing" Is the target word). The findings indicate that in cases where the subsequent information was congruent with the perceived acoustic featural information in the signal, participants were more likely to report the phoneme as being present.

Although the findings from Experiment 1 replicated those produced by Connine et al. (1991) and Samuel (1990, the findings from the subsequent experiments disconfirmed the temporal window hypothesis. To confirm the hypothesis, two things would have needed to have occurred. (1) No reduction in the added bias should have been observed across the one and multiple syllable conditions in Experiment three given that the duration within the intervening portion was identical across conditions. (2) The long and extra long conditions from Experiments 2a and 2b should have had fairly neutral biases since these conditions contained mean durations within the intervening portion of approximately one and two sec respectively.

Warren and Warren (1970) indicated know knowledge of and provided no predictions regarding what effects duration or the number of syllables within the intervening portion might have on phonemic restoration. Thus, only the near and one syllable conditions of Experiments 1 and 3 can fully be considered when evaluating their hypothesis. Across the two conditions, Warren and Warrens (1970) hypothesis was not supported. Recall that they hypothesized that once information (e.g., "ing") is obtained in the signal, it is retained by the perceptual system. As subsequent disambiguating context becomes available, the ambiguity is resolved by synthesis of the subsequent disambiguating
context and the phoneme is then restored. The measure which would most directly show evidence of phonemic restoration occurring would be the false alarms. Recall that a false alarm suggests that the participant is reporting an absent phoneme as present. Given that the disambiguating context within the congruent condition was congruent with the target word and the disambiguating context within the incongruent condition was congruent with a competitor of the target word (e.g., "The ring had diamonds", where "wing" is the target word), if the phonemic restoration hypothesis had proven accurate, a high false alarm rate should have been observed across both the congruent and incongruent conditions since no signal level information (i.e., acoustic featural) was present to help identify the target phoneme. Because the false alarms were relatively low as can be seen in Table 2, phoneme restoration was likely not regularly occurring in either condition. One interpretation of the findings is that when an ambiguous word is present, information in the signal (i.e., acoustic features) is used to begin to resolve the ambiguity. The perceptual system then waits for further disambiguating information to help resolution. As more information in the signal becomes available, a decision is made as to whether the resolution is congruent with the disambiguating context. If the resolution is deemed congruent with the subsequent disambiguating context, the perceptual system will commit to the identified word. If the disambiguating context is judged to be incongruent with the resolution, it is rejected; thus leading to a reduced bias to report that a phoneme is replaced when it is in fact present.
When the target word is initially heard, if the signal (e.g., target phoneme) is present, the perceptual system can initially resolve the ambiguity in one of four ways: (1) identify the congruent word (e.g., "wing"), (2) identify the incongruent word (e.g., "ring"), (3) identify another competitor word (e.g., "sing"), or (4) not be able to identify a particular competitor word (e.g., "?ing" where "?" indicates no phoneme distinction). Each of the above options will have some probability of occurring. Given that some acoustic features are available in the signal in this (added) case, it is likely that Condition 1 (e.g., identifying "wing") will have the greatest probability while condition 4 will have the smallest probability of occurrence. Conditions 2 and 3 will likely prove fairly equivalent to one another. Once this initial identification is made, the perceptual system then waits for furthering information. As disambiguating information becomes available, it will either be congruent (e.g., "feathers") or incongruent (e.g., "diamonds"), both of which will play an influential role on whether the phoneme is judged as being added to or replaced by noise. In condition 1, if "feathers" is heard, the probability that the item will be responded to as "added" will likely increase. Conditions 2-3 should produce the opposite effect whereby the probability of responding "added" is decreased. The probability will likely remain fixed in condition 4 as no specific identified word can be judged as congruent or incongruent. In contrast, if "diamonds" is heard, the probability of responding "added" will likely increase in condition 2 and decrease in conditions 1 and 3. As before because condition 4 should remain unchanged as no specific word was identified. An illustration of this process can be seen in Figure 1.
When the target word is presented with the target phoneme replaced by noise, the above four conditions again are possible, but with altered probabilities. Likely, Condition 4 ("?ing") will have the highest probability of occurring. Conditions 1-3 will likely have lower probabilities that are somewhat similar to one another. For example, condition 4 could hypothetically have a probability of .76 while conditions 1-3 all maintain probabilities of approximately .08. Recall that in the replaced case, no acoustic information was retained in the target portion of the spectrogram (e.g., /w/). Therefore, conditions 1-3 all should have a fairly similar probability of occurring if word frequency of occurrence and phonetactic probability are factored out. Further, Condition 4 should have a higher probability since it is likely that no specific phoneme will be identified. When disambiguating context becomes available it will again be congruent (e.g., "feathers") or incongruent (e.g., "diamonds"). In either congruency case, each of the above four conditions will have a probability of responding "added" and "replaced". Because no signal (e.g., acoustic featural) information was actually present, the probability of responding "added" across the four conditions should prove fairly similar. Thus, the false alarms across conditions should be nearly identical, as is evident in the near conditions in Table 1. Such an explanation falls somewhat in line with a model posed by Norris and McQueen (2008). Figure 2 provides an illustration of this process. The present findings however provide no conclusive explanation as to why increasing the number of syllables within the intervening portion reduced the effectiveness of the disambiguating context in helping to resolve the lexical ambiguity and why increasing the
duration in this region countered the weakened biased effect. Thus, three plausible hypotheses are posed below that provide suggestions as to why changes in duration of the intervening portion effected biasing when six to eight syllables were present within this region.

Across all experiments, in order to increase the number of syllables in the intervening portion while controlling for factors such as the total number of syllables in this region, it was impossible to keep sentence (e.g., semantic) complexity within the intervening portion controlled across sentences containing one or multiple syllables within this region. For example, a sentence such as "The *ing had an exquisite set of feathers." is more semantically complex than the sentence "The *ing had feathers." Thus, one explanation of the findings may be that the increased sentence complexity produced the observed weakened influence of subsequent disambiguating context on the ambiguous word while low sentence complexity had no such effect. If sentence complexity produced the effect, increasing the duration may have provided sufficient time to process the increased sentence complexity.

An alternative explanation may be that when sentence complexity is increased, early commitment occurs and the perceptual system simply ignores subsequent disambiguating context. This conclusion however fails to explain why the perceptual system continued to delay ambiguity resolution when the duration alone within the intervening portion in sentences containing six to eight syllables within this region was increased. Had the perceptual system committed early as sentence complexity increased, no duration
advantage should have been obtained in the long and extra long conditions in Experiments 2a and 2b respectively compared with the short conditions in these experiments.

One final explanation is that as the amount of information within the intervening portion is increased, a congruency judgment is made between the identified word and each subsequent word until some criterion is met. For example, if the word "wing" is initially identified as the ambiguous word in the sentence "The *ing had an exquisite set of feathers.", a congruency judgment is made between "wing" and "had", "wing" and "an", and so on until some disambiguation criterion is met. The advantage of making multiple judgments when the number of syllables in the intervening portion is increased is that if words within the intervening portion are not fully disambiguating, but are judged as somewhat disambiguating (c.f., van Alphen & McQueen, 2001) a final word identification may be made more rapidly. In contrast, if multiple judgments are made when the number of syllables is reduced within the intervening portion, final word identification may be slowed and thus comprehension may be impaired or delayed.

At present, no distinction can be made between the hypothesis suggesting that additional processing time is necessary to compensate for increased sentence complexity and the hypothesis suggesting that multiple congruency judgments are made until some criterion is met. To make such a distinction, further work is necessary. Experiments varying sentence complexity and duration while controlling for the number of syllables within the intervening portion may help distinguish between these hypotheses.
Once the distinction between the sentence complexity and multiple congruency judgment hypotheses is made, further questions can more adequately be addressed. For example, Connine et al. (1991) and Samuel (1990) explored the influence of clausal boundaries on the effectiveness of disambiguating context in the resolution of a prior lexical ambiguity. Because their results were mixed (e.g., Connine et al. (1991) obtained boundary effects while Samuel (1990) obtained no such findings), no clear conclusions can be drawn. However, once a better understanding of the effects of syntactic complexity and multiple congruency judgments is obtained, more adequate investigations of boundary and other relevant effects can be performed. Such investigations will thus provide a clearer picture of the processes involved in lexical ambiguity resolution when disambiguating information occurs subsequent to the ambiguous word.
References


Endnote

1 The data from the secondary task showed signs of a learned effect taking place. Thus, the data may not provide an accurate report of what words listeners were identifying. An examination of the data separated into quartiles (e.g., first quartile = Blocks 1-2) indicated that the number of written responses matching the actual produced target phoneme increased throughout the experiment. A two-factor repeated measures ANOVA with quartile and congruency as the two factors and percentage of responses matching the spoken phoneme as the dependent variable was conducted. The main effect of quartile, $F(3, 87) = 15.35, p < .001$, the main effect of congruency, $F(1, 29) = 88.43, p < .001$, and the interaction, $F(3, 87) = 7.97, p < .001$ were all reliable. Thus, given the learned effect present, this task was removed to simplify the experiment for participants as Task 1 (added/replaced judgment) was a relatively difficult task to perform.
Appendix

Stimuli for Experiments 1-3

The list below includes the stimuli from the four reported experiments. The word in italics was the word congruent with the incongruent context. The italicized word was not presented to listeners. The word prior to the parenthetical information made up the intervening portion in the near and one syllable conditions while the information within parentheses made up the additional syllables in the intervening portions from the far, short, long, extra long, and multiple syllable conditions. The final two words in each row provided the congruent and incongruent disambiguating information respectively.

The knock lock was (not quite able to be) heard/snapped.
The leak beak was (unexpectedly) fixed/sharp.
The lip rip was (very noticeably) chapped/stitched.
The list wrist was (found to be thoroughly) numbered/injured.
The log dog was (very actively) rotting/barking.
The look book was (not going to be) modeled/written.
The match latch was (readily able to be) struck/closed.
The math bath had (included a lot of) fractions/bubbles.
The mole bowl was (not adequately) digging/assigned.
The mug rug was (going to be completely) filled/swept.
The nap wrap was (unfortunately not) restful/tasty.
The nest guest had (some very colorful) sparrows/luggage.
The niece lease was (finally going to be) married/cosigned.
The night light was (not actually) starless/shining.
The roast ghost was (considered to be very) salty/spooky.
The rum gum was (not going to be) poured/chewed.
The well bell was (unexpectedly) dry/rung.
The wick nick was (insufficiently) burning/repaired.
The wife knife was (most definitely) pregnant/pointed.
The wig rig was (not going to be) shampooed/driven.
The wing ring had (an exquisite set of) feathers/diamonds.
The wish dish was (unexpectedly) granted/shattered.
The wool bull was (not going to be) knitted/angered.
The yarn barn was (in the first stage of being) woven/painted.
<table>
<thead>
<tr>
<th>Class</th>
<th>Near</th>
<th>Far</th>
</tr>
</thead>
<tbody>
<tr>
<td>liquid</td>
<td>187</td>
<td>187</td>
</tr>
<tr>
<td>nasal</td>
<td>184</td>
<td>182</td>
</tr>
<tr>
<td>glide</td>
<td>200</td>
<td>185</td>
</tr>
</tbody>
</table>

Table 1. Target phoneme mean durations by class

*Results are reported in rounded msec units.
Table 2. Mean number of hits and false alarms across participants and respective mean d' and beta scores for Experiment 1

<table>
<thead>
<tr>
<th>Distance</th>
<th>Congruency</th>
<th>d'</th>
<th>beta</th>
<th>hits</th>
<th>fa</th>
</tr>
</thead>
<tbody>
<tr>
<td>near</td>
<td>congruent</td>
<td>1.93</td>
<td>.65</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td>near</td>
<td>incongruent</td>
<td>.90</td>
<td>1.13</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>far</td>
<td>congruent</td>
<td>1.60</td>
<td>.81</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>far</td>
<td>incongruent</td>
<td>.80</td>
<td>.94</td>
<td>13</td>
<td>7</td>
</tr>
</tbody>
</table>

1) Hits and false alarms are rounded to nearest whole number in line with Samuel (1981, 1990) and are based on the n-value given above.

2) In line with Samuel (1981, 1990) d' and beta measures are given in exact units.

3) Fa = false alarms.

4) False alarms represent responding "added" to a phoneme replaced by noise.
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Near</th>
<th>Far</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Congruent</td>
<td>Incongruent</td>
</tr>
<tr>
<td>1 (varied dur/syll)</td>
<td>0.65</td>
<td>1.13</td>
</tr>
<tr>
<td>2a (varied dur, 6-8 syll)</td>
<td>0.69</td>
<td>1.01</td>
</tr>
<tr>
<td>2b (varied dur, 6-8 syll)</td>
<td>0.66</td>
<td>1.08</td>
</tr>
<tr>
<td>3 (fixed dur, varied syll)</td>
<td>0.53</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Table 3. Mean beta results across the four experiments

1) The terms "near" and "far" used in Row 1 are generic labels such that: "near" represents the near, short, and one syllable conditions across the four experiments and "far" represents the far, long, extra long, and multiple syllable conditions.

2) In Column 1 "dur" = duration, "syll" = number of syllables within the intervening portion.
Figure 1. Ambiguity Resolution when a Replaced Version of "*ing" is Presented

The top node indicates the word being presented. The next row level containing numbered nodes indicates the four conditions (1 = "wing", 2 = "ring", 3 = "sing", 4 = "?ing"). The final level of nodes indicates probability of responding "added" to a congruent disambiguation (Ca) or "added" to an incongruent disambiguation (Ia). Provided Probabilities are hypothetical and are not based on specific data points.
Figure 2. Ambiguity Resolution when a Replaced Version of "*ing" is Presented

The top node indicates the word being presented. The next row level containing numbered nodes indicates the four conditions (1 = "wing", 2 = "ring", 3 = "sing", 4 = "*ing"). The final level of nodes indicates probability of responding "added" to a congruent disambiguation (Ca) or "added" to an incongruent disambiguation (Ia). Provided Probabilities are hypothetical and are not based on specific data points.