Effects of Prosody on EFL Listening Comprehension

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Abstract:

Research in prosody and listening comprehension has shown a positive correlation between the two factors for language learning in general. The findings confirm that priming the intonation of an utterance may result in better processing of the speech signal. The current study examines whether EFL listening comprehension could be improved through intonational priming of speech utterances in English. Therefore, EFL listening comprehension is tested through true or false statements which were cued either by a "prime" (a suprasegmental sampling of the sound) or a neutral or foil cue. Thirty participants were enrolled in the study through15 EFL Saudi students and 15 native speakers of English. The results show that no significant improvement was found for the cue type. Perhaps listening comprehension could instead be improved by providing explicit instruction on attention to prosodic elements.

Key words: Prosody, Intonation, EFL, and Listening Comprehension

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الملخص:

أظهر البحث في مجال الفهم والاستماع والسمات الصوتية فوق المستوى المقطع وجود علاقة إيجابية بينهم لتعلم اللغة بشكل عام. تؤكد النتائج أن تهيئة المستمع من خلال تغير نبرة الصوت وإضاقة بعض السمات الصوتية فوق المستوى المقطعي قد يؤدي إلى معالجة أفضل لمداخلات اللغة بالنسبة للمستمع. تبحث الدراسة الحالية إمكانية تحسين فهم الاستماع للغة الإنجليزية كلغة أجنبية من خلال التحضير الصوتي للكلمات المنطوقة باللغة الإنجليزية. لذلك، يتم اختبار المشاركين على قدرتهم في فهم للغة الإنجليزية كلغة أجنبية (**EFL**) أثناء الاستماع من خلال عبارات صحيحة أو خاطئة والتي تم تعديلها صوتياً من قبل برنامج كمبيوتر لتظهر للمشاركين بأحد هذه الثلاث حالات: إما عن طريق تحضير المستمع من خلال إضافة بعض السمات الصوتية أو أن تكون بصوت محايد أو النقيض تماماً. تم تسجيل ثلاثين مشاركًا في الدراسة حيث كان ١٥ منهم طالبًا سعوديًا للغة الإنجليزية كلغة أجنبية و١٥ منهم الإنجليزية هي لغته الأم. أظهرت النتائج أنه لم يتم العثور على تحسن كبير للمداخلات المحسنه بسمات صوتية. لذاك ربما يمكن تحسين فهم الاستماع بدلاً من ذلك عن طريق توفير إرشادات واضحة للانتباه لتلك السمات الصوتية.

الكلمات المفتاحية: السمات الصوتية فوق المستوى المقطعي، الترنيم، الإنجليزية كلغة أجنبية، الاستماع والفهم

Introduction

This research study has mainly been motivated after an exposure to a special technique followed by some English instructors in ESL schools in Canada. They had developed creative techniques to supplement their more standard approaches such as audio-lingual practice, total physical response, elicitation procedures, and so on. One such technique they called "Clap the Stress," which they used to help students improve listening and speaking skills. Used for either words or phrasal elements, the tutor would accompany unstressed elements with a soft hand clap and stressed elements with a strong clap. After a few repetitions, the students would join in. The instructors reported positive results with this technique for nearly all students, except for those native speakers of languages which had radically different rhythms from English.

This interesting technique inspired this research experiment to follow almost the same idea of priming the learners to the target listening input through intonation. The intonation is manipulated through a computer software (Pratt) and presented to learners through the computer a simple computer for the presentation of the research task and the manipulated stimuli. Hence, having a computer program to extract the rhythm of an utterance might be a way to give students their own "Clap the Stress" tutor for any given utterance.

LITERATURE REVIEW

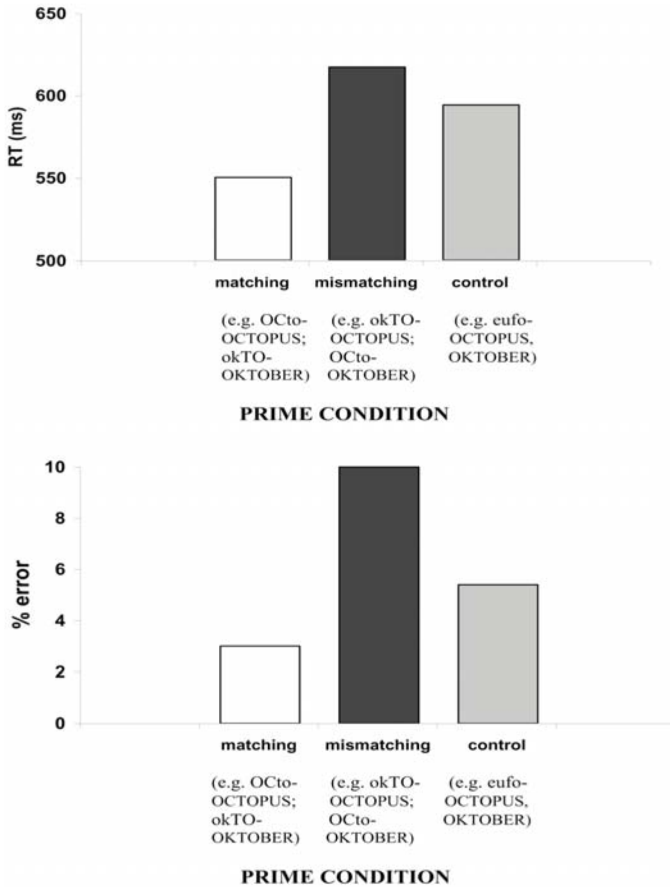
That prosody has a role in linguistic comprehension has been supported by research in psycholinguistic processing, including intonational priming experiments specifically. Although most of the research in this area focuses on L1 prosodic processing, there is some research on L2 processing. Furthermore, research into L2 teaching of prosody – both in production and comprehension – supports the idea that integrating prosody, both explicitly and implicitly, in a language learning setting could be beneficial (Li & Post, 2014).

Prosody's Role in Listening Comprehension

McQueen et al. (2003) note that despite differing theories in how spoken words are recognized, there is “broad agreement” amongst psycholinguistic researchers that spoken word recognition is a two-step process. First is a prelexical phase which converts the speech signal into an “abstract description of the utterance,” (p. 257). This is followed by an activation phase during which words in the lexicon that match the input compete in order to resolve the semantic content. Many psycholinguistic researchers have looked for clues that intonational priming can boost the efficiency of this process.

As an example, van Donselaar et al. (2005) show that suprasegmental priming leads to faster response times for a lexical identification task. In their study, a Dutch word such as okTOber was primed by either the matching fragment (okTO-), the mismatched fragment (OKto), or a control (eufo-). The experiment was performed in Dutch, a language with similar intonational patterns as English, to take advantage of minimal pairs such as okTOber/OCtopus. The experimental results showed significantly faster response times and correct results for the matching primes, as well as an inhibitory effect for the mismatched primes (see Figure 1).

Figure 1: Results from van Donselaar et al. (2005)'s priming experiment.



Prosodic cues also aid in sentence level processing. A reaction time experiment designed by Cutler (1976) and reproduced by Akker and Cutler (2003) showed that native listeners are able to detect a phoneme more quickly if the target had been previously presented in with a contrastive accent within a sentence than if the target-bearing word was non-contrastive in the same sentence. For example, the target phoneme /b/ was detected significantly more quickly if the target-bearing word was in a position of contrastive focus in the sentence (“The couple had quarrelled over a BOOK they had read.”) rather than a neutral position (“The couple had quarrelled over a book they hadn’t even READ.”). In these experiments the target-bearing word itself was replaced by an acoustically neutral version of the same word. That is, listeners were able to infer the contrastive prosody solely by the prosody of the surrounding words.

Ip and Culter (2017) went further to examine whether the findings that suggest that listeners follow prosodic cues to comprehend utterances as in English and Dutch are universal even in languages with different phonological systems such as Mandarin Chinese. They chose Mandarin Chinese specifically because it is a tone language hence, "in principle the use of pitch for lexical identity may take precedence over the use of pitch cues to salience" (p.1218). The study analysed data from 52 native speakers of Mandarin Chinese. The stimuli were presented in three versions manipulated by Praat. The first version was manipulated with emphatic stress for the target bearing word. The second version the word after the target bearing word was manipulated with emphatic stress. The third version was produced in a neutral manner for the target bearing word and the entire sentence. The data were analysed for response time and accuracy as well as for some acoustic analyses. The response time data shows that listening comprehension is facilitated when the preceding intonation predicted the focus on the target bearing word. The response time results are supported by the acoustic analyses which revealed greater F_0 range in the preceding intonation for the target-bearing words and sentences. Ip and Culter (2017) imply on how universality and language specific nature interact in the processing for the salience of the target language's phonological system.

Prosody's Role in Non-Native Speakers' Listening Comprehension

Most of the psycholinguistic studies on priming and intonation were performed in the L1 domain. However, Akker and Cutler (2003) ran Cutler's (1976) experiment examining prosodic cues to semantic structure on L2 listeners to see if they also were able to detect the target-bearing phoneme more quickly if it was in a focal position prosaically. The study included four experiments. The first experiment supported the study's hypothesis that English listeners are faster in attending to the target phonemes when the target-bearing words were in accented. In the second experiment a similar result was obtained with Dutch listeners and Dutch sentences. In the third and the fourth experiment, proficient Dutch users of English heard English sentences; however, the results did not show any interaction at all. These findings suggest that the L2 listeners showed the same improvement effects as the L1 listeners. However, the less efficient mapping of prosody to semantics may be the underlying reason for which nonnative listening fails to reach the native listening's level. The only drawback about this study is that the authors selected Dutch learners of English who had a high level of proficiency to perform the same task as the English speakers on an English stimuli set. Considering the prosodic similarities of Dutch and English, it is hard to determine whether the listeners were applying L1 or L2 strategies to the task.

One thing we do know is that native listeners exploit the rhythmic structure of their own language (Cutler, 2000-2001) in segmenting speech. For example, speakers of French and Spanish, which has a syllable-based rhythmic structure, detect targets that occur at syllabic boundaries more quickly. In contrast, speakers of Japanese, which has a mora-based rhythmic structure, are faster at detecting targets at moraic boundaries. Cutler goes on to show that listeners may attempt to apply these segmentation rules to non-native speech, and experience a penalty in doing so. Even in the case of bilinguals, one of the L1's rhythmic structure is preferred as a processing algorithm. Nonetheless, Cutler finds that bilingual listeners can inhibit their preferred segmentation processing when it interferes with their listening to language with a different rhythmic structure. Li and Post (2014) confirm these findings in an experimental study that reported a positive effect of L1 transfer on acquiring prosodic properties of the L2 phoneme and its semantic connotations.

However, Lee and Fraundorf (2018) examined the impact of contrastive pitch accents on the memory of L2 listeners in encoding the target language discourse. The study reported that low and intermediate proficiency L2 learners had no memory benefit from the contrastive accents. On the other hand, the high proficiency L2 learners showed moderate sensitivity to contrastive accents yet, they failed to fully integrate the information in their production. The authors argue that prosodic cues are strongly associated with the depth of processing therefore, L2 learners' use of prosodic cues increase as they advance in language learning.

Prosody in Second Language Instruction

Ever since the 1980's, when second and foreign language instruction moved away from the earlier audio-lingual techniques, there has been a growing consensus amongst applied linguists that intonation should be integrated into L2 speaking and listening instruction.

It has been observed that foreign accents can be detected by suprasegmental cues alone (Munro 1995). Hahn (2004) investigated whether using prosody effectively, specifically sentence-level primary stress, might help non-native speakers improve their comprehensibility. She measured native speakers' comprehension of non-native speech which was spoken with correct, incorrect, or missing primary stress. She found that although the native speakers' comprehension of the different stimuli was not significantly different, their recall of the correctly accented content was stronger and their impressions of the speaker more favourable than the other samples. Derwing et al. (1998) give experimental evidence that prosodic instruction improves speaker comprehensibility, accentedness, and fluency.

Mendelsohn (1995), as one example among many, stresses that learners should be taught listening comprehension explicitly, including top-down processes such as attention to prosody. As the signal processing technology has matured, there have been a number of studies (such as Anderson-Hsieh, 1992) about using visual feedback to teach prosodic elements. Chun (1998) gives an excellent review of these studies, including analysis of their shortcomings and recommendations for future research.

Capliez (2017) conducted an empirical research study to investigate the role of prosody teaching on listening and speaking skills of French learners of English. The main goal of the study was to examine whether focusing on the prosodic features of the L2 (i.e. stress, rhythm, and intonation) would improve learners' listening and speaking skills more than the focus on the segmental features (i.e. individual sounds). The study's results reported positive effect from both methods yet, there was no significant difference between them

In 2014, Thomson and Derwing conducted a narrative review of 75 pronunciation studies on L2 instruction. The authors reported mixed results on the efficacy of L2 pronunciation instruction including computer-assisted pronunciation teaching with modification to intonation and enhancement with prosodic cues for a single or multiple language features. Therefore, this study aims to contribute to research area by adding more research evidence on the efficacy of prosodic cues for L2 learners' listening comprehension.

In the same line MacAndrew (2019) performed a meta-analysis study by reviewing 17 research studies investigating the role of instruction on suprasegmental listening skills and the extent to which instruction is found to be beneficial to L2 learners. The meta-analysis of the previous studies revealed that instruction is positive and significantly beneficial in helping the learners to develop phonological categories for the suprasegmental features of the target language.

CURRENT RESEARCH

Theoretical significance

The literature in this kind of research falls into two categories: psycholinguistics and applied linguistics. This study relies more on the psycholinguistic studies for models to designing a priming experiment for two reasons. For one thing L2 listening is, after all, a psycholinguistic process. For another, the processing load for L2 listening comprehension is not accessible as readily as for the L1. It seemed that by priming the intonation of the utterance, learners might gain a boost of efficiency in processing depth of listening.

Research question

This study examines whether hearing a prime of the intonational pattern of an utterance will improve the comprehensibility of that utterance for L2 learners of English. Participants heard one of three cues before being hearing a sentence-level utterance which was either true or false. The study measured the reaction times and accuracy ratings of the subjects' responses. Finally, the study results were analysed for statistically significant performance improvements correlated to the cue type, which was either an intonational prime, a neutral intonational pattern, or a foil intonational pattern.

Objectives

Although the study was drawn from psycholinguistic principles, ultimately the results would inform applied linguistics as well. It might suggest ways to integrate suprasegmental audio processing cues into language learning software to assist L2 listening comprehension.

Hypotheses

L2 learners who hear an utterance that has been previously primed with the utterance's intonational pattern will have better comprehension than L2 learners who do not.

Methods

Participants

For the purposes of this study, 30 volunteers were recruited: 15 Saudi EFL learners and 15 native speakers to serve as controls. The EFL learners were intermediate level students. In order to separate the effect of L1 intonation from L2 acquisition of intonation, subjects for the experimental group were all Saudi EFL female students at Al-Imam Mohammed bin Saud Islamic University. All experimental participants were between the age of 20 and 22. Characteristics which were not considered likely to be factors in the experiment -- gender, other L2's, length of study, and were collected via a questionnaire. Another thing that was collected through the questionnaire is self-reported assessments of English skills. The EFL learners reported the values of 2 "Okay" and 3 "Moderate" for listening skills to assess that the EFL learners had *generally* the same language level. The native speakers were mostly friends or friends of friends residing all in Riyadh, Saudi Arabia. Their ages range from 22 to 32 years old.

None of the participants reported having any hearing problems.

Stimuli

The stimuli chosen for the experiment were a set of 39 sentences, 20 true and 19 false. The truth value of these sentences could be easily determined using the world knowledge. The sentences were from four to seven words long. Aside from a few proper nouns, the lexical content of the sentences were reported to be drawn from high frequency words per Sakley & Fry (1979). These particular sentences were drawn from a study by Munro (1998) and were selected as a convenient data set in that it had already been used (with some variations) in other studies. As such these sentences were judged to be easy to understand and unlikely to have semantic or functional load processing difficulties which might skew the results; most of these sentences had been winnowed earlier in a pilot study (Munro and Derwing, 1995) which eliminated those sentences which were difficult to understand or judged to be ambiguous.

Sample sentences include "People eat through their noses" and "Red and green are colours." Appendix A gives the complete list of stimuli.

The stimuli were recorded by the researcher in a quiet room using a Microsoft LifeChat LX-3000 microphone on a MacBook laptop computer running the Praat sound processing software. Afterwards the digital sounds were manipulated to produce corresponding cue files as shown in Table 1.

Table 1 The cue file descriptions with examples.

	Content/Manipulation	Audio clip
Original utterance (stim_f_AugustWinter .wav)	" August is a winter month."	
Prime Cue (utt. filename + _Cue_Prime)	Prime is the source utterance run through a low pass filter, then deepened to increase volume: Filter (pass Hann band)... 10 300 10 Deepen band modulation... 20 10 400 3 30 100	
Neutral Cue (utt. filename + _Cue_Neutral)	Mono sound created from following formula with max_pasc copied from source, then intensity boosted to source db level: 'max_pasc'*sin(2*pi*'pmean'*x)	
Foil Cue (utt. filename + _Cue_Foil)	The prime cue is sliced into separate sound objects of 0.1 seconds each, then randomly shuffled and reassembled.	

Note that all cues have the same duration as the source utterance. The complete Praat script to create the cues is listed in Appendix B.

Procedure

The experiment was set up on a Dell PC Laptop using the Paradigm software from Perception Research Systems. The program was run on a Dell PC desktop in a quiet room. Participants wore headsets. The participants were shown to the computer station and told that they were taking part in a listening study. They were given a brief overview of the experiment, along with instructions to respond as quickly as possible. The specific instructions were shown on the screen at the introduction of the experiment (see Appendix D).

A training task of four trials familiarized the participants with the program.

All of the participants heard each of the thirty-nine utterances, presented in random order. Each stimuli were preceded by a cue sound, either a prime, neutral, or foil. There was a 500 millisecond interval between the cue and the stimuli. The experiment control software used a Latin squares algorithm such that each sound was heard with each cue by one of the subjects. After hearing the stimuli, a screen prompted the subjects to press 1 for true or 2 for false. The subjects had four seconds to respond.

The trial data were logged automatically by the Paradigm software and saved as a separate Excel file. The experimenter manually copied the data into a single Excel file, inserted the information from the participant questionnaires, and put the file into a format appropriate for analysis by the SPSS statistics analysis software.

Results

The data set analysis described in this section was performed across the levels, factors, and variables as shown in Table 2.

Table 2: Variables used in analysis.

Independent Variables (Factors and Levels)							Dependent Variables	
Native Speaking Group		Cue Type			Utterance		Response Time	Correct
NS #15	NNS #15	Prime	Neutral	Foil	True	False	Changed to log()	Incorrect or missing omitted
NS #15	S #15	#1	#2	#3	#1	#2		

A first pass at the data showed two things right away. One was that the response times for the native and non-native speakers were extremely different, and the standard deviations were quite wild (Figure 2), a poor recipe for normal distribution. Therefore, a new variable was created, LogRT, containing the log values of the response times, omitted the missing or incorrect answers (per Munro, 1995), and then analyzed the means separately for each NS group (Figure 3). Because the NNS group bar chart looked like it had a bi-modal distribution, the author chose to run the stats separately for each NNS (Figure 4).

Figure 2: First pass at means.

Descriptive Statistics

Dependent Variable:ResponseTime

NS Group	CueType	Mean	Std. Deviation	N
Total NS#15	1	887.4582	934.00598	51
	2	877.2534	892.10943	50
	3	824.7388	906.66560	49
	Total	863.5683	905.56020	150

First pass at data – not very helpful.

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Figure 3: **Second pass at means – much better!**

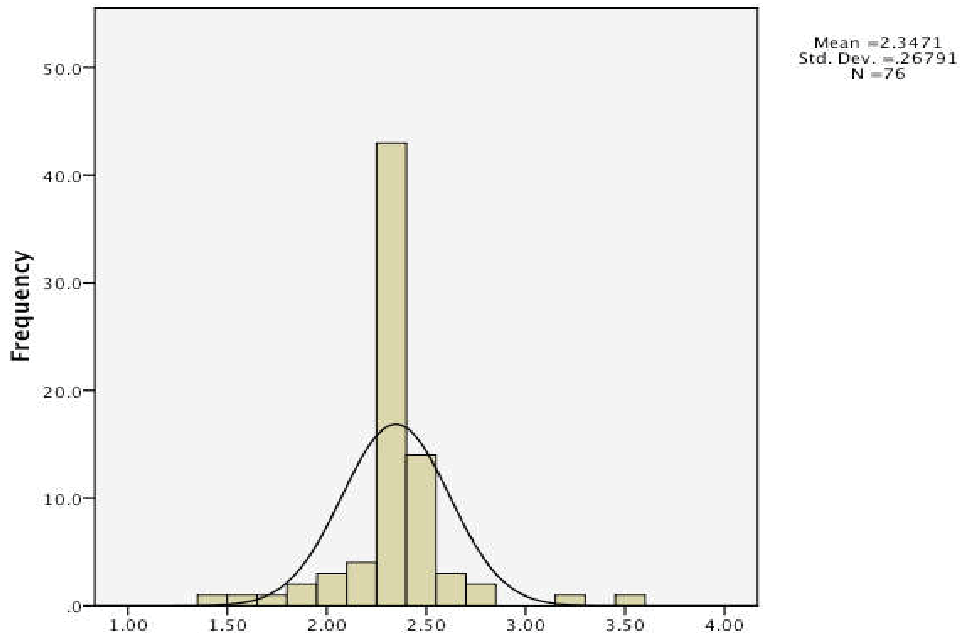
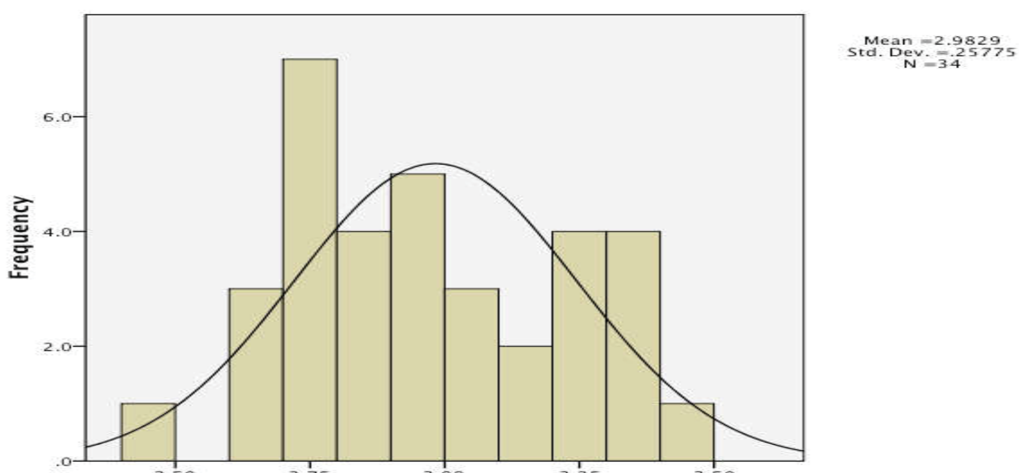


Figure 4: **Means for NNS.**



To find out what factors were significant, a univariate analysis of variance is used to test for between-Subjects' effects (Figure 5). The NS group and – interestingly – True/False value of the utterance were both significant.

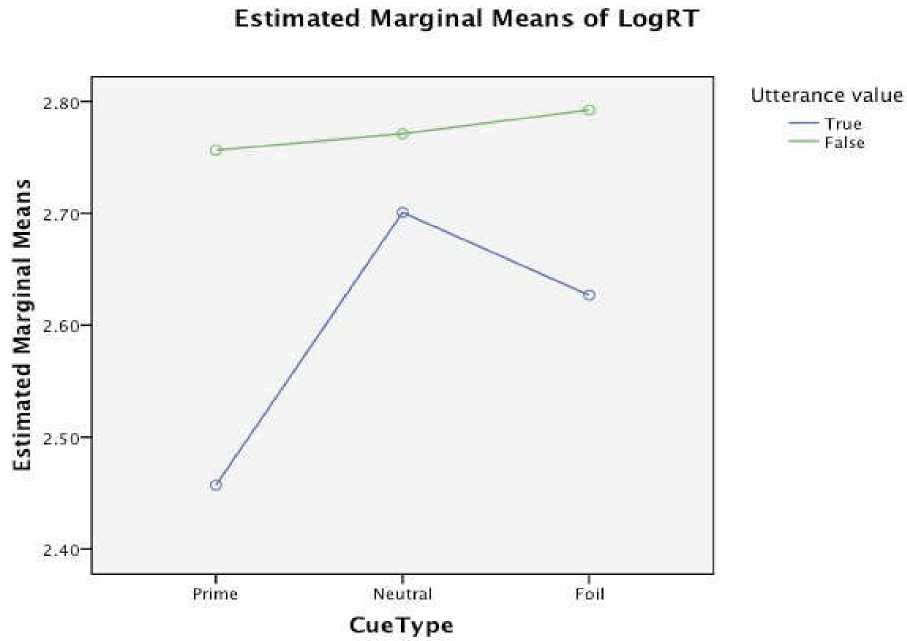
Figure 4: Tests of Between-Subjects Effects for Dependent Variable LogRT

Source	Df	Mean Square	F	Sig.
Corrected Model	11	1.558	22.033	.000
Intercept	1	888.172	12558.035	.000
CueType	2	.191	2.701	.071
TrueOrFalse	1	.981	13.865	.000
NSGroup	1	13.627	192.677	.000
CueType * TrueOrFalse	2	.137	1.940	.148
CueType * NSGroup	2	.045	.641	.529
TrueOrFalse * NSGroup	1	.071	1.002	.319
CueType * TrueOrFalse * NSGroup	2	.055	.778	.462
Error	122	.071		
Total	134			
Corrected Total	133			

Significance ($p<0.05$) was not found for CueType.

Even though the cue type did not reach significance, the profile plot of the estimated marginal means of LogRT did suggest an interplay between cue type and response times, particularly for the true statements (Figure 6).

Figure 5: Interplay between utterance value and cue type.



It would be interesting to see if this effect became significant with a larger sample.

Even though the statements were supposed to be comprehensible to the participants, the NNS group missed 17.9% of the value judgements, with 7.7% responses missing (and presumed timed out). An ANOVA analysis on the cue type and truth value found that although these factors were not themselves significant, the interception of the two were (Figure 7).

Figure 6: Cue type/truth value ANOVA for correct responses.

Tests of Between-Subjects Effects

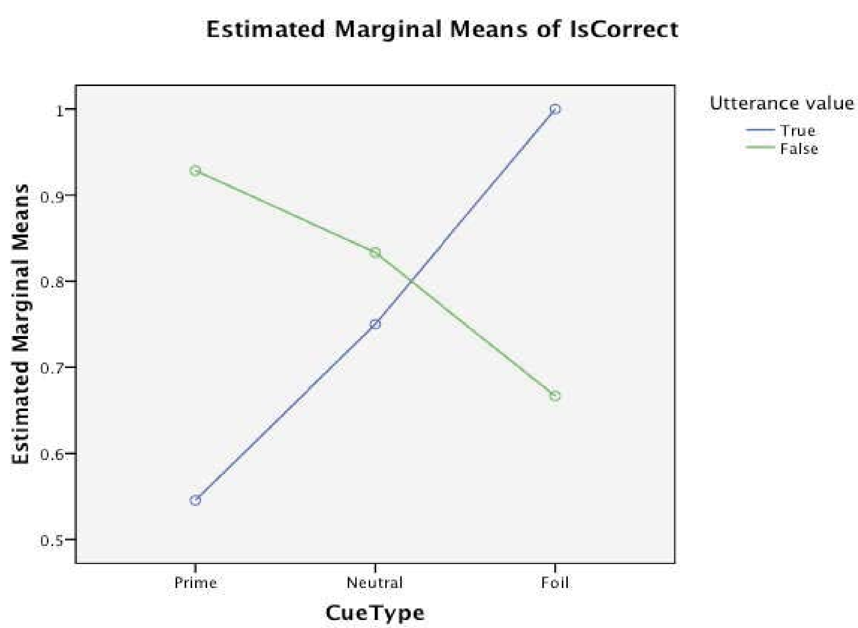
Dependent Variable:IsCorrect

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1.705[a]	5	.341	2.351	.050
Intercept	43.626	1	43.626	300.787	.000
CueType	.109	2	.054	.376	.688
TrueOrFalse	.035	1	.035	.239	.627
CueType * TrueOrFalse	1.494	2	.747	5.150	.008
Error	9.573	66	.145		
Total	58.000	72			
Corrected Total	11.278	71			

a. R Squared = .151 (Adjusted R Squared = .087)

The plot of the estimated marginal means is even more striking for this interaction (Figure 8).

Figure 7: Correlation between cue type and utterance value.



A significant interaction.

Discussion

The results of the study reveal insignificant impact for priming intonation on L2 listening comprehension based on three cue types used in the study. However, a significant correlation was found between the cue type and the utterance value. These findings indicate that listening comprehension can be increased by priming yet, no significant difference is found between all the three cues.

There are many possible explanations for the lack of overall significant effect of the prime cue on comprehension between all the three cue types used in the study. It may be related to L2 learners relying on L1 prosodic cues to process the sentence (Cutler, 2000-2001). However, since the priming effect wasn't seen in L1 learners either, previous literature provides more explanation for such insignificant results. Previous studies such as Akker & Cutler (2003), and Ip & Cutler (2017) found that native speakers can benefit from prosodic cues for better listening comprehension. Nevertheless, most of these studies used lexical rather than sentential tasks (van Donselaar, et al. 2005), or sentential tasks in which sentence level prosody was controlled for contrasting elements (Akker and Cutler, 2003 & Ip and Cutler, 2017).

Another thing, the findings seem to support previous studies with similar insignificant findings (e.g., Thomson and Derwing, 2014 & Lee and Fraundorf, 2018). The authors in such studies argue that native speakers are usually keen enough to comprehend their L1 easily. Prosodic cuing is more beneficial for those learners with listening difficulties or L2 learners.

The fact that a significant correlation was found between the truth values of the statements and the cue type was very interesting. However, this finding seems to be in consensus with Ip and Cutler (2017) who showed that the priming effect is universal and context-dependent at the same time to the target language nature. Hence, the nature of the L2 plays also a major role in lending itself to beneficial effect of prosodic cueing. This finding is definitely an interesting research question for future that needs to be teased apart in-depth.

Conclusion

The findings of this research implies that intonational cues to prime listening comprehension may appear like putting the cart before the horse. Perhaps students would be better served by explicit instruction on the role prosody plays in comprehension, training them to listen for prosodic clues at all levels of oral communication contexts.

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APPENDICES

Appendix A: List of Stimuli

Table A1 Stimulus sentences with simple vocabulary and syntax were selected so as to be comprehensible to L2 study participants.

True Statements	False Statements
Elephants are big animals.	Gasoline is an excellent drink.
Hot and cold are opposites.	Spaghetti grows on tall trees.
Exercise is good for your health.	The sun always sets in the north.
Japan is a wealthy country.	The inside of an egg is blue.
Shakespeare wrote many fine plays.	August is a winter month.
Most teenagers like rock and roll.	It always snows in July.
Some people love to eat chocolate.	March has thirty-eight days.
Some people keep dogs as pets.	Most people wear hats on their feet.
Young children can be very noisy.	The stars come out in the day.
Some roses have a beautiful smell.	Wednesday is the first day of the week.
Hungry cats like to chase mice.	All men can have babies.
Italy is a country in Europe.	All dogs have fifteen legs.
You can start a fire with a match.	People eat through their noses.
Red and green are colours.	A nickel is worth twenty-five cents.
Gold is a valuable metal.	You can buy medicine from the bookstore.
Many houses are made of bricks.	Milk comes from yellow chickens.
Many people drink coffee for breakfast.	Most swimsuits have long sleeves.
Ships travel on the water.	A monkey is a kind of bird.
You can buy a burger at McDonalds.	The Queen of England lives in Winnipeg.
The Canadian flag is red and white.	

All stimuli were taken from Munro 1998 (used with permission).

Appendix B: Praat Script to Generate Cues

This Praat script opens each AIFF file in a directory and creates a prime sound (1), a synthetic neutral sound (2), and a random foil (3). All sounds match the length and general volume of the source utterance.

```
###
### map_cue.praat (version 8)
### create foil, neutral, and prime cues from an utterance.
### save new files
###
### by Reem Alsadoon, IMAMU, FALL 2018
### this script may be freely used and distributed.

# Set value to direct which sound to use as source.
useSource$ = "read stim files"
#useSource$ = "selected"
#useSource$ = "top"
echo Manipulating: 'useSource$'

# Initialize
d$ = "/Volumes/raalsadoon/Linguistics/IMAMU/851_ResearchMethods/Experiment/SoundFiles/"

# branch
if useSource$ = "read stim files"
	inputFiles$ = "stim*.aiff"
	printline Reading stims from directory 'd$'
	Create Strings as file list... fileList 'd$''inputFiles$'
	fileList = selected("Strings")
	nSounds = Get number of strings
	for i to nSounds
		f$ = Get string... i
```

```
        Read from file... 'd$''f$'
        printline Reading 'd$''f$'.
        sourceId'i' = selected("Sound")
        select fileList
    endfor
    Remove
elsif useSource$ = "selected"
    nSounds = 1
    sourceId1 = selected("Sound")
    printline only using selected sound.
elsif useSource$ = "top"
    nSounds = 1
    select all
    sourceId1 = selected("Sound",1)
endif
printline

# ok, process.
for i to nSounds
    select sourceId'i'
    temp = 0

# Get names, variables, duration, pitch info,
intensity, etc..
    sourceSound = selected("Sound")
    sourceName$ = selected$("Sound")
    # Resave as wav.
    Write        to        WAV        file...
'd$''sourceName$'.wav
    dur = Get total duration
    db = Get intensity (dB)

    max_pasc = Get maximum... 0 0 Sinc70
    samp_freq = Get sampling frequency
    temp = temp + 1
    temp'temp' = To Pitch... 0 10 800
    pmin   =   Get   minimum...   0   0   Hertz
Parabolic
```

```
     pmax   =   Get   maximum...   0   0   Hertz
Parabolic
     pmean = Get mean... 0 0 Hertz
     printline Working on 'sourceName$'
     printline ... dur: 'dur'
     printline  ...  pitch:  'pmin'  to  'pmax';
mean 'pmean'
# (1)
# Use low-pass filter to generate prime.
     select sourceSound
     Play
     temp = temp + 1
     temp'temp' = Filter (pass Hann band)...
10 300 10
     cuePrime = Deepen band modulation... 20
10 400 3 30 100
     Rename...  'sourceName$'_Cue_Prime
     Write        to         WAV        file...
'd$''sourceName$'_Cue_Prime.wav
     printline ... saved resynthesized prime!
# (2)
#  Create  synthetic  neutral  sound  wave  from
duration, length, and intensity peak value.
     cueNeutral    =    Create    Sound    from
formula...  'sourceName$'_Cue_Neutral  Mono  0
'dur'                               'samp_freq'
'max_pasc'*sin(2*pi*'pmean'*x)
     # turn it down a bit.
     Scale intensity... 'db'
     Write        to         WAV        file...
'd$''sourceName$'_Cue_Neutral.wav
     printline   ...   wrote   neutral   cue   of
length 'dur' ...
# (3)
# Create foil by splicing prime randomly.
     tb = 0
     tsize = 0.1
     tindex = 1
```

```
    # first, chop
    while tb+tsize <= dur
         select cuePrime
         te = tb+tsize
         foil_part_'tindex'     =     Extract
part... 'tb' 'te' rectangular 1 yes
         Rename... foil_part_'tindex'
         tb = tb + tsize
         tindex = tindex + 1
    endwhile
```

```
     tnum = tindex - 1
     #   use   praat-built-ins   to   shuffle
splices.
     temp = temp + 1
     temp'temp'  =  Create  simple  Matrix...
shuffle 'tnum' 1  x*y
     temp = temp + 1
     temp'temp' = To TableOfReal
     temp = temp + 1
     temp'temp'  =  To  Permutation  (sort  row
labels)
     temp = temp + 1
     temp'temp' = Permute randomly... 0 0
     # now, dice.
     for tindex to tnum
          # copy splices to new order.
          select Permutation shuffle_randomly
          tnew = Get value... 'tindex'
          printline   shuffle   'tindex'   to
'tnew'
          select foil_part_'tnew'
          foil_part_new_'tindex'   =   Copy...
foil_part_new_'tindex'
     endfor
     # select them all
     for tindex to tnum
          if tindex = 1
               select foil_part_new_1
          else
               plus foil_part_new_'tindex'
          endif
     endfor
     cueFoil = Concatenate
     Write        to        WAV        file...
'd$''sourceName$'_Cue_Foil.wav
     Rename...  'sourceName$'_Cue_Foil
     printline ... saved resynthesized foil!
```

```
        # Now clean up temp objects.
        tempnum = temp
        for temp to tempnum
             if temp = 1
                  select temp'temp'
             else
                  plus temp'temp'
             endif
        endfor
        Remove
        for tindex to tnum
             plus foil_part_'tindex'
             plus      foil_part_new_'tindex'
        endfor
        Remove
   endfor
   # we did all the sounds!
```

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Appendix C: Sample Questionnaire

Listening Comprehension Experiment, January, 2019

Please complete the following brief questionnaire. Please note that your name and identifying details will be completely confidential.

Name: ____

Age: _________ Gender: ___________

Email: ___________________________

Do you have any hearing problems? ___________________

What is your first language(s): ________________________

What other languages have you studied, and for how long?

______________________________ _____________

______________________________ _____________

______________________________ _____________

EFL Students

How many years have you been studying English? __________

How would you rate your English skills?

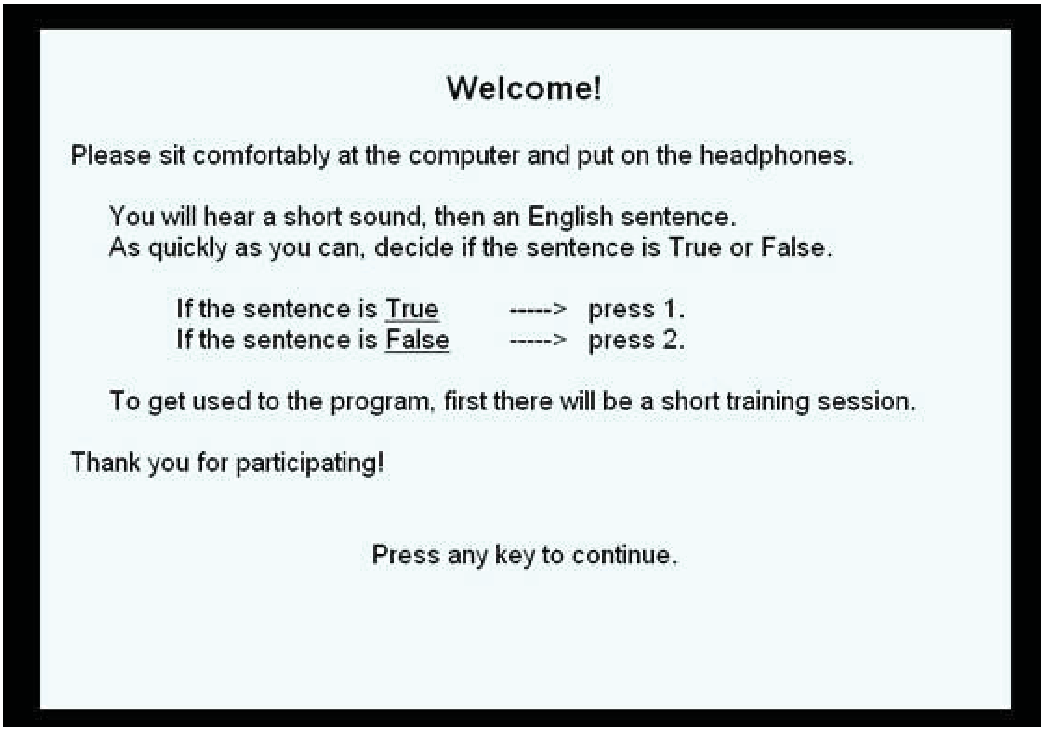
Skill	*Poor*	*Okay*	*Moderate*	*Very good*	*Great*
Reading					
Writing					
Speaking					
Listening					

Thank you for participating in the study!!!!!

- Contact: Reem Alsadoon at raalsadoon@imamu.edu.sa

Appendix D: Listener Instructions

Figure D1 Introductory experiment screenshot showing listener instructions.



Appendix E: Informed Consent Form

January 29, 2019

INFORMED CONSENT FORM

EFL Listening Study

Name:Reem Alsadoon

You have been asked to take part in a research project described below. The researcher will explain the project to you in detail. You should feel free to ask questions. If you have more questions later, Reem Alsadoon, the person mainly responsible for this study, will discuss them with you.

Description of the project:

You have been asked to take part in the study that studies listening comprehension. You have been asked to volunteer because your English language skills are advanced enough to listen to simple statements and judge whether they are true or false. The purpose of this study is to examine particular aspects of how English language learners process spoken sentences.

Procedures:

If you decide to take part in this study here is what will happen: You will sit at a computer and listen to a series of statements in English which are either true or false. The statements will be preceded by a noise. As soon as you decide if a statement is true or false, you will press the appropriate button on the keyboard. You will hear about thirty sentences. The study shouldn't take more than fifteen minutes.

Risks or discomfort:

The study is short and doesn't hold any risks or discomfort for you.

Benefits of this study: (Required in all consent forms)

This study may not hold any direct benefits to you, but will contribute to our understanding of language learning and suggest ways computers may be used to help in this process.

Confidentiality:

Your part in this study is confidential. None of the information will identify you by name.

Voluntary participation and withdrawal:

Participation in research is voluntary. You have the right to refuse to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time.

Questions, Rights and Complaints:

If you have any questions about this research project, please email me at raalsadoon@imamu.edu.sa

Consent statement

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