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The Influence of Short-Term L2 Study Abroad or Home Campus Experience on Speech Intelligibility of Varying Rates in Spanish

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Abstract

Second language (L2) listening is often critical in effective communication, but it is a skill that may be challenged by a number of factors, such as L2 proficiency level, learning environment, and input speech rate. In this preliminary, four-week empirical study, the intelligibility of word-level speech delivered at different rates (normal, moderately fast, and very fast) was examined among adult learners studying Spanish either on their home campus or abroad during a summer mini-semester. A repeated measures ANOVA revealed a significant improvement in decoding speech after four weeks and decreased speech intelligibility as rate increased, but no statistical difference between learning environment groups (i.e., home campus vs. study abroad). An ANCOVA partialling out Spanish oral proficiency as a covariate showed that proficiency surfaced as a mediating variable helping to explain the pre to post gains. Directions for future research will be discussed.

Keywords: Speech intelligibility, Speech rate, Listening, Study abroad, Proficiency, Second language acquisition

1. Introduction

1.1 Study Abroad Experience

It is clear by the expanding number of students who study abroad that studying overseas is increasing in popularity. In the most recent Open Doors report (Farrugia, Bhandari, & Chow, 2012), published by the Institute of International Education, the enrollment of U.S. higher education students in study abroad programs has more than tripled over the past two decades. Of the 25 top study abroad destinations, 20 were in countries in which English is not considered a primary language (Farrugia et al., 2012), and therefore a linguistic challenge for many U.S. students. The abroad experience has long been advocated by language educators who maintain that studying abroad provides linguistic benefits because learners are immersed, to some extent, in the target language community.

The assumption is that enhanced exposure to the L2 and heightened opportunities to interact with native speakers will translate into linguistic gains. There has been mounting evidence in second language acquisition (SLA) research, however, that can provide only limited support for such claims. Freed, So, and Lazar (2003), for example, examined gains in written and oral fluency, and found that written fluency was not enhanced by the study abroad experience but that oral fluency was, in restricted contexts (in speech fluidity, but not number of spoken words, speech rate, or length of the longest turn). Cheng and Mojica-Diaz (2006), in their study on the spoken use of the subjunctive, found that learners did not change their subjunctive use in oral production after their four-week study abroad experience. Learners did, however, report having greater confidence interacting in Spanish and being more likely to use comprehension strategies (e.g., confirmation checks and requests for interlocutors' assistance).

Notably, most study abroad investigations have focused on oral skills (Carlson, Burn, Useem, & Yachimowicz, 1991; Cheng & Mojica-Diaz, 2006; DeKeyser, 2010; Freed, 1995; Freed, Segalowitz, & Dewey, 2004; Galonka, 2006, Huebner, 1995; Magnan, 1986; Yager, 1998) and, to a lesser extent, reading (Dewey, 2004; Kinginger, 2008) and writing (Freed et al., 2003). Even fewer, however, have examined the receptive skill of listening (Cubillos, Chieffo, & Fan, 2008; Kinginger, 2008, Lapkin, Hart, & Swain, 1995; Rodrigo, 2011).

Cubillos et al. (2008) compared the listening comprehension of study abroad versus home country learners enrolled in the same course. Results indicated that, contrary to the researchers' expectations, participants who took a five-week intermediate Spanish course abroad did not have greater gains in listening comprehension of dialogues, short narratives, and long narratives than their home country counterparts. There was, however, a benefit found for learners who started the program with a higher level of self-perceived linguistic proficiency. Although no direct measure of proficiency was examined, their finding is nonetheless interesting because it highlights the role of individual differences in this type of research (see Lapkin et al., 1995, for the predictability of other individual traits, such as personality characteristics and initial proficiency level as measured by the Oral Proficiency Interview, on study abroad gains).

The impact of proficiency level or familiarity with the L2 on listening comprehension, as indicated by Bloomfield et al. (2010), could be related to the use of top-down and bottom-up strategies in the processing of aural information. In fact, it is argued that expert listeners can successfully engage in both bottom-up (e.g., decoding of the speech signal) (Tsui & Fullilove, 1998) and top-down processing (e.g., incorporation of the acoustic-phonetic information with their own background knowledge) (Field, 2004). Non-expert listeners, by contrast, attempt (oftentimes unsuccessfully) to rely on background knowledge to make up for their limited ability to accurately process L2 speech signals (Goh, 2000; Tyler, 2001).

Although Cubillos et al. (2008) administered a Metacognitive Awareness Strategy Questionnaire to gauge participants' general top-down and bottom-up listening strategies, it is unclear the source of processing error among participants in the actual aural tasks. Could the lack of listening comprehension gains across participants be directly attributed to errors in bottom-up processing? Can bottom-up processing be improved with sojourn experiences? Other studies (e.g., Kinginger, 2008, Llanes & Muñoz, 2009; Rodrigo, 2011) examining the impact of studying abroad on aural comprehension have pointed to positive effects, but without decomposing the processes involved in the comprehension of aural input, understanding why comprehension is improved or not remains an open question.

Given this gap in the literature, the current investigation was conducted to broaden the study abroad research on aural input processing accuracy, examining specifically one of the underlying mechanisms of listening comprehension necessitating bottom-up processing, namely, speech intelligibility. Furthermore, given that utterance intelligibility can be moderated by the speed of delivery and also given that learners receive aural input at different rates of speech, processing of input delivered at normal, moderately fast, and very fast rates will likewise be examined.

1.2 Speech Intelligibility

While research on foreign sojourns has examined a range of constructs, to include oral and written fluency, grammatical accuracy, listening comprehension, and social/affective factors, no published empirical research has examined the effect of studying abroad on the intelligibility of varying rates of L2 speech in particular. Speech intelligibility refers to how well a speaker's acoustic signal is accurately decoded, or recovered, by a listener (Kent et al, 1989; Yorkston & Beukelman, 1980). For aural production to be intelligible, it does not need to be considered "perfect" or "normal", as speech with a variety of alterations (e.g., articulatory omissions, substitutions, or distortions) may still be intelligible (Hustad, Schueler, Schultz, & DuHadway, 2012). The key issue in intelligibility, according to Hustad et el. (2012), is "whether listeners are able to map the acoustic signal onto the intended lexical units in spite of segmental- or suprasegmental-level problems" (p. 1177).

Intelligibility differs from listening comprehension, which is higher order and involves meaningful understanding of speech. Learners cannot be expected to fully comprehend L2 speech, however, if they are unsuccessful identifying the sounds or words transmitted. Speech intelligibility, therefore, involves bottom-up processing and is one of the underlying mechanisms in listening comprehension, rendering it crucial to examine.

Among L2 learners, a number of factors can make speech intelligibility difficult, including, to name a few, age of L2 acquisition and differences in L1 and L2 language structure, at the segmental (i.e., phonemic) and suprasegmental (i.e., prosodic) levels. There is research evidence showing that a late age of L2 acquisition can deteriorate the efficiency of speech processing abilities in bilingual listeners (Bunta & Ingram, 2007; Mayo, Florentine, & Buus, 1997). Specifically, in an experiment by Mayo, Florentine, and Buus (1997), native Spanish listeners who learned English after 14 years old (late bilinguals) showed significantly poorer performance on English speech intelligibility in a noise task than native Spanish listeners who learned English before age 6 (early bilinguals) and monolingual English listeners. What these findings suggest is that speech intelligibility is more of a challenge for late L2 learners than other groups. Although the precise reasons that late leaners of a second language do comparatively poorly continue to be explored, it is well known that in the case of Spanish and English, Spanish is a syllable-timed language whereas English is stressed-timed. To that effect, researchers, such as Dauer (1983), have noted Spanish-English differences in syllable structure, vowel reduction, and other phonological distinguishing factors between syllable-timed and stress-timed languages (e.g., Spanish has fewer occurrences of vowel reduction than English and, as quantified by Delattre (1966) and Hoequist (1983), also briefer stressed syllable duration when compared to English). Furthermore, whereas some researchers (e.g., Cutler & Mehler, 1993) propose that differences between languages can be examined at the rhythmic level, such that syllable-timed languages and stress-timed languages each trigger different processing mechanisms, others (Sebastián-Gallés, Dupois, Costa, & Mehler, 2000) posit that variables other than exclusively the rhythmic properties of language, such as the vowel system and/or the pattern of lexical stress, can play a role in L2 speech intelligibility. Indeed, it is likely that a combination of some or all of these factors impact learners' ability to identify oral information, especially when speech is delivered at rapid rates.

In the speech communication literature, there are two types of fast speech generally investigated: 1) naturally produced and 2) time compressed. Natural fast speech differs in its timing pattern from that of normal-rate speech (Janse, Nooteboom, & Quené, 2003; Max & Caruso, 1997; Port, 1981) at the syllable, word, and sentence level. For example, when speech rate is accelerated in English, there is a greater reduction of vowels relative to consonants, and a greater reduction of unstressed-syllable duration relative to the duration of syllables that are stressed. This less careful articulation in natural fast speech slows down processing (Janse, 2004) and can affect comprehension. Time-compressed speech (TCS), on the other hand, is normal speech that is speeded up digitally while preserving spectral information and voice pitch. This means that the high-pitch Mickey Mouse sound that is produced by some artificial methods of increasing speech rate is avoided and the frequency or spectral aspects of the sound signal remain unaltered.

Naturally produced accelerated utterances are subject to timing pattern alterations, less careful articulation (Janse, 2004), and pitch increases. Given that these modifications lack uniformity, researchers investigating accelerated speech that is naturally produced are unable to tease apart these potentially intervening variables (timing, articulation, and pitch variances) from the variable *speech rate*. In order to isolate the effect of speech rate alone, therefore, the study reported here used linear time compression as the method of speech acceleration. In fact, research has shown that listeners find artificially time-compressed speech, when linearly compressed, to be easier to process than accelerated speech that is naturally produced, even when the latter is perfectly intelligible (Janse, 2004). The implication of these findings is that TCS is not less intelligible than natural fast speech, and is thus an acceptable and perhaps preferred method of increasing speech rate for research purposes. Again, time compressed speech is used to simulate rapid speech rates because it allows better experimental control over variables that change when speakers adjust their speaking rate (Arons, 1992).

In a linguistics study examining the effects of time-compressed speech on listening comprehension, Linda Conrad (1989) compared native English speakers to high- and medium-level students of English as a Foreign Language (EFL). In her study, participants were presented with 16 simple English sentences, each delivered at five time-compressed speech rates ranging from 40% to 90% compression (i.e., 40%-90% faster than the original recording). Participants were asked to immediately recall the sentences. She found that overall recall of time-compressed sentences diminished with decreased proficiency in the language. Moreover, nonnative listeners tended to recall more words they had heard in sentence-initial or sentence-final position. These memory effects are in line with the information processing approach, which puts forth that we have a limited capacity for processing information and thus can have only so much in working memory before attentional resources are depleted. In the present preliminary study, therefore, words were chosen rather than sentences in order to control for the memory effects found in Conrad's (1989) study. Furthermore, research has shown that language intelligibility among native speakers is not noticeably reduced until presentation reaches a compression rate of about 65% of original playing time (Conrad, 1989). Therefore, departing from Conrad, who examined up to 90% compression, we chose compression rates of 0% (uncompressed), 30%, and 60% for our nonnative listeners. This helps to avoid creating a situation that would be too difficult even for native listeners of the language.

The following two research questions guided our preliminary study:

RQ 1. Are there significant effects of speech rate (0%, 30%, and 60%), short-term learning environment (home campus vs. study abroad), and time (pre to post) on speech intelligibility for time-compressed speech in nonnative Spanish listeners?

RQ 2. Are the results in RQ 1 mediated by listener's Spanish oral proficiency level?

Speech intelligibility is defined here as the accurate recall of words. Short term is defined as less than eight weeks of study, as indicated in the Institute of International Education's Open Doors report and as defined by Cubillos et al. (2008).

Our original hypotheses for the study were that: 1) due to signal degradation associated with time-compressed speech, L2 listeners would show more difficulty decoding speech at rapid delivery rates (as supported by Conrad, 1989); furthermore, 2) given the results of Cubillos et al. (2008) and Conrad (1989), who also examined aural processing and L2 proficiency, a connection between Spanish oral proficiency levels and intelligibility of time-compressed speech would be evidenced. Specifically, participants with a higher level of proficiency would be more accurate at engaging in bottom-up and top-down processes to compensate for the acoustic distortion of rapid speech rates. We also hypothesized that changes would be observed in the processing of compressed speech following listening experience, that is, that L2 learners, regardless of learning environment group, would be able to process time-compressed speech more efficiently after their summer Spanish program than at onset given their increased receptive exposure. And finally, with no consistent findings in the study abroad literature regarding the effect of foreign sojourns on L2 development, and no experiment investigating TCS intelligibility among home campus versus study abroad learners, data-driven hypotheses regarding the effect of learning environment on L2 speech intelligibility cannot be drawn. However, one might expect increased listening opportunities in the target community (as presumed to be the case in study abroad programs) to have a greater positive impact on fast speech intelligibility because of the following two assumptions: 1) increased listening opportunities improves familiarity with L2 phonology and by extension, accuracy in bottom-up processing, and 2) study abroad learners have more exposure to varying rates of aural input in the target community, including rapid speech.

2. Method

2.1 Participants

Twelve learners of Elementary to Advanced Spanish at a southeastern university in the U.S. studying either on campus or abroad for four weeks of the summer were recruited to voluntarily participate in this study. Criteria for inclusion in the final sample were as follows: participants had to be 1) native English speakers with no hearing loss, 2) who attended both sessions, 3) reported no previous extended abroad experience, and 4) were either studying abroad in Salamanca, Spain, for a month or were enrolled in a Spanish program on the home campus for the same time. Learners in the Salamanca program lived in dormitory accommodations with other *non*native Spanish speakers. Although participants studying in Costa Rica with a host family formed part of the original sample, they were eliminated to control for study abroad accommodations. After attrition and elimination, the final sample size consisted of 8 participants—4 home campus and 4 study abroad. Sample size was limited given that many learners either had work obligations in the summer or, in the case of the study abroad students, went back home rather than to the domestic university before and/or after their abroad experience.

Participants in each group were enrolled in one or two Spanish courses (Elementary, Intermediate, Conversation, Civilization, Composition, and Advanced Grammar) at the time of testing. Given this range of courses and to account for affective differences across classroom settings (Cubillos et al., 2008), participants completed a post-exposure questionnaire that addressed their learning experience. As reported on this questionnaire, both groups had a rather positive experience with their course professor(s) and most reported positive classroom experiences. To measure learner’s L2 oral proficiency and thereby control for linguistic level, participants completed an automated Spanish proficiency test (see section

2.2) called the Versant™ Spanish Test. All learners were compensated $20 for full participation in the study.

2.2 Procedure and Materials

Data for this quasi-experiment was collected in two sessions. The first session took place on the home campus at the onset of learners' Spanish programs (i.e., the week of or leading into the beginning of the semester). Reporting to the audiology laboratory, participants signed a consent form and, one-by-one, took a hearing test in a sound-treated audiometric booth meeting permissible noise levels (American National Standards Institute, 1991). The purpose of measuring participants' hearing was to ensure that any difficulty related to speech intelligibility would not be due to hearing loss. The audiological test protocols consisted of an otoscopic examination (to ensure normal ear canals), tympanometry (to ensure normal middle ear function), and pure tone audiometric testing (to determine normal hearing thresholds in both ears). All participants showed normal otoscopy and tympanometry findings while demonstrating normal hearing sensitivity in the frequency range from 250 to 8000 Hz (American National Standards Institute, 1996).

In the same laboratory, participants proceeded to take a speech intelligibility pretest. The audio for the pretest, produced by Auditec, Inc. and used in Flores & Aoyama (2008), was recorded by a native Spanish speaker voice talent from Mexico City on an audio engineered compact disk (CD). The CD contained four lists (Lists A, B, C, and D), each with 25 different high frequency bisyllabic words present in typical introductory Spanish textbooks (e.g., *ropa, leche, calle,* "clothes, milk, street") as well as in Davies' (2006) Spanish frequency dictionary. The four lists were on the CD at three rates of speech: normal (0% time compression), moderately fast (30% time compression, i.e., speech that was delivered at a rate 30% faster than normal), and very fast (60% time compression). "Normal" is defined as the rate at which listeners can usually easily comprehend an utterance (Rubin, 1994). Each target word was preceded by the carrier phrase "Diga Ud." (e.g., Diga Ud. *ropa*) to prepare participants for the target lexical item. The word lists were given in both randomized order and randomized speech rate. For example, Participant 1 could have heard List A at 30% time compression, List C at 0%, and List B at 60%. Learners were asked to repeat the target word they heard and write down their response. Orthographic transcription of responses (by tester and listener) is typical in L2 studies of speech intelligibility.

To test learners' proficiency in Spanish and determine whether oral proficiency would surface as a mediating variable, participants took a highly reliable (split-half reliability of .96 on the Overall Score), commercially available, automated oral proficiency test called the Versant Spanish Test, which gauges how well a person speaks and understands spoken Spanish. The Versant Spanish Test was delivered over the phone and took about 13-17 minutes to complete for each participant. Oral tasks included sections on reading, repeating utterances, opposites, short answer questions, sentence building, story retelling, and open questions. Based on learner output, five scores were generated—Sentence Mastery, Vocabulary, Fluency, Pronunciation, and Overall—of which we used the Overall score for analysis.

Returning to the audiology lab at the end of the semester (about four weeks after the pretest), participants completed Session 2. In this session, learners took a speech intelligibility posttest and completed three questionnaires. The posttest was administered in the same format as the pretest; this time with a new randomized order for both the word lists and the three speech rates. Questionnaires aimed at gleaning learners' 1) biographical information, 2) assessment of their own Spanish skills, and 3) impressions of both their Spanish instructor that summer and classroom experience were completed. The latter two questionnaires form part of a larger study and will not be analyzed here.

3. Results

A one-way analysis of variance (ANOVA) demonstrated that the groups were statistically comparable at onset for 0%, 30%, and 60% time compression. This means that any difference found in the remaining analyses was not because of any inherent differences between groups on the pretest.

The independent variables were time (pre and post), speech rate, or TCS, (0%, 30%, 60%), and learning environment (home campus and abroad). The dependent variable was the arcsine transformed (RAU) scores of the speech intelligibility test. That is, the percent accuracy scores were arcsine transformed for normal distribution purposes into RAU scores using a rationalized arcsine transformation calculator (Studebaker, 1985). Given that the participants consisted of learners at different stages in their Spanish development, L2 oral proficiency as measured by the Versant Spanish Test was partialled out as a covariate (that is, submitted to an analysis of covariance, or ANCOVA). This assesses the influence of oral proficiency as a continuous variable by statistically examining what the results would be if all learners had the same level of proficiency.

In order to answer Research Ruestion 1, which inquired into the effects of rate and learning environment on intelligibility of time-compressed speech, a 2 x 3 x 2 repeated measures ANOVA was carried out, with a one between-subjects (learning environment) and two within-subjects (speech rate and time) factor design. With the alpha level set to .05, results revealed significant main effects for both time, $F(1, 6) = 7.877$, $p = .038$, $\eta^2_p = .61$ and speech rate, $F(2, 5) = 134.605$, $p = .000$, $\eta^2_p = .96$. As demonstrated by the strength of association measure partial eta squared (.61 and .96, respectively), the effect size is large, meaning that the time and speech rate effects have a large magnitude in the greater population.

See Figure 1 for an illustration of the significant increase in mean between pretest (M = 70.3, SD = 3.8) and posttest (M = 76.9, SD = 2.5). Overall, learners improved their ability to accurately process speech, regardless of time compression, after a month of their Spanish program. Also, as can be seen in Figure 2, learners' ability to decode L2 speech deteriorated as the rate of delivery increased. Thus, as to be expected, speech delivered at a normal rate (0% time compression) was the most accurately processed across learners (M = 97.1, SD = 1.8), while speech that was delivered at a very fast rate (60% time comprehension) was the least well recalled (M = 41.8, SD = 4.2).

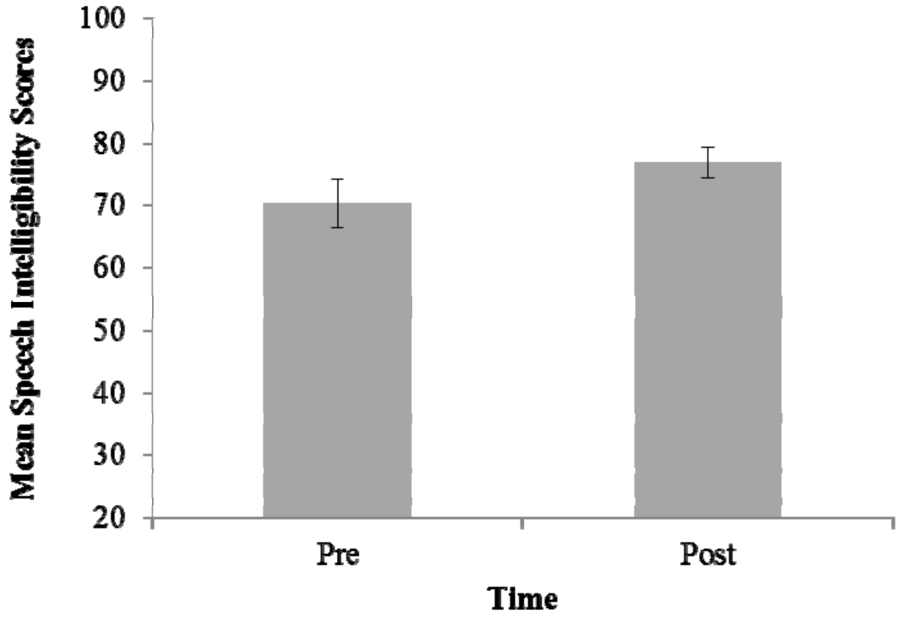

Figure 1. Mean Scores on the Speech Intelligibility Test Pre- and Post-Summer L2 Program

Note: Min score = 0, Max score = 100.

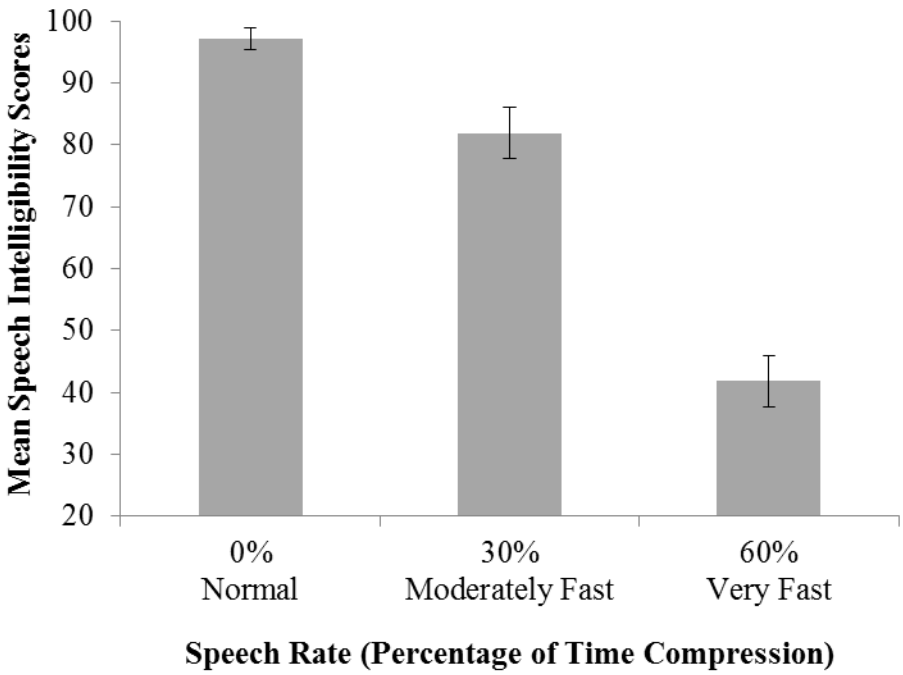

Figure 2. Mean Scores on the Speech Intelligibility Test at 0%, 30%, and 60% Time Compression

Note: Min score = 0, Max score = 100.

In terms of group, the ANOVA revealed no significant difference in learning environment,

$F(1, 6) = 2.207$, $p = .198$, with descriptive statistics showing a mean score of 78 (SD = 4.5) for home campus participants and 69.2 (SD = 3.9) for study abroad learners (see Figure 3). No significant Learning Environment x Time, Learning Environment x Speech Rate, or Time x Speech Rate interactions surfaced.

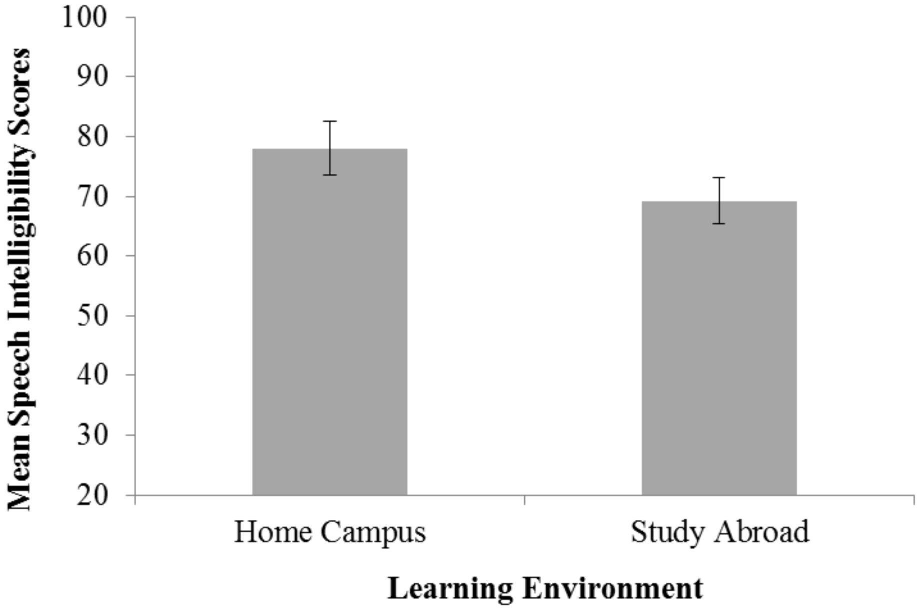

Figure 3. Mean Scores on the Speech Intelligibility Test for the Two Learning Environment Groups (Home Campus and Study Abroad)

Note: Min score = 0, Max score = 100.

In order to address the second research question (Are the results mediated by listeners' Spanish oral proficiency level?), proficiency was added as a covariate to the previous ANOVA, but a slightly different pattern emerged (see Table 1). Specifically, once proficiency level was controlled for, there was no longer a significant main effect of time, $F(1, 6) = 5.826$, $p = .073$. There remained, however, a main effect for speech rate at the significant level, $F(2, 5) = 5.822$, $p = .028$, $\eta^2_p = .59$, with a reduced, but nonetheless large effect size. With mean intelligibility scores of 96.5 (SD = 1.5) for 0% TCS, 79.9 (SD = 2.4) for 30% TCS, and 40.5 (SD = 4) for 60% TCS, it is clear that even after proficiency is partialled out, speech delivered at moderately fast and very fast rates deteriorates its intelligibility regardless of the oral competency of L2 listeners. The ANCOVA furthermore shows that, as with the ANOVA, no significant difference between learning environment groups surfaced, as well as no significant interactions.

Table 1. Repeated measures ANCOVA for time, speech rate, and learning environment

(covarying Spanish oral proficiency)

Source of variability	*df*	Sums of squares	Mean squares	*F*	*p*	Partial eta^2
Time	1	220.67	220.67	5.826	.073	.59
Speech Rate	2	892.31	446.15	5.822	.028*	.59
Learning Environment	1	225.42	225.42	1.404	.302	.26
Oral Proficiency	1	1172.53	1172.53	7.301	.054	.65
Time x SR	2	26.28	13.14	.413	.675	.10
Time x LE	1	51.56	51.56	1.361	.308	.25
Time x OP	1	136.68	136.68	3.609	.130	.47
SR x LE	2	74.29	37.14	.485	.633	.11
SR x OP	2	217.60	108.80	1.420	.297	.26
Time x SR x LE	2	62.48	31.24	.983	.415	.20
Time x SR x OP	2	45.59	22.79	.717	.517	.15

Note: SR = Speech Rate, LE = Learning Environment, OP = Oral Proficiency
*$p < .05$

4. Discussion and Conclusion

The main purpose of this preliminary study was to investigate the effects of speech rate and study abroad experience in adult L2 learners. Another goal was to determine whether oral proficiency level could help to explain the results. Regardless of Spanish proficiency, L2 participants performed poorer on speech intelligibility of time compressed speech at moderately fast (30%) and very fast (60%) rates in comparison to uncompressed speech (as was shown in Figure 2). No interaction between speech rate and oral proficiency indicates that even the most proficient L2 speakers are unable to overcome the challenge of decoding speeded bisyllabic words. This highlights the importance of delivery speed in listening tasks. If learners struggle with speech intelligibility, chances are that they will also toil with listening comprehension. Task designers should, therefore, consider speech rate when selecting aural tasks (for measures of speech rate with longer stimuli, see, for example, Blau, 1990; Derwing & Munro, 2001; Robb, Maclagan, & Chen, 2004).

In order to understand the decline in speech intelligibility for time-compressed speech in Spanish, we did a post-hoc examination of segmental perception errors, in line with Gordon-Salant and Fitzgibbons (2001), who showed that selective time compression of consonants leads to a decline in brief acoustic cues related to place of articulation of consonants. In Gordon-Salant and Fitzgibbons (2001), five listening conditions were used to determine speech intelligibility. These conditions included: 1) undistorted speech, 2) uniform time compression applied to vowels, pauses, consonants, 3) selective time compression of pauses, 4) selective time compression of vowels, and 5) selective time compression of consonants. Their results showed that selective time compression of consonants led to the greatest decline in speech intelligibility of consonants compared to the other compression conditions. To investigate consonant confusions in our study, therefore, a post-hoc analysis was carried out to examine the consonant perception errors that were clearly made in terms of: 1) place of articulation (bilabial, dental, alveolar, etc.), 2) manner of articulation (stop, fricative, affricate, etc.), and voicing (voiceless versus voiced). We found that most of the simple errors were related to place (M = 2.1 errors) and manner (M = 1.7 errors) of articulation, while very few errors related to the voicing feature of consonants (M = .4). Hence, perception of brief acoustic transitions of consonants relating to place and manner of articulation may help to explain the decline in speech intelligibility for Spanish time-compressed speech. Future studies need to investigate these errors further by careful selection of stimuli for two reasons: 1) to gain insights into the speech perception of Spanish consonants and 2) to increase understanding of such cues among adult L2 learners.

Our results also revealed a significant increase in Spanish intelligibility from pre- to post-program for uncompressed and time-compressed speech before controlling for proficiency. After oral proficiency was partialled out, however, the effect of time on speech intelligibility disappeared. This suggests that initial proficiency is a mediating variable that helps to explain why L2 learners are able to improve decoding of aural information over a four-week language program. A pure control group that is not enrolled in any Spanish courses during the weeks of the study, however, will help to rule out test effects (participants performing better the second time because they knew what to expect) as a contributing factor to the initial pre to post improvement. In fact, a number of variables could be examined in forthcoming studies to shed light on other factors that may influence change in speech intelligibility over time. For example, does quantity (e.g., increased number of hours) and quality of listening (e.g., active rather than passive listening, or target-like aural input rather than input with non-targetlike phonology) in the target language during the investigation period contribute to an enhanced ability to decode the speech signal?

Another result found in our investigation is that studying abroad short term does not seem to improve bottom-up processing of aural input. This is reflected in the fact that the study abroad learners failed to show significant advantages over home campus learners with respect to speech decoding at different rates of utterance delivery. This may be due to the limited sample size, which increases the possibility of incorrectly accepting the null hypothesis. However, there may be other explanations for the null impact of learning environment.

First, it may be that four weeks is too short to see any significant advantage of one group over the other. Studies on brain plasticity have shown that L2 perceptual learning can induce changes in the auditory brainstem in adults even after short-term audio training (eight 30-minute sessions) (Song, Skoe, Wong, & Kraus, 2008). Little is known, however, about the plasticity in the adult auditory brainstem in less controlled, non-training environments, such as in the study abroad setting, and the time it takes to witness such changes. It may be that a period longer than four weeks is needed to induce any bottom-up processing difference among groups. What may be even more important for speech decoding ability, however, is the combination of quantity and quality of listening experience, not just the overall period of L2 exposure nor the foreign versus domestic learning environment. As Voss (1984) found, the more familiar listeners are with the L2 phonology, the greater their reliance on L2 phonological cues (bottom-up information) when processing aural input.

Second, we posit that the sojourners' housing accommodations could be another contributing factor to why no difference between learning environment surfaced. In this case, participants in the Salamanca study abroad program were housed not with host families but rather with other English speakers in dormitories. This type of lodging accommodations arguably impacts learners' level of immersion with native speakers as well as limits their opportunities for further linguistic development outside of class. This reduced contact is augmented by the fact that even within the study abroad classroom, linguistic opportunities may be restrained. Studies such as those of Miller and Ginsberg (1995), Carson and Longhini (2002), and Huebner (1995), for example, found a common tendency of immersion students to recreate home campus classroom behavior in the target language environment. For greater understanding of why studying abroad may or may not impact listening processes and speech intelligibility, future studies should quantitatively compare the amount of time spent listening to target-like Spanish (normal speed on the one hand and fast speed on the other) among study abroad and home campus learners. Other information could likewise be helpful, such as how much of that time was spent actively listening (e.g., when understanding the message transmitted was necessary) versus listening only passively (e.g., as background music), or how much of aural input was from native or near-native speakers (with targetlike phonology) or from their L2 learning peers (with non-targetlike phonology). Freed et al. (2004) found that in terms of oral fluency, it is not the context of L2 learning per se (e.g., study abroad versus domestic programs) but rather the "nature of the interactions, the quality of the experiences, and the efforts made to use the L2 that render one context superior to another with respect to language gain" (p. 298). This may be true for listening skills as well.

Third, the accent learners were exposed to and the accent of the native speaker in the testing materials may be another factor explaining why no group effect emerged. *Accent*, as defined by Crystal (2008), is the cumulative auditory effect of pronunciation features that identify where a person is from. The speaker in the testing materials was from Mexico City and articulated what may be considered standard Latin American Spanish. Learners exposed to a different acoustic Spanish variety during their summer program (as was the case with the study abroad group, who studied in northwestern Spain), may have been better at processing Spanish spoken with an accent similar to that to which they were exposed during their summer study, but perhaps not that of other varieties. This explanation is not likely in the current study of bisyllabic words, however, given the findings of Weil (2003). In an L1 study examining whether receiving training with speech from a speaker of a given foreign accent improved auditory intelligibility for other speakers of that same accent, Weil (2003) found that although sentence intelligibility was improved, single-word intelligibility was not. Therefore, the difference between the accent exposed to and the accent in the testing materials is not likely to impact processing of single words.

Finally, a fourth possible explanation for the lack of significant difference between home campus and study abroad learners is that both groups struggle equally with the decoding of bisyllabic words because they are all late learners perceptually transitioning from a stressed-time language to a syllable-time language and have not achieved optimal L2 bottom-up processing abilities. Perhaps, then, the acoustic degradation in time-compressed speech is too challenging for these L2 learners, regardless of the learning context.

Although the results must be interpreted in light of the sample size herein, which precludes broad generalizations from being made, the findings are nonetheless interesting because they suggest that learners may indeed be able to improve speech intelligibility after intensive language exposure, but it is crucially L2 proficiency and not simply exposure itself that helps to explain the gains. This may be because L2 proficiency is associated with familiarity with non-native phonology (Bloomfield et al., 2010), which in turn relates to reliance on bottom-up information (decoding of the speech signal). In fact, both Goh (2000) and Voss (1984) found that the more familiar students are with L2 phonology, the greater their reliance on bottom-up information. Therefore, we posit that L2 proficiency mediates improvement in speech intelligibility because those with a higher level of L2 proficiency have better speech decoding abilities than those with a lower level.

The findings also suggest that studying abroad with L1-dominate dorm accommodations, at least on the short term, does not help learners to be more adept at identifying L2 utterances that are delivered at normal and rapid rates. The lack of effect of short-term studying abroad on speech intelligibility may, in fact, help to explain the lack of between-subjects difference in Cubillos et al.'s (2008) listening comprehension results. It stands to reason that if speech intelligibility is one of the underlying mechanisms in listening comprehension, problems with *comprehending* speech may be at least partially attributed to *intelligibility* of speech. This suggests that future research on listening comprehension should consider including a test of speech intelligibility to gain a better understanding of the variables that impact aural input processing.

5. Future Research

The results of our study are preliminary and should be interpreted with caution due to the limited sample size. It would be worthwhile for studies, however, with an increased participant pool, to examine not only the same variables studied herein but also a combination of different testing conditions, factors, and listening tests to further examine speech intelligibility and the impact learning environment may have on speech decoding abilities. For example, lengthier timeframes, such as 3 months, 6 months, or 1 year can be put under the investigative microscope, with questionnaires that glean information such as the quantity and quality of aural input received. Likewise, different living arrangements can be examined, e.g., living with a host family in the target L2 community vs. living with other L1 speakers abroad, but again, data on their listening tendencies and exposure is needed.

Additional speech intelligibility tests that consist of lengthier stimuli, such as sentences, should also be considered, along with tests of working memory to address cognitive constraints. This is especially critical given that L2 speech is often delivered in connected discourse rather than isolated words.

Moreover, a fruitful avenue of further L2 research is the examination of speech intelligibility in concert with listening comprehension. An investigation including both intelligibility and comprehensibility of the same aural information is needed to further understand bottom-up and top-down processes at work. Most researchers examine either speech intelligibility or listening comprehension, or even conflate the two (by saying they measure speech intelligibility but instead actually use a test of comprehension); however, there is a paucity of research that examines the two variables within the same study. Two ongoing studies in our laboratory are currently being performed to study both speech intelligibility and listening comprehension of L2 sentences delivered at different rates of speech.

Indeed, investigations on speech intelligibility and delivery rates encompass a number of broader issues. For example, if improved speech intelligibility leads to better listening comprehension, what can students or educators do to increase speech decoding abilities, independent of L2 proficiency level? Researchers could thus examine the impact of auditory training with varying L2 speech rates to determine whether a training program can influence bottom-up processing. Training investigations such as these have primarily been done in first language research, particularly in English (see Foulke & Sticht, 1969), but L2 research of this nature is virtually non-existent. Auditory training can also be statistically compared to other factors, such as the length or type of interaction with the target language in order to determine what best improves speech intelligibility and thereby potentially comprehension.

A final issue that could be explored in the future is the speech rate that is needed to understand target language discourse in Spanish. We know that delivery rate impacts word intelligibility (as found in the present study), such that faster speeds are more difficult to decode. What we do not know in Spanish, however, is whether the rate spoken by native Spanish speakers at the sentence level is also a threat to speech intelligibility, whether it impacts comprehension, and whether there is a threshold rate learners must be able to attain and process in order to be successful decoders and comprehenders of connected speech.

With listening an underinvestigated skill, exploration into intelligibility, comprehensibility, and rate of speech is not only necessary, but also promises to shed further light on the complex nature of L2 auditory processing.

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