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L2 intelligibility and comprehensibility: trying out new measurements with AEPI

Inteligibilidad y comprensibilidad en L2: puesta a prueba de nuevas mediciones con AEPI

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Abstract

This paper presents and discusses new means of testing and measuring the constructs of 'intelligibility' and 'comprehensibility'. Firstly, we present a short agenda of works which contributed with both theoretical and empirical insights on intelligibility and comprehensibility (Munro & Derwing 1995; Munro & Derwing 2001; Derwing & Munro 2015; Munro & Derwing 2015; Nagle, Trofimovich & Bergeron 2019; Albuquerque 2019). Afterwards, the AEPI application (developed by Bondaruk, Albuquerque and Alves 2018) is presented. AEPI is an open source tool that not only allows for a more traditional measuring (transcription task) but also introduces new variables to the studies on intelligibility and comprehensibility by providing an oral repetition task and response time measurements. Finally,

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AEPI's use and contributions to some research studies are posed and discussed (Alves, Albuquerque & Brisolara 2019; Salves, Wanglon & Alves 2020; Albuquerque & Alves 2020).

Keywords: Intelligibility, comprehensibility, AEPI (Application), oral repetition task, time measurement.

Resumen

En este artículo se presentan y analizan nuevos medios para verificar y medir los constructos de 'inteligibilidad' y 'comprensibilidad'. Primeramente, presentamos una breve agenda de trabajos que contribuyeron con discusiones teóricas y empíricas sobre inteligibilidad y comprensibilidad (Munro & Derwing 1995; Munro & Derwing 2001; Derwing & Munro 2015; Munro & Derwing 2015; Nagle, Trofimovich & Bergeron 2019; Albuquerque 2019). Posteriormente, se presenta la aplicación AEPI (desarrollada por Bondaruk, Albuquerque y Alves 2018). Se trata de un programa de código abierto que no solo permite una medición más tradicional (tarea de transcripción) sino que también introduce nuevas variables a los estudios sobre inteligibilidad y comprensibilidad, al proporcionar una tarea de repetición oral y mediciones de tiempos de respuesta. Finalmente, se plantean y analizan el uso y las contribuciones de la aplicación AEPI a algunos trabajos de investigación (Alves, Albuquerque & Brisolara 2019; Salves, Wanglon & Alves 2020; Albuquerque & Alves 2020).

Palabras clave: Inteligibilidad, comprensibilidad, aplicación AEPI, tarea de repetición oral, medidas de tiempo.

Introduction

In the last thirty years, an agenda of studies has been trying to shed some light on pronunciation phenomena through the lens of intelligibility and comprehensibility studies (Derwing & Munro 2015). The most commonly adopted perspective of both constructs relies on the extensive list of contributions by Tracey Derwing and Murray Munro, who not only brought innumerous theoretical insights but also introduced a whole set of empirical measurements in the literature on the constructs.

Munro and Derwing (2015:14) define intelligibility as the "extent to which listeners' perceptions match speakers' intentions (actual understanding)," and comprehensibility as the "perceived degree of difficulty experienced by the listener in understanding speech." As these authors mention, intelligibility and comprehensibility should not be seen as completely different constructs but as complementary ones, since both represent a shared ability of both listeners and speakers. Moreover, intelligibility would be connected to a more objective measurement of the comprehension phenomenon, whereas comprehensibility could be seen as a subjective one, since it characterizes an impression of the listener's difficulty in understanding a speaker.

Taking into account a different view on the comprehension phenomenon, intelligibility has been traditionally measured through dictation tasks (orthographic transcription), comprehension questions, true/false sentences, among others, being most frequently approached via transcription tasks (Munro & Derwing 2015). In turn, comprehensibility is usually measured by using a Likert scale. As explained in Munro and Derwing (2015), comprehensibility tasks generally use a 9-point Likert scale (in which '1' indicates "very difficult to understand" and '9', "very easy to understand").

As Munro and Derwing (2015) mention, transcription may be considered an efficient way of measuring intelligibility, since the results can be easily compiled in a short amount of time. Although the above-mentioned means of measurement has been used by the authors since 1995, it has recently received some criticism. This is because some gaps seem to exist, considering the vague notion of what 'understanding' really means, the language conception underlying the construct, or its form of measurement. Lindemann and Subiterelu (2013) argue that some of the empirical results on intelligibility and comprehensibility research are more inclined to be indicating listeners' attitudes towards foreign L2 speech than actual linguistic information about production/perception processes. To some extent, this questioning seems to be present in Munro and Derwing (2001).

In addition, concerning the recent criticism on the measuring techniques, some concerns have been raised about the use of transcription as a tool. Zielinski (2006) points out that 'intelligibility' is a construct that involves an accommodation process between both speakers and listeners and that it should imply an ability that could be improved, modified, learned and (retro)feedbacked throughout time. Moreover, the author poses some criticism towards the use of transcription as a form of measurement alone, since it does not seem to present any data on where the lower scores of intelligibility may be, for example. Besides, according to Zielinski , an incorrect transcription may be related to other aspects that go beyond speech production issues, which may be connected to cognitive functions, such as difficulties memorizing statements, difficulties in accessing orthographic knowledge, distraction and other factors. Kang, Thomson and Moran (2018) also point out to a potential working memory overload effect and question whether the usage of this form of measuring might influence intelligibility results.

Departing from these considerations, recent works as Nagle, Trofimovich and Bergeron (2019) and Albuquerque (2019) propose a more dynamic perspective on the intelligibility and comprehensibility constructs. Albuquerque's perspective is based on a Complex, Dynamic Systems account (Beckner *et al*. 2009; De Bot 2017; Lowie & Verspoor 2015, 2019) and sees both constructs as follows:

> [They are] imbricated in a comprehension gradient, going through stages ranging from the processes of recognition/tuning, retrieval, and phonic and lexical processing, to semantic association and linguistic-cognitive accommodation (not necessarily following a linear order along this gradience). (Albuquerque 2009:121).

By taking a dynamic perspective into account, Albuquerque (2019) also proposes that both constructs should be operationalized by allowing listeners to reply with the content they could actually recover from the sentence heard, whether a sound, a group of sounds, full words or the whole idea, depending on the semantic content. Therefore, the author proposed complementary ways of measuring intelligibility: an oral repetition task and a response time measurement.

The oral repetition task is based on the linguistic and cognitive aspects previously mentioned, *e.g.* cognitive functions (Zielinski 2006; Kang, Thomson & Moran 2018) and criticism of the transcription tool (Zielinski 2006). Moreover, the time measurement[1] was set as an exploratory way of accessing participants' comprehension in a less subjective way, *i.e.*, both oral repetition task and Likert scale measurements could be considered more subjective measurements, since they are the outcome of meta-cognitive answers from the participants. The time spent to start producing what one heard could, in this sense, offer more accurate clues on the cognitive process involved in receiving information.

In view of these new methods to approach the constructs of 'intelligibility' and 'comprehensibility,' it was thus necessary to gather all the above-mentioned empirical settings in one electronic tool. Although there are some tools which could implement these measurements, they were not open-source apps or not so user-friendly. Given this scenario, Bondaruk, Albuquerque & Alves (2018) created AEPI (Perception and Intelligibility Application)[2] to be an open-source tool that could work not only with the oral repetition task, but also with both Likert scale and time measurements.

In this paper, we describe this new tool, its resources and applications. By doing so, we aim not only to invite researchers to start testing this new app, but also to discuss the need of alternative ways of testing the constructs of intelligibility and comprehensibility. AEPI's design and working procedure is described in the next section.

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[1] The time measurement for this study is understood as the time between the audio stimulus' end and the first interaction with the AEPI application, through the 'record button'. A more detailed description of the time measurements available in AEPI will be presented in the next section.

[2] Free software, available on http://aepi.e-pi.co. AEPI stands for "Aplicativo para Estudos em Percepção e Inteligibilidade" in Brazilian Portuguese.

AEPI: Designing a tool for Perception and Intelligibility measurements

AEPI was designed to meet very specific needs that had not been met by other software suits, as evaluated at the time. TP (Rato *et al*. 2015) closely met many experiment demands, but fell short of disposing a transcription space and the possibility of gathering other measurements on the same screen. On the other hand, although PsychoPy library (Peirce 2007) could meet these needs, it demanded a steep learning curve.

Since it was evaluated that creating an application from scratch would be easier than leveraging the existing tools, the Python language was chosen to build AEPI. Python is commonly used for scientific purposes because of its flexibility and high-level approach (*i.e.*, it permits abstracting lower layers of computing), as described by Oliphant (2007), and it met the experiment needs. Another design choice was to not use a setup or configuration window for setting up an experiment. As previously mentioned, the transcription task is a doubled-edged sword, *i.e.*, it is controversial in its positive and negative outcomes. Therefore, AEPI has two versions, one for transcription tasks, in which the participant hears a stimulus and transcribes what was understood, and the oral repetition task (labeled as 'recording version' in the app), in which the participant records his/her repetition of the stimulus. Both applications contain the following structure:

a) The audio folder, which contains the stimuli.

b) The results folder, which contains the experiment results.

c) The disc file, which contains the disclaimer shown to the participant when the application starts. It usually contains the experiment instructions (which can be customized according to each experiment).

d) Test.kv, which is the graphic interface configuration file.

e) The executable file that runs AEPI.

This structure can be seen in **figure 1**.

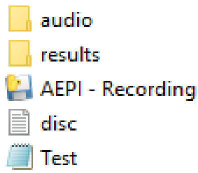

Figure 1. AEPI Setup (Source: the authors)

Setting up the experiment should follow three simple steps.

1- Download AEPI from http://aepi.e-pi.co.
2- Extract files from AEPI.
3- Add the stimuli to the audio folder as .wav files.
4- Update the Disc.txt with the experiment instructions.
5- Run the executable file (.exe).

Once the application is started, one should see the screen as shown in **figure 2**.

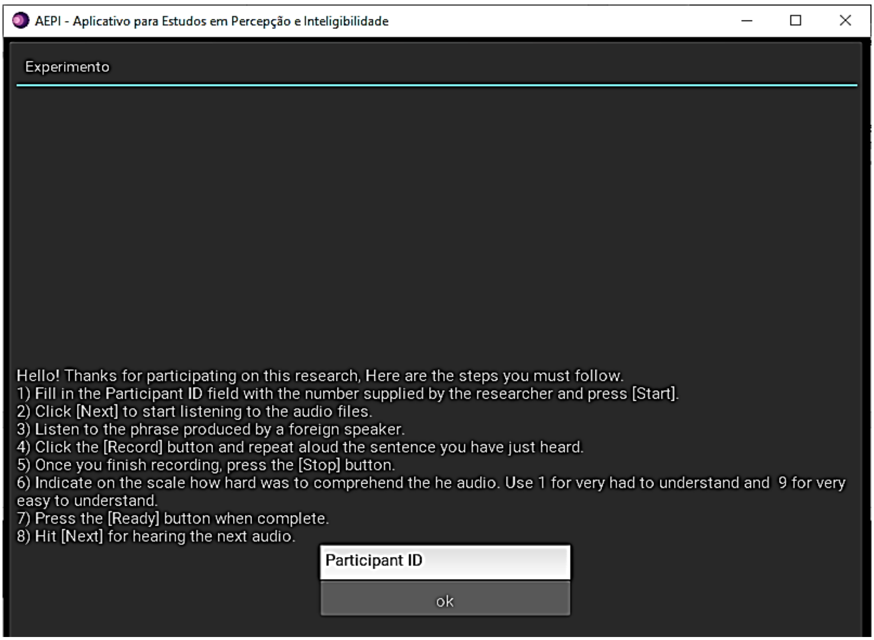

Figure 2. AEPI First Screen (Source: the authors)

The 'participant ID' field is used for identifying the participant and once the 'ok' button is clicked, the experiment will start. The textual information on the screen is set up by the researcher, who should provide information on the experiment by updating the disc.txt file, as said above.

Figure 3 shows what the transcription version looks like.

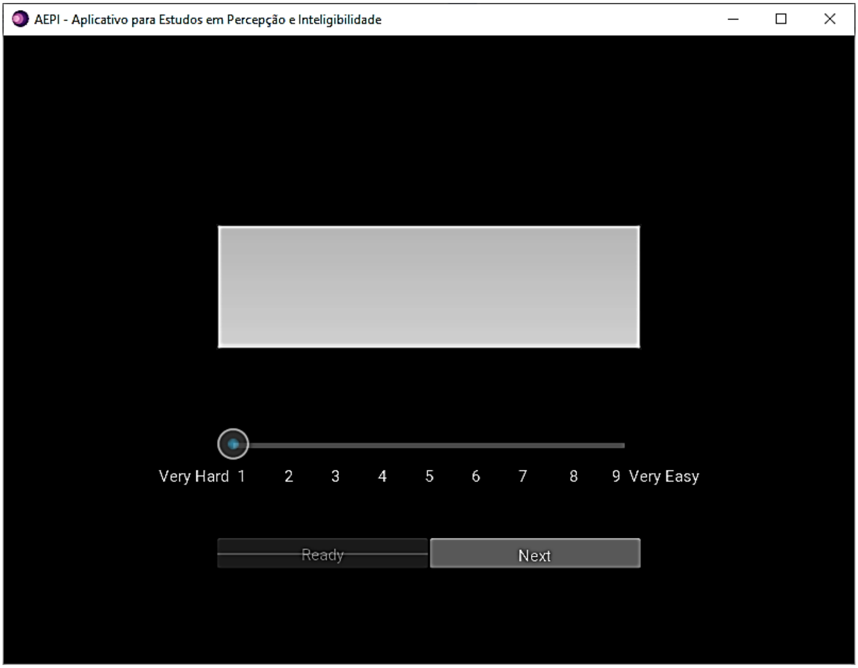

Figure 3. AEPI Transcription task screen (Source: the authors)

Alternatively, the oral repletion task (recording version) can be seen in **figure 4**.

On both versions, participants will click on the 'next' button to hear the stimulus and then either transcribe or record what they understood. On the recording version, participants need to click on the 'stop' button to stop the recording. Afterwards, they evaluate comprehensibility on the Likert scale and hit 'ready' to finish the evaluation of the stimulus. In order for participants to move to the next stimulus, they have to click on the 'next' button.

For the transcription version, the transcribed text will be stored on a .csv file on the root folder. As for the recording version, AEPI will create a folder labeled 'Results_participant ID' and store the recorded audios within it, enabling the researcher to evaluate the participant oral comprehension.

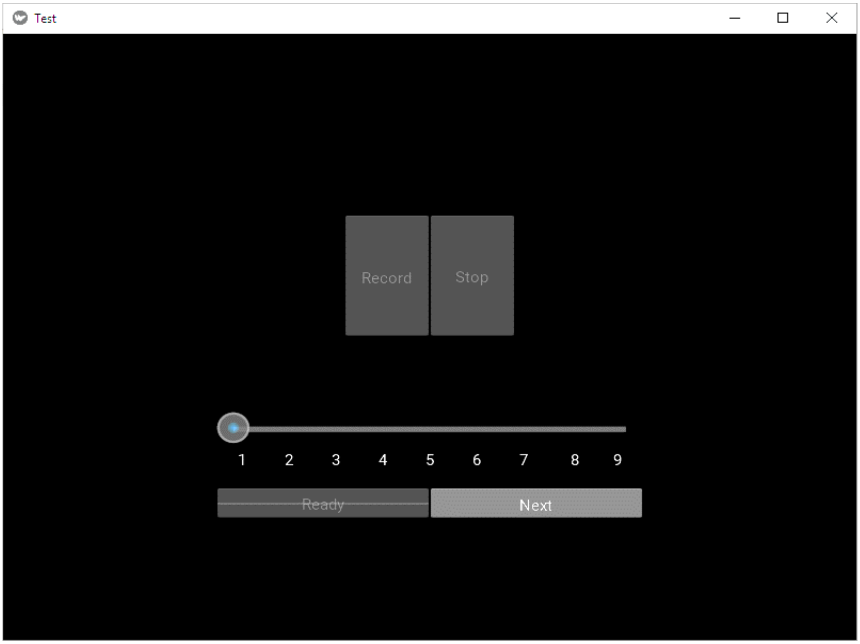

Figure 4. AEPI Recording (Source: the authors)

After the participant listens to all stimuli (both in the transcription and recording versions), the collected data is stored on a .csv file. **Table 1** and **table 2** exemplify this file.

Table 1. Data collected with AEPI to the transcription task

Audio	Likert	Decision Time	Audio Length	Total time	Transcript
Exemplo1.wav	4	5,902	2,495	9,843	Transcript text
exemplo2.wav	5	4,992	2,417	10,403	Transcript text
exemplo3.wav	1	4,996	3,437	10,763	Transcript text

Table 2. Data collected with AEPI to the recording version

Audio	Likert	Decision Time	Audio Length	Total time
Exemplo1.wav	4	5,902	2,495	9,843
exemplo2.wav	5	4,992	2,417	10,403
exemplo3.wav	1	4,996	3,437	10,763

In both Tables, the first column contains the name of the file that contains the stimulus, followed by the Likert scale value.

As previously mentioned in the first section, so that more accurate cognitive measures could be added, a time measure was implemented. The time measurements in AEPI are defined as follows:

a) Decision time: it is the time elapsed between the beginning of the stimulus and the first interaction with the app. As for the transcription task, 'interaction' means the first click on the text box (*i.e.*, the participant starts transcribing) and, for the oral repetition task, this is when the participant hits the 'record' button. When the participant hits 'next', the clock starts and the stimulus is played. The time (in seconds) of the next interaction with the app is recorded and stored in the decision time column. The interaction measured by the decision time varies based on the AEPI version:

   (i) The transcription version will time the first click on the text box, as the participant needs to click it before he/she can start transcribing.

   (ii) The oral recording version will time the click on the 'record' button.

b) Audio length: it is the length of the audio stimulus. It is a measure of the stimuli file itself. That said, the stimuli must be adequately edited to trim any silence period, whether in the beginning or at the end of the stimulus, as it can play a role in the experiment results.

c) Total time: it comprises the whole stimulus' time, *i.e.*, from the moment the participant starts listening to the stimulus to the moment when the 'ready' button is clicked. When the participant hits the ready button, the total time is recorded.

Figure 5 illustrates the different time measurements in AEPI.

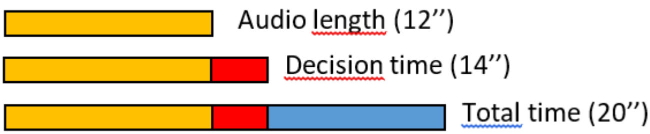

Figure 5. Time measurements in AEPI (Source: the authors)

The Audio length from the Decision time should be excluded, but note that a negative value is possible, and that means the participant started typing/recording before the audio finished playing. In this case, the researcher must decide how to treat those cases according to his/her investigation goals.

Using AEPI in research studies

As described in the previous sections, AEPI allows users to test intelligibility in a traditional way (transcription) as well as employ other data collection methods, such as oral repetition tasks. AEPI also introduces a new variable to the studies on intelligibility and comprehensibility by providing a record of decision times.

Though AEPI was developed only two years ago, some studies carried out in our research group have already tested some of the app functions. In this section, we review three studies that have tested some of these functionalities. In Salves, Wanglon and Alves (2020), the transcription tool was employed to obtain intelligibility data. In turn, in Alves, Albuquerque and Brisolara (2019), the oral repetition tool was employed to test intelligibility. Finally, in Albuquerque and Alves (2020), the analysis of response times provided some new insights to the theoretical conceptualization on intelligibility and comprehensibility. Therefore, in this section, in describing the methodology and main findings of each of these studies, we aim to discuss the implications of the new testing methodologies (oral repetition and response times), made available by AEPI, to the theoretical discussions on intelligibility and comprehensibility.

In Salves, Wanglon and Alves (2020), the authors adopted a more traditional data collection procedure by using sentence transcriptions to collect intelligibility data and a Likert scale[1] for obtaining comprehensibility scores. Following a Complex, Dynamic Systems account (Beckner *et al*. 2009; De Bot 2017; Lowie & Verspoor 2015, 2019), the authors investigated the effect of familiarity with Brazilian-accented English (L2) in the intelligibility of speech samples when judged by native English listeners. Oral data in English had been obtained from five Brazilian learners, who were enrolled in the English II course (A2 level of proficiency) in the English Teaching major from Universidade Federal do Rio Grande do Sul (UFRGS), Brazil.

The Brazilian students who participated as speakers were given four topics to choose from (based on Cruz and Pereira 2006) and were asked to speak freely about two of them. After that, the researchers listened to all recordings and searched for deviations that could affect intelligibility. Thirty-five sentences (average: 11 words each) were selected. From these sentences, one was chosen as the test sentence ("Ok, I chose the culture subject," pronounced as [oʊkei aj tʃoʊs (.) ʌ (.) di 'kjutʃʊʳ (.) subi'ʒɛktə]). This sentence was played in all the longitudinal recordings. All the other sentences were used as distractors throughout the longitudinal testing phases.

The group of British listeners was comprised of four female undergraduate students who had been living in Brazil for a very short period of time and had little previous exposure to Brazilian English. They all participated in

[1] It remains to be said, however, that the data on comprehensibility are still being analyzed and are going to be published in a future paper.

weekly intelligibility transcription tasks, administered over the course of five weeks. In these sessions, each participant listened to ten out of the 35 sentences, with the target sentence being played to all British participants in all sessions. By providing nine different distractor sentences, the authors aimed to make sure that participants did not realize or remember the sentence they were being tested on.

In view of the dynamic account adopted in the study, the authors carried out both group and individual analyses on the rate of intelligibility of the target sentence in the five longitudinal data collections. The results confirmed the original hypothesis that the listeners' growing familiarity with Brazilian English had an effect on their intelligibility scores. As for the group scores, a rise by about 8% was found from the first to the fifth session of data collection. In turn, these analyses suggested that the individual learners' trajectories are not linear, as falls and plateaux were found in some individual longitudinal data.

As for the use of the AEPI application, it proved appropriate in allowing for a sentence transcription task on a computer, avoiding a more traditional pen-and-paper version of the transcription tasks. The results in Salves, Wanglon and Alves (2020) were innovative in providing longitudinal analyses of intelligibility, focusing on an increased listener experience with L2 speech. In this study, however, intelligibility data were collected through a traditional method, *i.e.*, sentence transcription, and were rated through a word count of correct transcriptions.

The transcription method employed in the aforementioned study contrasts with that adopted in Alves, Albuquerque and Brisolara (2019)[1]. In this article, by making use of AEPI, the authors propose an oral repetition task in order to collect intelligibility data. In other words, instead of transcribing what they had heard, listeners were invited to say the sentence again; in case they did not understand all of the words, they were encouraged to rephrase what they had understood. According to the authors, this

[1] As mentioned in the Introduction, this method of data collection was proposed in Albuquerque (2019).

methodology should be preferred in intelligibility studies because (i) it tends to simulate a real interaction, in which at many times the hearer has to confirm what has just been said by a clarification request or a recast; (ii) unlike transcription tasks, it does not demand a heavy working memory load (Kang, Thomson & Moran 2018); (iii) it allows listeners to use oral compensation strategies to explain what has been understood from the message. In other words, the authors claim that this sort of task allows listeners to express what they had actually understood from the speech sample.

The stimuli in the study had been obtained from six native speakers of Spanish learning Brazilian Portuguese (L2), who had been living in Brazil for no longer than a year[1]. They were asked to record their readings of six sentences (eight words each), in which they explained their everyday life and their opinion about living in Brazil. These sentences were presented to 30 Brazilian listeners with no previous experience with Spanish or Spanish-accented speech.

As for the rating of intelligibility scores, Alves, Albuquerque and Brisolara (2019) proposed that the oral sentences in which participants did not repeat the original sentence word-for-word, but expressed their understanding of what had been said, should count as 'fully intelligible sentences.' This is suggested in view of the authors' discussion on what is implied by the term 'understanding' in most traditional definitions of the construct (Munro & Derwing 1995; Derwing & Munro 2015; Munro & Derwing 2015). With this in mind, the authors verified the listeners' intelligibility rates under both the traditional (word count) view and this new format. The authors show that, with this new method on counting correct responses, 10 of the 19 sentences that did not exhibit 100% of accuracy rates in the previous counting of correctly transcribed words were considered to be fully intelligible. With this new method, speakers were

[1] These learners were originally from different countries in Latin America, such as Venezuela, Peru, Honduras, Colombia, Ecuador and Mexico.

able to make use of other words/expressions in order to express the idea conveyed by the speakers.

By raising this issue, Alves, Albuquerque & Brisolara (2019) conclude that the oral repetition task provides listeners with a greater amount of freedom so that they use other words or expressions in order to compensate for the single words they have missed. Moreover, the task also allows listeners to employ a larger amount of top-down strategies in order to recover some (synonym) words that eventually might have been lost. More studies testing this methodology, which was made possible with the aid of AEPI, are therefore necessary.

Finally, in addition to employing a word-repetition task and rating comprehensibility scores, in Albuquerque and Alves (2020) the decision times (the time span used for listening to the sentence and starting to repeat it) were also taken into consideration. In this exploratory study, the authors aimed to verify if this new testing measure would correlate with either intelligibility or comprehensibility scores. The motivation for using this new measure was grounded on the recognition that comprehensibility scores, which are based on Likert scales, tend to be rather subjective. It might be the case that response times could represent a clearer, less subjective measure of comprehensibility.

Fifty-seven Brazilian students who played the role of listeners took part in the study. They were assigned to one of the three groups of the study, according to their experience with a foreign language: (i) Group 1: 16 monolingual listeners; (ii) Group 2: 20 Brazilian learners of French (L2); (iii) Group 3: 21 Brazilian leaners of English (L2). With these three groups, the authors aimed to investigate if experience with an additional language could have an effect on intelligibility (word repetition), comprehensibility (Likert Scale) and decision time scores.

All participants listened to 20 sentences (from 8 to 10 words) produced by 2 Haitian learners of Brazilian Portuguese who had been living in Brazil for no more than a year. It was hypothesized that participants in Group 2, who were acquainted with the French language, would find it easier (higher intelligibility rates; better comprehensibility; shorter decision times) to understand the learners' accented speech. Group 3 was expected to come next, as its participants were not acquainted with French, but were used to listening to accented speech due to their L2 learning experience. Monolingual speakers, then, were expected to have more difficulties in understanding accented speech, as well as show lower comprehensibility rates and longer decision times.

The results of the study, however, did not confirm all the hypotheses. Group 3, instead of Group 2, presented the best results of intelligibility and comprehensibility. As expected, Group 1 showed the worst intelligibility and comprehensibility rates. As for the decision times, no correlation was found between this variable and intelligibility or comprehensibility. Finally, despite showing the highest intelligibility rates, participants in Group 3 surprisingly showed the highest response times among the three groups.

In view of these results, Albuquerque and Alves (2020) suggest that a larger response time does not necessarily imply greater difficulty in understanding speech. Rather, it might imply the use of different cognitive strategies in dealing with the understanding of oral speech. It might be the case that participants in Group 3, though having had fewer difficulties in understanding accented speech, took longer to repeat the sentences because they made use of top-down cognitive strategies that allowed them to "recover" words whose perception was difficult. In turn, participants in the other groups did not use such strategies and simply gave up when confronted with unintelligible words. Albuquerque and Alves (2020) therefore suggest that "decision time" corresponds to a variable in itself, which does not necessarily correlate with or is equivalent to intelligibility or comprehensibility.

In sum, the three studies discussed above have addressed the constructs of 'intelligibility' and 'comprehensibility' through different methodological approaches. The use of these different methodologies is the result of distinct ways of conceiving these constructs. All these implementations were made possible with the use of the AEPI app, which opened new avenues for different data collection methodologies as well as new theoretical discussions.

Final remarks

In this paper, we discussed new means of addressing, testing and measuring the constructs of ‘intelligibility’ and ‘comprehensibility.’ We have also presented AEPI (http://aepi.e-pi.co), a free software meant for conducting experiments in intelligibility and comprehensibility. This new software allows for both traditional (transcription) and more innovative methodologies of data collection, such as oral repetition. In addition, the software provides a new measure of decision times. This last measure, according to recent studies (Albuquerque 2019; Albuquerque & Alves 2020), has proved to represent a different construct in explaining listeners’ strategies when dealing with accented speech. The results in these studies show that AEPI allows for a new way of testing and quantifying intelligibility and comprehensibility, as well as shed some light on the conceptualization of these constructs.

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