Association between allophonic transcription tool use and phonological awareness level

Kacper Łodzikowski, Adam Mickiewicz University, Poznań

Abstract

This is the first paper that provides correlational evidence about how interacting with an online allophonic transcription tool helps learners of English as a Second Language (ESL) to improve their phonological awareness. The study investigates 55 advanced ESL learners at a Polish university enrolled in a course in English phonetics and phonology. The course placed heavy emphasis on reading and writing allophonic transcription based on the International Phonetic Alphabet. Apart from obligatory practice with traditional pen and paper worksheets, learners could also practise with a supplementary custom-designed web application that allowed them to enter the phonemic transcription of any word in order to receive its allophonic transcription. The results show that using this tool at least once during the course is associated with an expected increase in midterm test score of 5.03 percentage points, 95% CI [-10.61, 20.67]. The estimated benefit is higher for learners who space their usage of the tool; each additional distinct day of usage is associated with an additional increase in the expected midterm test score of 2.62 percentage points, 95% CI [-3.25, 8.49]. Additionally, some learners practised transcription on non-words, and these learners were observed to perform better on phonotactics-related assessment.

Keywords: Computer Assisted Pronunciation Teaching, IPA Transcription, Learner Autonomy, Learning Analytics

Language(s) Learned in This Study: English

Introduction

Challenges in Pronunciation Instruction

Discredited since the 1970s, pronunciation instruction in the context of English as a Second Language (ESL) acquisition has returned to favour towards the end of the century (Pennington, 2015). Over the following two decades, a growing body of research has shown which pronunciation features should be prioritised at the segmental level (e.g. Jenkins, 2000; Munro & Derwing, 2006; Gao & Weinberger, 2018) and at the suprasegmental level (e.g. Munro, 1995; Rogerson-Revell, 2012, 2014).

Despite these advancements, the teaching of pronunciation to ESL learners is still of secondary importance because the curriculum is traditionally dominated by other aspects of the English language and instructors do not have the proper training and resources (Pennington & Rogerson-Revell, 2019). This is especially a challenge for non-native ESL instructors who lack the confidence in their pronunciation skills (Bai & Yuan, 2019). And even when non-native instructors report that they are comfortable with teaching pronunciation, observations show that their teaching is rather simplistic and reactive (Buss, 2016). This is echoed by research into the instruction of other languages, such as French and Spanish (Huensch, 2018).

Role of Phonological Awareness in Facilitating Pronunciation Instruction

Traditionally, pronunciation instruction would encompass implicit exposure to speech and explicit

pronunciation drills. Most recently, a new strand of research and practice has focused on supplementing that with training in phonological awareness, such as the knowledge of how the phonological system of English as the target language is different from the phonological system of the learner's native language (Wrembel, 2005). The underpinnings of this approach can be traced to theories of second-language perception, such as Best (1995), in which the central element is the interference between the two systems, and the resulting challenges in the perception, and therefore also the pronunciation, of target language sounds.

One way of developing phonological awareness is by practising transcription based on the International Phonetic Alphabet (IPA). It is a skill that helps to consolidate various aspects of declarative phonological awareness and practical pronunciation ability (Mompean, 2017). Perhaps its main benefits are that it can help learners better understand the English phonological system (in comparison to their native system) and make them more aware of issues with spelling-to-pronunciation correspondence (Mompean & Lintunen 2015). The less-detailed phonemic transcription seems to offer the best return on investment for beginner and intermediate learners who would like to work on segmental errors that impact intelligibility, for example, substituting consonantal phonemes (Gao & Weinberger, 2018). The more complex allophonic transcription is a better choice for advanced learners, such as the participants in this study, who want to work on the less salient features, such as aspiration of fortis plosives or word-initial epenthesis, in order to sound more native-like on top of being intelligible.

The link between transcription and ESL learners' phonological awareness is substantiated by research on native speakers of English in the context of communication disorders. For example, Robinson et al. (2011) showed that a pre-test of phonological awareness can predict native speakers' difficulties in learning transcription, and Werfel (2017) showed that native speakers improved their phonological awareness after completing a transcription course.

Computer-Assisted Transcription Training

Despite all its benefits, transcription is still a rare teaching technique. This is partly because many teachers do not have the time needed to prepare engaging transcription exercises. Moreover, many learners get bored by the lack of variety or frustrated by the lack of feedback (García Lecumberri, Maidment, et al., 2003). As such, transcription is a great candidate for benefitting from automation through the use of computer software.

The best example of an automated transcription tool designed for second-language acquisition is the Web Transcription Tool prototyped as a desktop application by Cooke et al. (2001). It was subsequently redesigned as a web application by García Lecumberri, Cooke, and Maidment (2003) and further improved in García Lecumberri, Maidment, et al. (2003). The tool contains phonemic transcription exercises for English, Spanish, Swedish and Romanian. It also supports selected connected speech processes and tries to provide learners with relevant feedback. The complexity of the tool requires the instructor to provide a reference transcription for each exercise. A notable mention is Jensen (2005); while it is not a transcription tool per se, it includes a variety of freely available simple transcription-related activities.

Teachers and learners who would like to use allophonic transcription instead of phonemic transcription do not have much choice. Several free transcription tools are available online, but they only offer transcribing spelling into phonemic transcription. Some of them offer a limited selection of allophonic processes, for example, checking the transcription of 'salt' would show velarisation but not pre-fortis clipping. One could again turn to the field of communication disorders, where several systems were prototyped that combine perception tasks and allophonic transcription (e.g. Bruijn et al., 2011; Bates et al., 2010). However, the former tool is not freely available, and the latter covers only selected allophonic processes. Since none of the freely available tools were appropriate for automated practice of single-word allophonic transcription, this study relies on a custom tool (Łodzikowski & Aperliński, 2016).

The Study

Purpose

This study answers two research questions. First, how do advanced ESL learners use a supplementary allophonic transcription tool? Second, how is the usage of the tool associated with learners' level of declarative phonological awareness?

Tool Design

Figure 1 shows the transcription tool used in this study. It is a simple web application written in HTML5 and hosted at a university server. The logic of the application is based on conditional statements that reflect the rules of selected allophonic processes (e.g. a sound categorised as a vowel should undergo pre-fortis clipping if followed by a sound categorised as a fortis consonant). The descriptions of those rules were obtained from English phonetics and phonology textbooks, such as Cruttenden (2014), that formed the curriculum of the present course. Understandably, these textbooks are meant to give a broad descriptive overview of English speech, so the rules may be overgeneralised.

Figure 1. Example input entered into the transcription tool.

Note that the tool does not evaluate if the input is correct. If a learner enters a sequence of symbols that does not correspond to an actual word, for example <ðpt>, the tool will still provide an output that observes the phonetic rules for actual English words, for example [ð̥p̚t]. Similarly, if the learner enters the spelling form of a word, for example <neat>, the tool will incorrectly treat it as the phonemic form and provide

[neaʔt] instead of [niˑʔt].

Institutional Context

The transcription tool was implemented as part of a blended-learning course in English phonetics and phonology taken by first-year students of English Studies at a Polish university. This obligatory course, which aims to increase learners' phonological awareness, was offered alongside a four-semester practical pronunciation course that focuses on implicit exposure and drilling. The programme curriculum goes beyond intelligibility and focuses on achieving near-native pronunciation.

The English phonetics and phonology course was conducted in a flipped classroom manner (i.e. the learners were asked to watch an instructional video and complete close-ended activities before showing up to class). Each week of the course covers a different topic. The first semester focused on the speech chain, the English phonological system and allophonic variation, and the second semester focused on connected speech processes and prosody. The course started in early October and ended in mid-June. The learners received access to the transcription tool in December, when the topic of allophonic transcription was first introduced. While transcription homework was obligatory, the use of the tool was voluntary. And while the learners were encouraged to use it, no particular pedagogical guidance was given, other than the instructions in Figure 1.

While 70 learners were given access to the tool, the study focuses on the 55 learners who did not drop out before reaching the midterm test in the second semester. The learners were on average 20 years old, and 41 of them were females.

Data Collection and Cleansing

The transcription tool contains a built-in data collection mechanism: A snippet of JavaScript tracking code executed by the user's browser. Whenever someone visits the tool or clicks on the Submit button to request allophonic transcription, their browser sends a tracking message to a server running a free analytics application Piwik (Aubry, 2014). The Piwik database logs an event containing the following metadata: visit timestamp and duration, entered text (input), device information (e.g. screen resolution), and additional user information (e.g. approximate geographical information). Because the tracking code is executed by the browser, a small amount of errors is to be expected, for example, a visit is not logged if someone visits the tool and the browser window is closed because the browser crashes before the tracking script is executed.

A separate process was used to identify learners across visits. This required an orchestrated onboarding of learners, so that their first visit to the tool was made from Moodle. A link to the tool was put on the Moodle course homepage, and a message was sent to each learner encouraging them to start using the tool. When a learner clicked on the link, Moodle passed that learner's unique identification (Learner ID) to the tracking code sent to Piwik, which assigned that Learner ID to its own unique tracking identification (Visitor ID), and then asked the browser to store that Visitor ID in a cookie. As a result, even if that learner made subsequent visits to the transcription tool directly (e.g. by bookmarking the address), he or she had the same Visitor ID. If the learner cleared browser cookies, the relationship was re-established the next time the learner visited the tool from Moodle. In the meantime, Piwik guessed the visitor by device fingerprint (e.g. device type, operating system, screen resolution, browser type and plugins, IP address, etc). The risk of cookie loss means this data collection method is not infallible. However, it provides a good balance of reliability and ease of use, compared to adding an extra sign in screen. Moreover, an exploratory analysis of the log data did not reveal any patterns suggesting that learners were misidentified. For example, everyone who accessed the tool from a new device did it from Moodle, which established the relationship between Learner ID and Visitor ID, and which created the device fingerprint. Furthermore, in the accompanying demographic survey, all learners stated that they owned a personal computer or mobile device, so it is unlikely they used a public computer for homework. It is similarly unlikely that they frequently cleared browser cookies because that would require them to repeatedly sign into Moodle and possibly other web services like social media or email. One unavoidable scenario of misidentified transcriptions would be if one learner shared a personal device with another learner, for example during

classroom pair work.

Expectedly, the online log data collected for this study required some pre-processing. Based on summary statistics, a number of outlier entries were identified and examined. For example, 16 visits with legitimate inputs showed a duration of 0 seconds. After a careful inspection, these tokens were interpreted as legitimate, and they were included in the analysis. Other outliers were entries that contained phrases instead of single words. This is probably because some learners wanted to use the transcription tool for practising connected speech processes, which it does not yet support. These entries were excluded from the analysis. The data cleansing and subsequent modelling was done in R (R Core Team, 2018) and RStudio (RStudio Team, 2016). The data and code that generated the findings are available at bit.ly/phontrans_analysis. The source code for the transcription tool is available at bit.ly/phontrans_webapp. Please note that deploying the app to a server requires software engineering skills, so most teachers will need to ask their school IT administrator for assistance.

Findings

Transcription Study Patterns

Of learners who were given access to the transcription tool, 91% visited it at least once. Of those learners, about 51% visited it five or more times, and about 16% more than ten times. The learners entered a total of 3,119 inputs over the course of 312 visits. The median number of inputs per visit was four (1st quartile = one; 3rd quartile = 12). The median duration of a visit was about 8 minutes (1st quartile about 1 minute; 3rd quartile about 23 minutes).

Figure 2 shows the distribution of visits across the period from when the transcription tool was made available midway through the first semester (December) until the end of the second semester (June). Overlaid are the dates of selected assessments relevant to this study. In the first three post-class quizzes and the midterm test, phonemic transcriptions of words were provided, and learners needed to mark the relevant allophonic processes. The activity type and rubric were the same as in classroom practice, but the examples were different. The midterm contained additional transcription activities (e.g. the learners needed to choose the correct allophonic transcription out of three provided—example: 'crude' [kɹuːd̥], *[kʰɹuˑd̥], *[kɹʉˑd̥])— or the learners needed to correct the provided phonemic transcription of a word—example: 'throughout' given as */θruwˈaʊt/). The words did not appear in previous practice or quizzes. The final assessment relevant to this study is the post-class quiz on phonotactics. Learners needed to decide if five non-words were acceptable from the point of view of English phonotactics, and justify their decision (e.g. /skrɔː/ is a licit onset because it occurs in a word such as 'screen')

By examining Figure 2 from the left, we see spikes in visits to the tool in December and January, around the dates of the three quizzes. We then see that learners continued practising with the tool between late February and early March, even though the topics covered during that period (connected speech processes and weak forms) required only phonemic transcription. This could be because allophonic practice helped the learners understand the connected speech concepts or, more likely, because they wanted to continue practising allophonic transcription before the midterm test in April. The midterm was also preceded by a spike in visits. Most of the longer periods of inactivity are due to holidays.

Figure 3 shows that about 9% of visits were made from mobile devices (of which just one was from a tablet), and that these usually occurred during the day. Most likely, this activity was generated by learners who used the tool in the classroom. Desktop visits were made mainly in the evening, and some learners studied well into the night. We do not show another interesting segmentation, namely that some learners visited the tool relatively regularly, while others visited it only a couple of days before assessment.
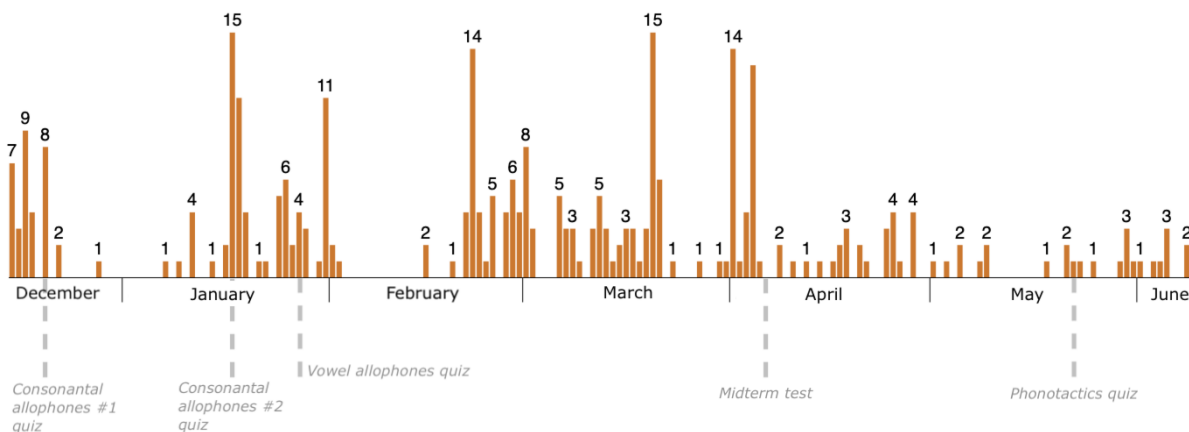
Figure 2. Course-wide distribution of learners' 312 visits to the transcription tool. Note that one learner could make more than one visit per day, so the first bar on the left represents a total of seven visits made by a total of six learners (not shown).
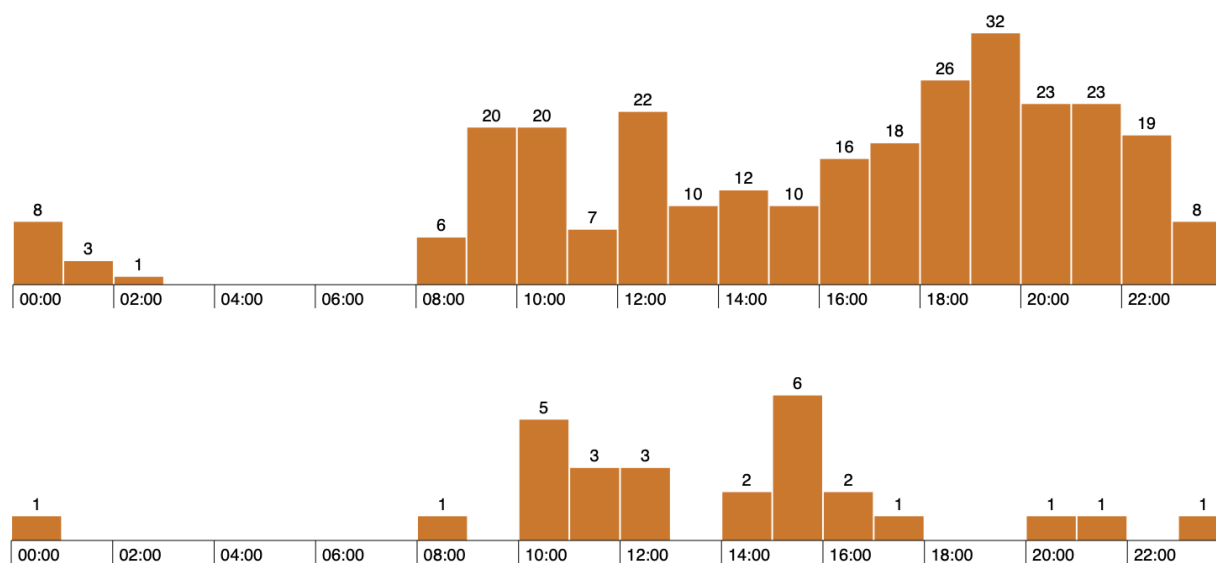

Figure 3. Distribution of times of day at which learners visited the transcription tool from desktop browsers (top) and mobile device browsers (bottom). For clarity, the figure shows all 312 visits overlaid on one chart, i.e. as if they occurred on one day.

Of the 3,119 inputs, 68 were non-words written in phonemic form. The remaining inputs were mainly words written in their phonemic forms, and some words written in their spelling forms. Words in their phonemic forms were manually mapped to their spelling forms, so that summary statistics could be calculated. This was done for two reasons. First, some words were over-represented because learners entered the same word multiple times, either by accident or to see how the resulting allophonic transcription looks with different settings enabled (e.g. with or without glottal reinforcement of /t/ and /tʃ/). Second, some words were written using the standard (Gimson's) IPA scheme for English (so that 'bet' is transcribed as /bet/) and some using

a modified (Upton's) IPA scheme (so that 'bet' is transcribed as /bɛt/). While the former scheme is required of the learners in the phonetics course, some of the materials used by the learners in the practical pronunciation course may have used the latter scheme. The mapping to spelling showed that out of the 3,051 word inputs, 1,105 were distinct words.

The 15 most frequently entered words account for 10.29% of all entered words. These are: 'potential' (1.57%), 'cute' (1.21%), 'twelfth' (0.72%), 'grandchild' (0.69%), 'alcohol' (0.66%), 'bead' (0.66%), 'love' (0.59%), 'be' (0.56%), 'beat' (0.56%), 'guilty' (0.56%), 'spoilt' (0.52%), 'supermarket' (0.52%), 'pat' (0.49%), 'rescue' (0.49%), 'try' (0.49%). Many of the 50 most frequently entered words appeared on in-class transcription worksheets. On the one hand, this is a positive surprise because it shows that the learners used the tool for the reason it was designed (to supplement out-of-class practice in the phonetics course). On the other hand, after each class the learners always received the worksheet answer key anyway, so using the transcription tool mainly to check answers to worksheets is a rather limited use.

Association Between Tool Use and Phonological Awareness Level

We will construct a linear regression model that predicts a learner's midterm test score based on that learner's usage of the transcription tool. Observations following the test date (April) were excluded. The control variables included sex and prior achievement (scores from written and oral Matura, i.e. secondary school final exam). Initially, group was added as a random variable but then it was removed because it did not explain any more variance. Figure 4 visualises the model's fixed effects. While all associations are rather weak ($R^2 = 0.56$), three of them are worth noting. First, learners who visited the transcription tool at least once were observed to score higher on the midterm test by 5.03 percentage points, 95% confidence intervals [-10.61, 20.67], after controlling for sex and prior achievement. Second, while the total number of visits to the tool showed, unexpectedly, a slightly negative association with midterm scores, it seems that the spacing of the visits was more important. This was measured by looking at distinct days of visit, e.g. visiting the tool once on Monday and once on Tuesday yields a higher number of distinct visit days than visiting it twice on Monday. We see that each additional distinct visit day is associated with an increase in the expected midterm test score of 2.62 percentage points, 95% CI [-3.25, 8.49]. Third, each additional second spent during an average visit is associated with an increase in the expected midterm test score by 0.01 percentage points, 95% CI [-0.00, 0.01]. While this may seem small, note the average visit duration was 14 minutes and 34 seconds. Another explanation for the rather weak model fit is that some learners used the transcription tool in the expected way (entering legitimate transcriptions from worksheet examples) but did not show the expected improvement because their overall course performance was at the bottom quartile of the class, possibly due to their overall low ability or aptitude.

We will now discuss one unexpected finding. The analysis of the transcription tool logs showed a creative use of the tool, namely entering non-words. The context for this is that when the learners first started studying allophonic processes, they were advised to practise marking those processes on non-words. The reason for that was that such practice could help reinforce the learners' intuition about the fact that the presence of a phonetic process depends on the phonetic composition of a word (e.g. a consonant cluster will likely involve a change in how the consonants are released). It is unclear, however, why some learners wanted to transcribe the non-words. The transcription tool is agnostic of phonotactic constraints, and it does not give any feedback regarding licit and illicit onsets and codas. Most of the non-words came from the practice worksheet for the phonotactics course topic.

To further investigate this behaviour, a linear model similar to the one in the previous paragraph was built, with the difference that the outcome variable is the phonotactics quiz score, and a new variable was added indicating whether a learner entered three or more non-words over the course of using the transcription tool. The threshold was chosen arbitrarily based on the distribution of the data. While this model showed a weak fit ($R^2 = 0.3$), it predicted an increase in the phonotactics quiz score of 31.15 percentage points, 95% CI [-13.06, 75.36], for those learners who entered a total of three or more non-words. This could mean that those learners who obtain an understanding of allophonic processes have a more intuitive understanding of which combinations of sounds are licit and which are not. This incidental finding is important in the light of Gao

and Weinberger (2018) who showed that syllable-level errors such as illicit elision of plosive in phrases such as 'ask her' are an important source of accented speech.
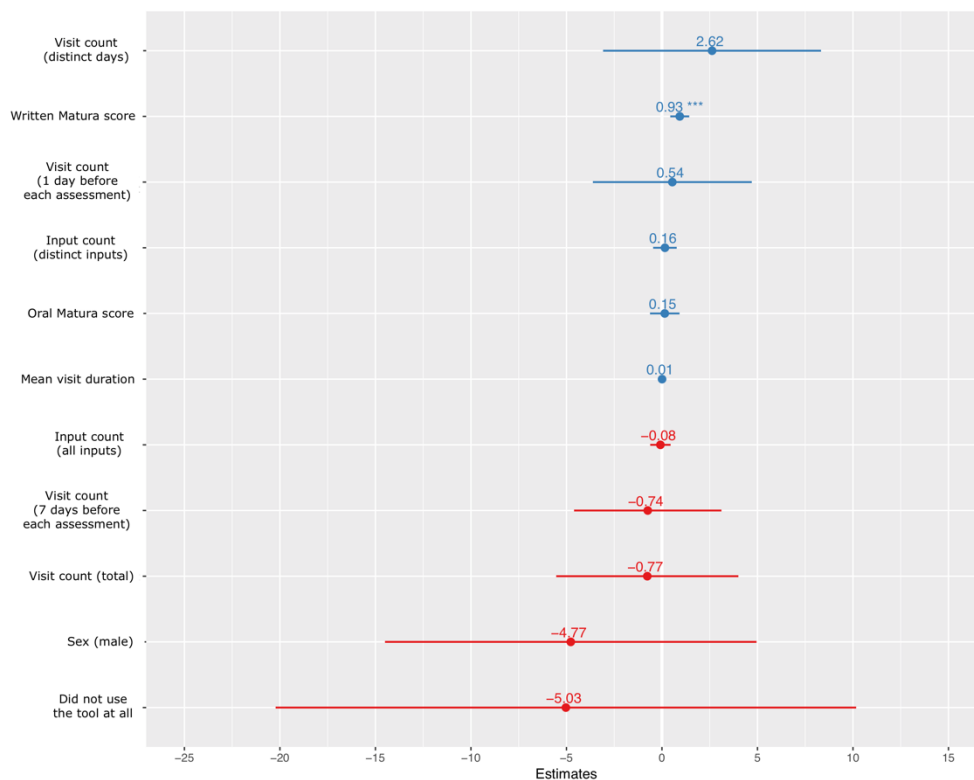

Figure 4. The association between midterm test score and transcription tool usage. Whiskers show 95% confidence intervals. The bottom fixed effect shows the estimated decrease in midterm test score for learners who did not use the tool.

Conclusion

Summary of Findings

This work is a practical investigation of ideas posed by previous researchers who pointed to studying IPA-based transcription as one of the best ways to improve learners' phonological awareness. Undergraduate students of English studies at a Polish university were given access to a custom-designed IPA-based allophonic transcription tool to supplement a two-semester course in English phonetics and phonology. Based on a linear regression model, for the 91% of learners who visited the transcription tool at least once, we estimate an expected increase in the midterm test score of 5.03 percentage point, 95% CI [-10.61, 20.67]. Moreover, we observed that the total number of visits to the tool is less important than the self-regulated spacing of those visits; each additional distinct day with a visit was associated with an increase in the expected midterm test score of 2.62 percentage points, 95% CI [-3.25, 8.49]. Additionally, we saw that some learners used the transcription tool for entering non-words, which could help them in grasping the rules of English phonotactics, although this association is weak and needs further investigation. Due to the limitations of this observational study, the claims presented here are associative and directional rather than causal and definitive.

Implications

While the transcription tool described here was borne out of necessity, this research was conducted out of curiosity, and it is reported here in the spirit of highlighting the role of IPA-based transcription in ESL

pronunciation acquisition. It is hoped this study will inspire instructors to implement transcription exercises in their curricula, even if they are in the form of simple paper and pencil activities. In fact, instructors willing to start this practice do not need to create time-consuming worksheets with answer keys. The simplest solution is to seek example worksheets online or in dedicated textbooks such as Tench (2011), or to find sources of annotated authentic speech in such corpora such as The Speech Accent Archive (Weinberger, 2015).

Those instructors who would like to leverage such automated transcription tools as those described in this study are encouraged to review the References section. Some solutions are publicly available and can be easily implemented in an existing course. At the moment, the allophonic transcription tool described here is not available publicly. However, the code repository is available to anyone who would like to host their own instance of the application, or to modify it.

Regardless of whether the instructor chooses manual or automated transcription practice, the effort will be worth it. As Pennington and Rogerson-Revell (2019 p. 202) said:

> Learners and teachers need to be aware that developing pronunciation skills, from individual sounds to discourse-level intonation patterns, is a gradual process of acquisition involving all of these subskills, rather than just correcting the odd individual pronunciation error in an isolated listen-and-repeat session. The ultimate aim is for learners to be able to recognize and correct their own errors rather than rely on the teacher to do so, thus developing learner autonomy.

IPA-based transcription has the potential to increase such autonomy by equipping learners with a framework that facilitates the identification and correction of errors.

Future Research and Practice

Regarding future research and development of such transcription tools, a welcome addition to this and similar tools would be simple ear-training activities along the lines of those proposed by Ashby et al. (2009). A good example of how these ideas could be implemented is the freely available WebFon web application (Bates et al., 2010), which allows its users to listen to authentic recordings of speakers with developmental speech disorders and juxtapose them against transcriptions.

Once such online transcription tools become more popular, instructors should be able to leverage the power of data to inform their decisions. Just like with learning management systems such as Moodle, the immediate use case for tracking real-time learner performance data is identifying learners who struggle with a given part of the material (in this case, particular phonetic processes). The long-term use case is the ability to inform curriculum design by reviewing aggregated data on the most common errors and (a)typical usage patterns.

Acknowledgements

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About the Author

Kacper Łodzikowski's academic and professional interest is in educational technology. His academic research focuses on computer-assisted language learning (esp. pronunciation acquisition) and educational data mining. His professional work focuses on artificial intelligence in education, especially natural language processing, including automated speech recognition, natural language understanding, and natural language generation.

Email: klodziko@amu.edu.pl