THE RELATIONSHIP BETWEEN PHONOLOGICAL WORKING MEMORY AND SPEECH PRODUCTION IN YOUNG MULTILINGUALS

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ABSTRACT

Phonological working memory is positioned as a crucial predictor in the acquisition of phonology of new languages; it may influence the discrimination of phonological features, resulting in the formation of their more accurate representations (e.g. [1]). To investigate the role of this potential predictor, the study tested phonological working memory of 25 adolescent sequential trilinguals (L1-Polish, L2-English, L3-German). The results were correlated with the overall scores of L2 and L3 individual phonological accuracy obtained in a delayed repetition task (the focal features/processes included rhotics and final obstruent devoicing). The observed correlations indicated a moderately positive relationship between phonological working memory and phonological accuracy; the participants with higher PWM scores exhibited more target-like features in L2 and L3 production.

Keywords: multilingualism, language production, phonological working memory.

1. INTRODUCTION

Phonological working memory, in other words, phonological short term memory constitutes a component of working memory responsible for the maintenance of verbal and acoustic information [2]. Phonological working memory (PWM) has been described as a substantial factor in linguistic performance, which may be related to maintenance and processing of linguistic information, vocabulary acquisition or reading in monolingual and bi-/multilingual contexts [4, 7, 8, 11, 12]. Moreover, phonological working memory is highly individual [5], therefore, it may serve as a measure of individual differences in language acquisition.

A number of studies exploring the relationship between phonological working memory and foreign language speech perception and production have shown that memory capacity may be linked to the improved performance in the second or additional language (L2/ Ln). It was observed [1] that a group of Spanish-Catalan EFL learners scoring high on phonological working memory exhibited higher perceptual accuracy in the perception of English monophthongs. Further, higher storage capacity was found to be related to the overall phonological development in L2 phonological processing of adult Korean-English bilinguals [5]. A study focusing on the interface of phonology and semantics, showed a relationship between phonological working memory and the acquisition of cross-linguistic phonological regularities in a study of cognate acquisition in Frisian-Dutch bilingual children [3]. The results obtained in the studies listed above, allow to hypothesise that phonological working memory may play a significant role in the identification of phonological features as well as formation of their accurate representations [1, 5, 3].

The overviewed studies resorted to different measures in order to assess the capacity of phonological working memory, including a serial nonword recognition task, a digit-based simple span task (backward and forward) and sentence repetition tasks. According to Perrachione et al. [13], tasks based on nonwords and pseudoword repetition tap into the mechanisms of core speech perceptions such as encoding, storage and production by isolating these components from the influence of semantics. Additionally, nonword and pseudoword tasks based on L1-phonotactics [10, 14] may show the relationship between the mechanisms of L1 speech processing, and their influence on the subsequently acquired languages.

The relationship between language acquisition and phonological working memory has rarely been examined beyond the bilingual context. By reaching out to multilingual participants, and accounting for their speech production in L2 and L3, the current study aims to broaden the previously adopted perspective. The investigation of phonological working memory in a new context of multilingualism may further explore its role as a potential predictor of third or additional (L3 / Ln) language acquisition.

2. METHOD

2.1. Aims

The present study aims to examine the relationship between the phonological working memory, operationalised as accuracy in a pseudoword repetition task, and foreign language speech production, operationalised as target-like renditions of rhotics and final obstruents.

The research question posed in the study was as follows: what is the relationship between phonological working memory and speech production of young multilinguals?

It is hypothesised that the participants who score high on the pseudoword repetition task will also exhibit higher scores on L2 and L3 production measure due to their more accurate representations of the examined features. The focal features were determined by the contrasts between the phonological systems of L1 Polish, L2 English and L3 German. Polish and German) feature final obstruent devoicing, whereas English has no phonological devoicing. Further, rhotic consonants articulations differ across the investigated languages, with L1 Polish including an alveolar trill, L2 English a postalveolar approximant and L3 German a uvular fricative or trill. Such a selection of focal features was thus intended to examine participants' sensitivity to contrastive features manifested in speech production in multiple languages.

2.2. Participants

The participants were 27 adolescent trilinguals (mean age=12.64, SD=0.48), L1 native speakers of Polish, acquiring English as L2 (years of formal instruction, M=7.1) and German as L3 (years of formal instruction M=0.19) in the formal context of primary education. All participants were enrolled in the same class of a Polish primary school and received foreign language instruction from the same teachers. Two participants were excluded from the analysis due to their differing linguistic profiles (based on language background questionnaires). The participants were tested individually in a quiet room on the premises of the school. Three tasks described below were a part of a larger battery of tests examining phonological development of young multilinguals in a longitudinal research project.

2.3. Production task

The L2 and L3 production was examined in delayed repetition tasks (separate for each language). The task consisted of a sequence of pre-recorded mini dialogues. Sentence 1. contained a target word with a target feature, namely, a rhotic consonant or a final obstruent. Sentence 2. served as an intervening material, reducing a short-term recall and the risk of direct imitation in order to access the participants' representations of the features. Each participant was instructed to listen to the pre-recorded material, and repeat sentence 1. after hearing the complete sequence of a mini-dialogue. The sequences were recorded by native speakers of the respective languages (the varieties used in the study were Standard Southern British English and Standard German).

An example of a mini-dialogue in the delayed repetition task in L2:
Sentence 1 (speaker 1): I say *target word* again.
Sentence 2 (speaker 2). What do you say?
Participant: I say * target word* again.

Each task included 4 tokens containing one of the two feature (16 tokens in total). The responses of the participants were audio recorded by means of a dynamic microphone plugged to a computer via an external soundcard (2 channel recordings, 16bit, 44.1 kHz). The task was non-speeded, and adjusted to the individual pace of the participants. The set of tokens included also other contrastive features, which will be analysed as a part of a larger project.

2.4. Pseudoword repetition task

PWM was assessed in a pseudoword repetition task which involved the repetition of 29 pseudowords abiding by the rules of Polish phonotactics. The items recorded by a native speaker were arranged in the order of increasing length (from 2 to 6 syllables). The participants were asked to repeat each word immediately after a short sound signal following the presentation. The pseudowords were selected from the Polish Pseudo-words List (PPwL) [9]. PPwL was independently rated according to the criteria of permittable syllable structure, fluency of reading, compliance with Polish spelling rules and dissimilarity with the words existing in Polish. Words featured in the task had the congruency index of 1. The 6-six syllable category was not present in the original list, therefore, a set of additional words created by combining randomly selected PPwL items was added (phonotactically permitted and not associated with any existing word). The pseudoword repetition task correlated positively with the results obtained in a standardised measure of working memory, i.e. a forward digit span task that was also administered in the present study (r=.665, N=25, p<.001).

3. RESULTS

3.1. Accuracy ratings

3.1.1. Pseudoword repetition task

Recordings of the pseudowords obtained in the task were rated in terms of their accuracy on the phonemic level. Each item was classified as 'accurate' or 'inaccurate', scoring respectively 1 or 0 points (amassing to 29 for 100% accuracy). The most common errors in rendition of the pseudowords included phonemic substitution and deletion (both on segmental and syllabic level). The results of the accuracy ratings are presented in Table 1.

Table 1: The results of the accuracy rating in the pseudoword repetition task.

|	pseudoword repetition task
N	25
Mean	21.4
Median	21
SD	3.5

3.1.2. Delayed repetition task in L2 and L3

Recordings obtained in the delayed repetition tasks in L2 and L3 were rated by two independent, phonetically trained raters, who received extensive instructions regarding the target features and the general nature of the task. The rating scale was binary, therefore, the production was rated as either accurate or inaccurate; accuracy being operationalised as target-like production of a given feature. For the L2 delayed repetition task (in English), the target-like rendition of rhotics was a postalveolar approximant, and no phonological devoicing for final obstruents. For the L3 delayed repetition task (in German), the target-like realisations included uvular fricative or trill and final obstruent devoicing. Inter-rater reliability measured using Cohen's Kappa indicated a substantial agreement ($k=0.67$, $p<.05$) between the two raters. Items which obtained a low congruency score were rated by an additional, third rater. The accuracy results for L2 and L3 were added up to generate a global, multilingual accuracy score ($M=6$, $SD=2.4$). Maximum global score was 16 (4 items per feature in each language; 8 items per language in total). Table 2 demonstrates the scores in L2 and L3 production of the features under investigation.

Table 2: The scores (accuracy rating) for L2 and L3 production.

	L2 score	L3 score
N	25	25
Mean	3.5	2.5
Median	3	2
SD	1.8	1.61

Figure 1 shows the comparison of the results in the pseudoword repetition task and the global scores for L2 and L3, both transformed into percentages.

Figure 1: The individual scores (accuracy rating) of L2 and L3 production (global) and phonological working memory task (in percentages).
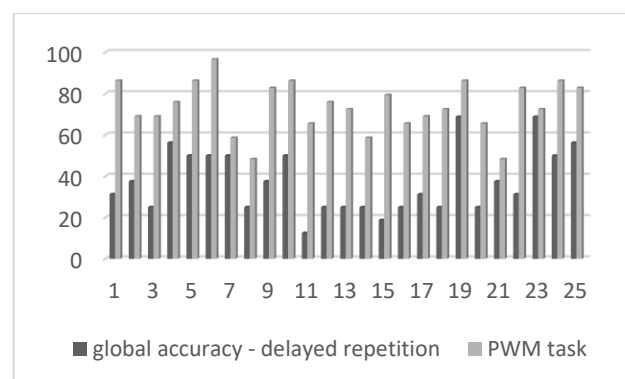

Non-target like production for rhotic consonant in L2 English included L1-like realisations and occasional substitutions with other sounds, whereas final obstruents were devoiced. Non-target realisations for L3 German rhotic consonant included L1- and L2-like realisations, and voiced obstruents for final obstruent devoicing.

3.2. Across-task comparison

It was hypothesised that the participants who score high on the pseudoword repetition task will also exhibit improved scores on the L2 and L3 production measure due to their more accurate representations of features. In order to examine this relationship Pearson's correlation coefficient was computed between the datasets obtained in a pseudoword repetition task and delayed repetition tasks (combined – global). As shown in Figure 2 the pseudoword repetition scores correlate moderately with the global accuracy scores for L2 and L3 ($r=0.41$, $N=25$, $p<.05$). A moderately positive relationship between the scores on the phonological working memory task and the L2 and L3 production task indicates that higher memory capacity is related to the development of more target-like categories in

multilingual speech production. Results for the correlation between the PWM measure and the L2 and L3 languages treated separately were not statistically significant (for L2 – r=0.32, p=0.13; for L3 – r=0.26, p=0.22).

Figure 2: Scatter plot showing a moderately positive correlation between the scores obtained in the pseudoword repetition task and the L2 and L3 delayed repetition tasks (global).
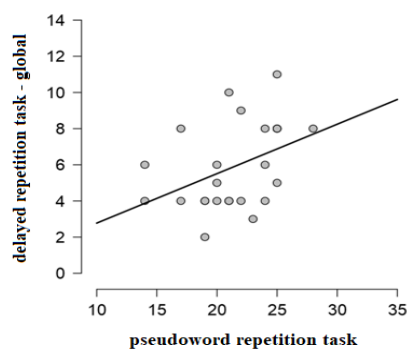
4. DISCUSSION AND CONCLUSIONS

The study investigated the potential relationship between phonological working memory and speech production in young multilinguals. Emergent trilinguals took part in a pseudoword repetition task aimed at examining the capacity of phonological working memory. Multilingual speech production of the participants was examined by means of a delayed repetition task in their L2 and L3. The obtained results suggest that there is a moderately positive relationship between the scores on the phonological working memory task and the L2 and L3 production. Such a finding indicates that higher memory capacity may be related to the development of more target-like categories in multilingual speech production.

The present findings correspond with the results of the previous studies [1, 5, 3], which observed a positive relationship between the phonological development (operationalised as both perception and production) and phonological working memory capacity. Consequently, such results may indicate that phonological working memory plays a significant role in the identification of the phonological features and formation of their representations observed in multilingual production. Moreover, this relationship may further suggest that pseudoword repetition task constitutes a valid measure of individual differences in the investigation of multilingual phonological development.

In order to examine the relationship between multilingual speech production and phonological working memory in a broader context, the analysis of the remaining contrastive features in L2 and L3 is required. Consequently, with a greater number of testing items the global score of phonological accuracy may be replaced by separate scores for each language, more sensitive to varying proficiency levels. Additionally, the auditory analysis can be supplemented with an acoustic analysis.

Further analysis of the data obtained in the subsequent testing sessions in the study (T2, T3) is necessary to account for the role of the increasing proficiency in the production accuracy for both languages. Moreover, a comparison with the scores and profiles obtained in the perception task, metalinguistic awareness task and language background questionnaire, which were also administered as part of a larger project, would cast more light on the acquisition process. Such an evaluation of the additional measures will account for other variables (such as speech perception, psychotypology, language exposure), and generate a wider picture of phonological development in multilingual acquisition.

The analysis of the pseudoword repetition task may be also extended to encompass the syllabic level; an accuracy score may be computed on the basis of the number of correctly rendered syllables. Additionally, in order to increase its comparability with a digit span task which employs a cut-off threshold, the accuracy score may be counted up to the point of incorrect renditions of two subsequent items.

The current study aimed to fill the existing gap in the research on how phonological working memory relates to language acquisition in multilingual speakers. The findings point to a moderately positive relationship between phonological working memory capacity and speech production in L2 and L3. Further research is needed to corroborate the role of PWM as a predictor in the acquisition of foreign language phonology from a multilingual perspective.

6. ETHICS STATEMENT

The informed consent was obtained from the parents/legal guardians and the participants. The study was positively evaluated by the ethics committee at Adam Mickiewicz University, Poznań.

7. ACKNOWLEDGEMENT

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