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Discrimination of Uncategorized-Categorized and Uncategorized-Uncategorized Greek consonantal contrasts by Russian speakers

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Abstract

The purpose of this study is to investigate the discriminability of two different assimilation types, the Uncategorized-Categorized (UC) and the Uncategorized-Uncategorized assimilation (UU) (Best and Tyler, 2007), as reflected in the discrimination accuracy and reaction times towards non-native contrasts by Russian speakers. The discriminability of these assimilation types varies in the literature. To this purpose, the same Russian speakers who evaluated Greek consonantal contrasts as UC and UU types in an assimilation test of a previous study completed an AXB discrimination test in this study to detect the discriminability of these assimilation types. The findings demonstrated that most of the UU non-overlapping (UU-N) types, and specifically those with focalized-focalized responses, were more accurately discriminated and had faster RTs than the UC non-overlapping (UC-N) type. However, one UU-N type with clustered-clustered responses did not differ in terms of discrimination accuracy and reaction times with the UC-N type. It is suggested that despite having the same overlapping parameters (non-overlapping), UU types might be more discriminable than UC types with respect to consonants. Also, similarity of uncategorized phones with other assimilated phones (e.g., focalized, clustered, dispersed) might shape the UC-UU type relationship. Finally, it is assumed that the discriminability of UC-UU types might be consonant-specific.

Key words

reaction times, uncategorized-categorized assimilation, uncategorized-uncategorized assimilation, discrimination accuracy, Greek consonants, Russian speakers

1. Introduction

It is usually difficult for adult speakers to accurately perceive the acoustical information of non-native phones due to the effect of their first language (L1) (Best, 1995; Flege, 1995; Best and Tyler, 2007; Escudero, 2009; Georgiou, 2018; 2019a 2019b). A very well cited example is the discrimination of the English consonantal contrast /r/-/l/ by Japanese learners of English. Usually, adult Japanese speakers do not discriminate accurately the aforementioned consonantal contrast since it is not found in their L1 phonological system (Miyawaki et al., 1975; Best and Strange, 1992; McClelland, et al., 2002). Probably, Japanese speakers assimilate both English /r/ and /l/ to the Japanese phonological category /r/. So, if an L1 phone is perceived as acoustically similar to a pair of contrastive non-native phones, the discrimination of the non-native phones will be difficult.

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The *Speech Learning Model* (SLM) (Flege, 1995) aims to examine the extent to which individuals learn to accurately perceive and produce segments in an L2. SLM takes into account the effect of several sociolinguistic factors on speech perception and production, such as age of arrival in the L2-speaking country, age of L2 acquisition, and L1/L2 use (Flege, 2002). The model argues that if much phonetic dissimilarity is discerned between an L2 phone and its closest L1 phone, the production of the L2 phone might be accurate. By contrast, if an L1 and an L2 phone are perceived as being phonetically similar, then merged L1-L2 categories will be formed leading to the inaccurate production of the L2 phone; this is driven by the mechanism of equivalence classification. Thus, the formation of a new phonetic category is prevented. Also, for SLM, phonetic categories are not static but constantly evolving, depending on L1 and L2 experience and usage (Flege, 2005). For instance, in the early stages of L2 learning, even L2 phones that exist in merged L1-L2 categories might be produced fairly well. Furthermore, L2 phones that are perceived as very dissimilar to an acoustically close L1 category might be produced poorly at early stages, but over the decades these L2 phones might be more accurately produced than L2 phones which are more similar to a close L1 phone.

The *Perceptual Assimilation Model* (PAM) (Best, 1995) is one of the most influential models in the area of speech perception. The model forms predictions about the perception of non-native phones by monolingual listeners while its extension, PAM-L2 (Best and Tyler, 2007), expands its predictions for L2 listeners as well. PAM supports the direct perception of gestural cues found in the speech signal. Both PAM and PAM-L2 suggest six types of assimilation of non-native phones to the L1 phonological categories; each of these assimilations predicts a different discriminability of a pair of non-native phones. In particular, *Two Category* (TC) assimilation occurs when two non-native phones are assimilated to two different phonological categories of the listeners' L1; discrimination of non-native contrasts is predicted to be excellent. *Single Category* (SC) assimilation indicates that two non-native phones are assimilated to a single phonological category of the listeners' L1 both as equal exemplars of that category; predicting poor discrimination of these phones. *Category Goodness* (CG) difference discrimination occurs when two non-native phones are assimilated to a single phonological category of the learners' L1, but one of them constitutes a good exemplar of that category while the other constitutes a deviant one; the discrimination of the non-native contrasts might be moderate to good. *Uncategorized-Categorized* (UC) occurs when a non-native phone is assimilated to an L1 phonological category but the other does not (though it falls into the phonological space); this type predicts very good discrimination of the phone contrast. *Uncategorized-Uncategorized* (UU) assimilation in which two non-native phones are not assimilated in any L1 phonological category; poor to very good discrimination is predicted Finally, *Non-Assimilable* (NA) is a rare type in which the non-native phones are not perceived as speech sounds; their discrimination might fluctuate from poor to very good.

The discriminability of the assimilation types proposed by PAM/PAM-L2 has been investigated in many studies. Specifically, research with respect to the discriminability of the TC, CG, and SC assimilations concluded that TC was the most discriminable type, followed by CG and SC. For example, Best et al. (2001) after investigating the perception of Tigrinya and Zulu consonantal contrasts, evaluated the discriminability of TC, CG and SC types. The findings of the study confirmed the relationship of TC > CG > SC. Best et al. (1988) examined the perception of Zulu clicks by English adults and infants to conclude that the SC was the most difficult assimilation type. Regarding the UC type, PAM predicts that it will be better discriminated than the SC type and worse than the TC type, and might be comparable to the best discriminations of the CG type. Furthermore, the relationship of the UU type with the other types is difficult to determine since the accuracy depends on the proximity of the contrastive phone members.

By contrast, evidence from several studies supports that the discriminability of the UC assimilation type varies and sometimes differs from that proposed by PAM. Mahmoud (2013) investigated the Arabic consonantal perceptual patterns of 22 adult American speakers who were learning Arabic at a university in the US. The author found that learners discriminated contrasts that yielded a UC assimilation only in a poor manner (but one was discriminated significantly better than the other) failing to confirm PAM's hypotheses. Similarly, Guion et al. (2000) studied the perception of English consonants by Japanese learners of English who were living in Japan pointing out that one UC type contrast showed discrimination scores that were below what was predicted by PAM while the others led to moderate-to-good discrimination. The authors attributed this divergence to the role of phonological distance between the categorized and uncategorized phones which should be considered in UC assimilation types.

Similarly to the UC type, variation has been observed in the discriminability of the UU type. For example, Harnsberger (2001), who examined the identification and discrimination of non-native nasal consonants by speakers of several L1s, found that the UU type could be better discriminated than the SC type but worse than the TC type. Mahmoud (2013) observed that two out of three Arabic consonantal contrasts indicated very good discrimination accuracy, while one contrast had poor discrimination. The author suggested that each contrast of this type should be examined separately considering as well the phonetic proximity of the contrastive L2 phones. Moreover, he concluded that the UC and UU types did not differ significantly in their discriminability for most of the consonantal contrasts. A recent effort has been made by Faris et al. (2016) to advance the theory with respect to discrimination accuracy of UU and UC assimilation types and provide a revision of PAM. For the first time, they divided uncategorized phones according to their similarity with other phones assimilated to the same L1 category (focalized, clustered and dispersed), and they considered degrees of overlap between two contrastive L2 phones (overlapping, partially overlapping, non-overlapping). Their results indicated that discrimination accuracy was modulated by perceived overlap with native phonological categories. For example, UC/UU types with no overlap (i.e., two phones that are identified in completely different sets of L1 phones) could be better discriminated than UC/UU types with partial overlap (i.e., two phones with at least one shared above-chance category), and phones with partial overlap could be better discriminated than phones with complete overlap (i.e., two phones assimilated to the same set of L1 categories). Also, Faris et al. (2018) suggested that a UC/UU non-overlapping type in monophthongs was discriminated almost with the same degree as the TC type but with respect to diphthongs, the TC type was more accurately discriminated than the UC non-overlapping type. However, Faris et al. (2016, 2018) focused on vowels, and, therefore, conclusions cannot be generalized to consonants.

Reaction Time (RT) measures are important parts of phone contrast discrimination tests. The time needed for the selection of a response in a discrimination task (decision whether a non-native phone is different or same as one other) reflects the perceptual processing level and the type of information that is demanded for the appropriate response decision (Schneider et al., 2011). Several studies in the past investigated the correlation between RT and discrimination accuracy. Pisoni and Tash (1974) pointed out that a clear perception of the acoustic difference between two phones leads to shorter RTs, while when perception of the acoustic information between two non-native phones befuddles speakers, RTs tend to be longer. The authors employed the RT matching paradigm developed by Posner and his colleagues (Posner and Mitchell, 1967; Posner, 1969). The purpose of the study was to investigate whether participants were able to respond to phone acoustical differences in a categorical perception task or if these phones are processed on an abstract phonetic level. Pisoni and Tash (1974) used synthetic speech phones that ranged from /ba/ to /pa/. The English subjects of the study were instructed to respond "same" if a pair of phonetic stimuli included the same phones (e.g., /pa/, /pa/) and "different" if a pair of phonetic stimuli included different phones (e.g., /ba/, /pa/). Perceiving two acoustically different speech sounds as being identical implies that abstract features are compared at a higher level of perceptual analysis rather than perceiving two acoustically identical stimuli as being the same (Schneider et al., 2011). The results of the study indicated that in the acoustically identical stimuli (A-A), the "same" response noted faster RTs compared to the acoustically different stimuli (A-a) for the same phonetic category.

The correlation between discrimination accuracy and RT was also examined in the study of Schneider et al. (2011) who investigated the categorical perception of the two German boundary tone categories, L% and H%. The findings showed that when the difficulty of the perceptual tasks rose, RTs were longer, whereas when the perceptual tasks were easy, RTs were shorter. Specifically, when the goodness-of-fit rating was high, RTs were shorter. Also, in the discrimination task, poor discrimination performance resulted in long RTs; this indicates that when participants were unsure about the response, they were slower to provide a response. The authors argued that RT might be a gender-related variable since there were differences between male and female subjects of the study.

The aim of the present study is to investigate the discrimination accuracy and the RTs of two different assimilation types on the basis of the discrimination of Greek consonant contrasts by Russian speakers. Specifically, it aims to check if UC assimilation types differ in terms of discrimination accuracy and RTs from the UU assimilation types by taking into account the similarity between the assimilated consonants and the overlapping parameters of the L2 consonantal pair members; these factors will be taken into account for the first time in consonants instead of vowels. This study will focus on a crosslinguistic investigation of Greek and Russian, two languages that have not been investigated both phonologically and phonetically in the past.

2. Materials and methods

2.1 Participants

Sixteen Russian speakers, who were students at RUDN University, Moscow, participated in a categorization test in a previous study (Georgiou, et al., 2019) and in an AXB discrimination test in this study. Before taking the test, participants completed a questionnaire in order to collect individual information about them such as age, knowledge of foreign languages, country of origin, etc. The participants' ages varied from 19-26 years (mean age: 21.25 years) and they did not have any knowledge of Greek. However, they reported a basic knowledge of English and other languages (e.g., Georgian, Azerbaijani, Chinese, etc.); none of these were native languages of the listeners. Some participants originated from Moscow whereas others originated from other parts of Russia, and their families were of moderate income. The participants declared that they did not speak any other dialect of Russian but Standard Russian. Also, none of them had ever suffered any language or hearing disorder. The participants singed a consent form according to the Declaration of Helsinki before becoming involved in the test.

2.2 Stimuli

Two Greek native speakers (1 male and 1 female) recorded eight Greek consonants that formed four consonantal contrasts ([θ]-[t], [ð]-[d], [ɟ]-[g], [ç]-[x]) in VC nonsense syllables ([aC]). The recordings were made in a sound-attenuated room, and the sampling rate was 44.1 kHz. The stimuli were selected on the basis of possible difficulties in their discrimination since the contrastive pairs [θ]-[t], [ð]-[d] are often confused by Russian speakers (the first member is not present in the Russian phonological system). Also, the first member of [ɟ]-[g], [ç]-[x] contrasts, which is not present in Russian and constitutes an allophone of the second member in Greek, might be difficult to be distinguished. There were four trial types (AAB, ABB, BBA, BAA; A= first member of the consonant contrast, B= second member of the consonantal contrast) for each consonantal contrast with each trial to include the same consonants. The recordings were digitized and transferred to the PC. The AXB discrimination test was presented using a Praat script (Boersma and Weenink, 2019), and the triads of syllables were presented to the Russian speakers through a set of headphones.

2.3 Procedure

Both the assimilation and the AXB discrimination test (Best et al., 2001) were carried out in the phonetic laboratory of RUDN University, Moscow. In the assimilation test, which was completed in a previous study, participants listened in random order to one of the eight Greek consonants [θ t ð d ɟ g ç x] in /VC/ syllables (V=vowel, C=consonant) and had to select the most similar Russian consonant to it from 22 alternative responses by clicking on the onscreen text options. Then, they had to rate how similar the Greek consonant was to the already assigned L1 category by clicking on a scale from 1 to 5 (1=very bad, 5=very good). Each participant assimilated a total of 48 items (16 consonants × 3 repetitions), however, for this study we selected only the /VC/ assimilations (24 items: 8 consonants × 3 repetitions).

In the AXB test, participants were seated in front of a laptop (approximately 30 cm), and they listened to triads of Greek syllables containing the Greek consonants; stimuli were presented at a comfortable level of 75 dB and they were in a random order. The laptop script included the labels "first" and "third" and participants were instructed to decide, by clicking on the appropriate label, whether the middle consonant was the same as the first or the third consonant. In total, they discriminated 48 items (4 contrasts × 4 trials × 3 repetitions), while after the 24th item they could have a five-minute break. The inter-stimulus interval was set at 2 s. The X token was physically different (produced by different Greek speakers) from the A and B token so as to avoid a solely auditory decision (Polka, 1991; 1992). Praat automatically recorded their RTs with respect to the selection of each response. The RT measuring onset was just after the hearing of the last stimulus. Participants were told to respond as fast as possible, however, there was no set time limit for their responses. The total duration of the experiment was approximately 30 minutes, and participants were tested individually without having any contact with each other during the experiment.

3. Results

3.1 The assimilation test

In a previous study, Georgiou et al. (2020) investigated the Greek consonantal assimilation patterns of Russian speakers who did not have any knowledge of Greek. The study indicated different assimilations for particular Greek consonantal contrasts. Phones would be uncategorized if they failed to reach the predetermined categorization threshold which was set at 70% in this study; i.e. uncategorized is a phone that fails to be selected for more than 70% of the participants' responses (see also Antoniou et al., 2012). The Greek consonantal contrast [θ]-[t] in /VC/ context resulted in a UC assimilation since one of the contrast members was assimilated to an existing L1 phonological category, while the other remained uncategorized; [θ] was not assimilated to any Russian category while [t] was assimilated to the Russian [t]. The Greek consonantal contrasts [ð]-[d], [ɟ]-[g] [ç]-[x] resulted in UU assimilations since both of the contrast members remained uncategorized. The same Russian speakers who participated in the aforementioned study also took part in the present study by completing an AXB discrimination test in order to determine the discrimination accuracy and the RTs of the aforementioned UC and UU assimilation types. Table 1 illustrates the assimilation of Greek consonants to the Russian phonological categories (Georgiou et al., 2019).

Table 1. Percentage of assimilation of Greek consonants to Russian phonological categories and goodness-of-fit ratings in brackets (1=poor, 5=good). The bold cells represent the categorized consonants. Assimilations below 5% are not reported. The categorization threshold was set at 70%.

	Russian consonants														
Greek	/g/	/gʲ/	/d/	/dʲ/	/f/	/fʲ/	/s/	/sʲ/	/x/	/xʲ	/t/	/z/	/zʲ/	/vʲ/	/k/
[θ]					13 (2.5)	19 (2.3)	44 (2.9)						13 (3.1)		
[t]											**100 (3.6)**				
[ð]												65 (3.2)	19 (3.3)	8 (3)	
[d]			60 (2.9)								33 (2.9)				
[ɟ]		42 (2.7)		38 (2.4)											
[g]	44 (3.9)														52 (3)
[ç]								15 (2.9)	17 (2.7)	65 (3.1)					
[x]					10 (2.1)				56 (3)	19 (2.9)					

Faris et al. (2016; 2018) suggested three ways of phone assimilation according to the similarity of uncategorized phones with other phones: (a) *focalized* responses: an L2 phone is similar mainly to a single L1 phonological category but still below the categorization threshold, (b) *clustered* responses: an uncategorized L2 phone is similar to a small set of L1 phonological categories, and (c) *dispersed* responses: a range of similar L1 categories is selected for an uncategorized L2 phone. The assimilation subtypes can be applied only for assimilation types that include at least one uncategorized phone (i.e., UC and UU). The results of Georgiou et al. (2019) showed seven uncategorized consonants. To determine whether these two consonants are focalized, clustered or dispersed, *t-tests* compared the mean categorization percentages of each Greek consonant with each Russian response against a chance score of 4.54% (taking into account the 22 possible options of native Russian consonant categories that Russian speakers had to select from) (following Faris et al., 2016); if $p < .05$, then a response was selected more often than chance. The analyses showed that Greek [θ ð d ç x] were focalized responses whereas Greek [ɟ g] were clustered responses.

The next step was to identify whether the one UC type ([θ] - [t]) and the three UU types ([ɟ] - [g], [ð]-[d], [ç]-[x]) were *non-overlapping* (UC-N), that is, identified in a different set of L1 categories, *partially overlapping* (UC-P), that is, to have at least one shared above-chance category, or *completely overlapping* (UC-C), that is, both non-native phones are identified with the same above chance L1 vowel or set of L1 vowels. Note that a focalized response cannot partially overlap with a categorized phone or another focalized response (Faris et al., 2018). In our findings, [θ] - [t] (focalized-uncategorized) were non-overlapping (UC-N) and, similarly, [ð]-[d] (focalized-focalized) (UU-N), [ɟ] - [g] (clustered-clustered) (UU-N), and [ç]-[x] (focalized-focalized) (UU-N) were non-overlapping. With respect to our hypotheses, it is predicted that all assimilation types will be discriminated in the same manner (excellent discrimination) since all contrasts are non-overlapping and, therefore, learners will perceive two contrastive phones as being non-ambiguous.

3.2. The discrimination test

Table 2 presents the discrimination scores (in percentages of correct responses) and RTs (in milliseconds) of Greek contrasts (UC and UU types) in VC context as discriminated by Russian speakers. The assimilation type of these contrasts was determined in Georgiou et al. (2019). From the very first view, it can be observed that the discrimination accuracy of both UC-N and UU-N assimilation types ranged from very good to excellent. The most discriminable consonantal contrast was [ç]-[x], while the least discriminable was [θ]-[t]. The longest RT was observed for the [θ]-[t] contrast, while the [ð]-[d] contrast noted the shortest RT. Figure 1 shows the RTs for the discrimination of the Greek consonantal contrasts.

Table 2. Discrimination accuracy and RTs of Greek contrasts as discriminated by Russian speakers. "SD" indicates the Standard Deviations of discrimination scores and RTs. U=uncategorized, F=focalized, C=clustered

Contrast	Similarity	Type	Accuracy (%)	*SD*	RT (m/s)	*SD*
[θ]-[t]	F-U	UC-N	84	23.9	612	18.44
[ð]-[d]	F-F	UU-N	92	24.8	569	9.78
[ɟ]-[g]	C-C	UU-N	87	14.5	597	12.30
[ç]-[x]	F-F	UU-N	93	24.9	571	15.6

A one-way repeated measures ANOVA was carried out to reveal the effect of contrast on the discrimination scores. The dependent variable was *Scores* (discrimination accuracy as derived from the percentages of correct responses), while *Contrasts* (the 4 consonantal contrasts) was the within-subjects factor. The results showed a significant effect of *Contrasts* on *Score* [$F(3, 42) = 4.29$, $p=0.03$). The Bonferroni post-hoc test showed that there were significant differences for [θ]-[t] and [ð]-[d] ($p=0.047$), and for [θ]-[t] and [ç]-[x] ($p=0.022$); the UC-N type was more accurately discriminated than the UU-N type. No significant differences were observed for the [θ]-[t] - [ɟ]-[g], and for the [ð]-[d] - [ç]-[x], [ð]-[d] -[ɟ]-[g], and [ɟ]-[g] - [ç]-[x] contrasts.

A one-way repeated measures ANOVA was carried out to investigate the effect of contrast on the RT. The dependent variable was *RT,* while *Contrasts* was the within-subjects factor. The results showed a significant effect of *Contrasts* on the *RT* [$F(3, 42) = 8.71$, $p=0.01$]. The Bonferroni post-hoc test showed that there were significant differences for [θ]-[t] (UC-N) and [ð]-[d] (UU-N) ($p=0.02$), and for [θ]-[t] (UC-N) and [ç]-[x] (UU-N) ($p=0.011$); the UC-N type had again slower RT than the UU-N types. The [θ]-[t] - [ɟ]-[g], [ð]-[d] - [ç]-[x], [ð]-[d] -[ɟ]-[g], and [ɟ]-[g] - [ç]-[x] contrasts did not show any significant differences.

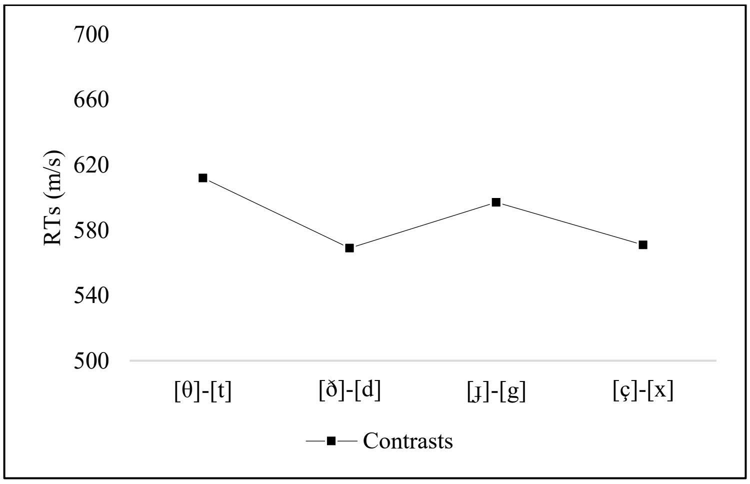

Figure 1. RTs for the discrimination of Greek consonantal contrasts by Russian speakers

4. Discussion

The aim of the present study was to investigate the discrimination accuracy and the RTs of two different assimilation types proposed by PAM, the UC and UU assimilation types, using a 70% categorization criterion. The discriminability of these types varies according to evidence from many studies in the literature. The investigation took into account the similarity of the uncategorized non-native consonants with other assimilated consonants and degrees of overlap for L2 contrastive consonants in order to provide a deeper relationship between UC and UU assimilation types. The study took into account a new set of languages, that is, Russian and Greek.

The discrimination accuracy for all Greek contrasts was very good to excellent since it ranged from 84% to 93% (for discrimination criteria, see Tyler et al., 2014). These results are not consistent with the results of Mahmoud (2013) in which UC and UU types led to poor to moderate discrimination. Similarly, Guion et al. (2000) pointed out that both UC and UU types resulted in poor discrimination scores. In order to give a possible explanation for these divergences, it has to be considered that although Guion et al. (2000) did not use any systematic overlapping criteria for the members of the UU types, they attributed the low discrimination scores of this type to the fact that both phones fell in between the same Japanese categories (overlapping phone categories). Also, the low scores that the UC types obtained were justified by the authors as an overlap of the L2 categorized consonant with the uncategorized consonant. So, high discrimination scores for the UC and UU types in the present study can be explained due to the non-overlapping parameters of the members of this type; i.e., the two non-native consonants of each contrast were assimilated to a different set of L1 phonological categories.

Moreover, according to the findings of this study, the UC-N type was less accurately discriminated and had slower RTs than the majority of the UU-N types (those involving two focalized members). By contrast, Mahmoud (2013) observed that the discrimination scores of UC and UU types did not differ. As discussed earlier, the proximity of the two type members in the phonological space was a significant factor for this relationship. The findings also showed that the UC-N contrast did not differ from one UU-N contrast of which both of its members were clustered responses. Furthermore, there were not any significant differences in discrimination scores and RTs among UU-N types with both focalized members in each. This was roughly expected since these types were all of the same type (UU), their members had the same type of similarity with other consonants (focalized-focalized), and all of them had the same degree of overlap (non-overlapping). Non-significant differences were also found between UU-N types with both focalized members and UU-N types with both clustered members.

So, the study provided evidence that supports the more accurate (and thus easier) discrimination of non-native contrasts containing phones not categorized in any L1 phonological category (UU-N) compared to contrasts in which only one phone was mapped into an L1 category (UC-N). Despite the fact that the members of both assimilation types were non-overlapping, these types could be discriminated to a different degree. Thus, this study suggests the relationship: UU-N > UC-N (a UU-N assimilation type might be more accurately discriminated than a contrast that yields a UC-N assimilation type). Nevertheless, we should not ignore the fact that the UC-N type showed discrimination scores and

RTs that were similar to one UU-N type. This happened only when the members of the UU-N contrast were clustered responses. Thus, the relationship of the assimilation types according to the findings of this study can be redefined as UU-N ≥ UC-N (a UU-N assimilation type might be more accurately discriminated than a contrast that results in a UC-N assimilation type, or they might be equally discriminated). Three implications can be drawn. First, a UU-N type is more discriminable than a UC-N type in general. Second, the similarity of uncategorized phones with other responses (e.g., focalized, clustered, dispersed) might play a role in the relationship between UC and UU assimilation types even if the phones' overlapping parameters coincide (e.g., the UU-N type with focalized-focalized responses might be better discriminated than the UC-N type, whereas the UU-N type with clustered-clustered responses might not differ from the UC-N type). Third, the discriminability of UC-N and UU-N types might be consonant-specific and, therefore, might differ between different consonantal contrasts.

As mentioned earlier, the results of this study provide evidence that UU types might be better discriminated than UC types (at least for the majority of contrasts) when the members of both types are non-overlapping. We still do not know how this relationship would be shaped if these types were partially overlapping or completely overlapping. Also, the findings of this study offer implications for consonantal contrasts, and more specifically contrasts which listeners do not have experience with (for vowel contrasts, see Faris et al., 2016; 2018). It is suggested for speech perception studies to consider *category overlapping* and *similarity of the phones* for the investigation of uncategorized phones as it might give more details about the discriminability of these phones and the relationship between the UC and UU assimilation types.

5. Conclusion

The present study investigated the relationship of two assimilation types proposed by PAM: the UC and UU types. The main findings show that UC and UU non-overlapping types did not differ in terms of both discrimination scores and RTs. Also, the similarity of the uncategorized phones to other assimilated phones defined the discriminability of the assimilation types. We hypothesize that discriminability might also be determined by the structure of both listeners' L1 and the target language, by the nature of the phone (e.g., vowels vs. consonants, monophthongs vs. diphthongs, etc.), and by the context of the target phone (position of the target phone, preceding/following phones, etc.). However, more studies which should take into consideration the aforementioned parameters are needed to examine this relationship. Furthermore, one of the limitations of this study is its sample size, which was relatively small and does not allow us to introduce modifications to PAM but instead to provide some evidence about the relationship of the UC and UU assimilation types based on an assimilation and a discrimination task.

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