TILDA NEUBERGER

Hungarian Research Centre for Linguistics
neuberger.tilda@nytud.hu

Tilda Neuberger: Effects of L2 exposure on the perception of the singleton/geminate contrast in Hungarian
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Effects of L2 exposure on the perception of the singleton/geminate contrast in Hungarian

Several studies have investigated the perception of the singleton/geminate contrast in various languages; however, there is sparse literature on the possible phonological/phonetic attrition related to geminate perception in bilinguals. The present study examines the geminate perception of native Hungarian immigrants in foreign language environments (USA, Germany). Since length is a distinctive phonological feature in the Hungarian consonant system but not in English or standard German, we hypothesized that long-term exposure to L2 and lack of L1 input might affect the perceptual sensitivity to the durational correlates of the consonant length contrast. Our results showed no dramatic changes or significant weakening of L1 skills on the phonological language level concerning geminate perception in late bilinguals compared to monolinguals.

Keywords: geminate, stop consonant, perception, late bilinguals

1. Introduction

1.1. Consonant length perception

Perception of the singleton/geminate contrast has been investigated in many languages in which consonant length is a distinctive feature, including Arabic (Obrecht, 1965), Finnish and Japanese (Yoshida et al., 2015), Hungarian (Neuberger, 2016), Italian (Altmann et al., 2012), Turkish and Bengali (Hankamer et al., 1989).

Some studies also examined consonant length perception among non-native listeners and language learners (e.g., Hayes, 2001; Wilson et al., 2005; Sonu et al., 2013; Porretta & Tucker, 2015; Tsukada et al., 2018). Their findings indicate that non-native listeners tend to have difficulties identifying length contrasts. While native Finnish speakers began to perceive geminate consonants in the expected range (around 177 ms), naïve English listeners of Finnish only did it in the case of longer consonant duration (Porretta & Tucker, 2015). In a perception experiment of Japanese length contrast differentiation by English listeners, non-native listeners did not use cues that vary by speaking rate but instead used absolute durational criteria (Wilson et al., 2005). Similar findings were observed in Korean learners of Japanese (Sonu et al., 2013). Another study showed that Japanese native speakers identified the single/geminate contrast categorically, while monolingual English participants identified it rather linearly depending on the consonant length; L1 English learners of Japanese fell in between the two above groups (Hayes-Harb, 2005). The length of exposure to a foreign language may improve learners' perceptual performance, as evidenced by Hayes (2001).

Furthermore, higher proficiency and experience with L1 length categories might be helpful when listeners process consonant length in another language. It was confirmed that listeners rely on their knowledge of L1 when processing an unknown language if the two languages behave similarly with respect to a consonant length distinction, like Italian and Japanese (Tsukada et al., 2018). It was shown that native Italian listeners' L1 experience was as beneficial as the non-native learners' Japanese (as a foreign language) learning experience when deciding whether a consonant was short or long (Tsukada et al., 2018). Altmann et al. (2012) found that a non-native vowel length contrast was perceived just as well as the native consonantal length contrast in Italian speakers. However, novel length contrasts for consonants seemed more challenging to process. German speakers (whose native language has a vowel length contrast but not a consonant length contrast) could perceive Italian consonant length, though still clearly different from native Italian speakers. The sensitivity for consonantal length contrasts improved with increased exposure to Italian (Altmann et al., 2012). Based on the evidence of the studies mentioned above, the (interfering or beneficial) influence of the first language on the later learned language seems noticeable. The question arises whether the opposite process exists: Does L2 also affect the L1 (after some time)?

1.2. Interaction between L1 and L2

Literature on second language acquisition/learning and bilingual development has pointed out that L1 and L2 are linked, and there is constant interaction or interference between them (Flege, 1995; Pavlenko, 2004; Köpke & Schmid, 2004; Schmid & Köpke, 2007; Navracsics, 2015). The L2 influence can take several forms: borrowing, convergence, shift, restructuring, or attrition, and can be observed at any linguistic level, such as phonetics/phonology, morphosyntax, lexicon/semantics, and pragmatics (Pavlenko, 2004; Schmid & Köpke, 2007). Previous research has convincingly established that L2 may influence and even overtake L1 in childhood (Murphy & Pine, 2003), but the L2 may also influence the L1 in adulthood. L2 can quickly become the dominant language when the speaker uses it more frequently and experiences a decrease in L1 proficiency (Navracsics, 2015). Bergmann et al. (2015) studied to what degree language co-activation affects German monolingual and bilingual adults' speech fluency and evinced language competition during speech production based on the analysis of temporal fluency and disfluency markers. In a study that investigated the L1 lexical performance of Hungarian–Dutch late bilinguals, a correlation was found between the length of residence in the L2 environment and the performance on a verbal fluency task; however, none of the examined extralinguistic variables (e.g., age at emigration, length of residence) predicted lexical diversity of narratives (Bátyi, 2020).

L1 attrition is usually defined as “a loss of the L1 or a gradual decline in proficiency mainly caused by interference from an L2” (Alkhudidi et al., 2020: 1). This definition seems to assume that attrition necessarily involves interference from an L2. In our view, L2 use *per se* does not cause a loss in L1 but rather the shift in frequency of use. When previously monolingual speakers become (late) bilinguals by immigrating to a foreign language country, they tend to use L2 more often and face reduced opportunities for L1 usage. Lack of input data may result in parts of the L1 becoming forgotten by healthy individuals (Ecke 2004).

The majority of studies on L1 attrition have focused on the lexicon/semantics, also in Hungarian (e.g., Navracsics, 2002, 2015; Bátyi, 2020). There is also a considerable amount of research related to the phonetics-phonology level, in which attrition or shift refers to changes in the acoustic-phonetic properties of an L1 sound. The literature on phonological/phonetic attrition has examined various aspects of the L1, for instance, voice onset time (Flege, 1995; Hrycyna et al., 2011), final obstruent devoicing in Russian (Dmitrieva et al., 2010), production of the German lateral phoneme /l/ (de Leeuw et al., 2013). Korean–English bilinguals’ perceptual performance was poorer on L1-specific contrasts than that of monolinguals, and their accuracy was significantly correlated with age of arrival in an L2 environment (Ahn et al., 2017). Authors suggested that “the earlier bilinguals are extensively exposed to L2, the less likely they are to perceive L1 sounds accurately” (Ahn et al., 2017: 719).

Concerning consonant length contrast, several studies investigated geminate attrition in production data (e.g., Rafat et al., 2017; Alkhudidi et al., 2020). They found that geminates became shorter, and the overlap of geminates and singletons increased (i.e., matching with shallower perceptual boundaries) in each successive generation of immigrants (Rafat et al., 2017; Alkhudidi et al., 2020). This suggests that the likelihood of loss increases with generation.

To the best of our knowledge, only one study has examined geminate attrition in the perception of bilingual listeners. Celata and Cancila (2010) investigated the discrimination of the geminate-singleton contrast in Italian in first- (FG) and second-generation (SG) immigrant groups living in the U.SA. The performance of the SG group (whose mother tongue is considered to be American English, AE) was poorer than that of the FG group; however, the results of both groups differed from that of the control group (which consisted of Lucchese-dialect speaking monolinguals). Authors “argued that the perceptual behavior of SG immigrants was based on an AE-like phonological system, where no length distinctions in intervocalic consonants are lexically represented” (Celata & Cancila, 2010: 19), while some familiarity with the length feature was postulated for FG immigrants. It is worth mentioning that length functions contrastively, albeit with a small functional load in English in the case of 'fake' geminates (juncture phenomena), which arise across morphemes, e.g., *top pick* vs. *topic*.

1.3. Consonant duration in Hungarian, English, and German

It is known that Hungarian vs. American English, as well as Standard German, behave differently with respect to consonant length. Length is a distinctive phonological feature in the Hungarian consonant system, but it is not in English or Standard German consonant systems. Geminate and singleton consonants are contrastive in Hungarian, and the opposition does occur in morpheme-internal and morpheme-boundary conditions, e.g., HUN *ép* 'unhurt' : *épp* 'right now,' *vasal* 'he is ironing' : *vas+sal* 'with iron.' English and Standard German do not have phonemic consonant geminates at the word level, i.e., consonant length is not distinctive within root words; however, phonetic gemination occurs marginally. Fake geminates are defined as sequences of identical consonants across morpheme boundaries within a word or phrase; e.g., ENG *greenness*, *pine nut*, GER *zahllos* 'countless', *Schulleiter* 'headmaster,' and are produced nearly twice as long as their non-geminate counterparts (e.g., *pine nut* vs. *pineapple*) (Kotzor et al., 2016).[1]

Although it is difficult to compare the average consonant durations of different languages due to different experimental materials and methods, we list here some mean values of stop consonants in the three languages to observe similarities and differences depending on the place of articulation (PoA) and quantity. In a read list of words containing English intervocalic stops, closure duration (CD) proved to be 26–92 ms (Sharf, 1962).[2] Crystal & House (1988) found that the mean CD of American English stop consonants (necessarily singletons) varied between 49 and 58 ms (depending on PoA), with the tendency for alveolar stops to be shorter than labial and velar stops. CD of English obstruent fake geminates (in C#C compounds: 173 ms) was significantly longer than that of their singleton counterparts (in C#V compounds: 91 ms) in the study of Kotzor et al. (2016).

A significant difference was found between the CD of fake geminates and singletons (230 and 150 ms, respectively) in German compounds (Kotzor et al., 2016). Considering German voiced and voiceless labial and alveolar stops, the mean CD was 85 ms for singletons and 155 ms for geminates arising by concatenation of homorganic stops across morpheme boundaries (Mikuteit, 2007). The labial stops were significantly longer than the alveolar ones. The geminate-to-singleton ratio was 1.82.

In Hungarian, the mean CD of intervocalic single voiceless stops varied between 70 and 90 ms in read non-words (Gráczi, 2013).[3] It varied between 63 and 79 ms for singleton [p, t, k] and between 106 and 122 ms for their geminate

[1] Examples of fake geminates are from the study of Kotzor et al. (2016).
[2] [p] 92 ms, [t] 26 ms, [k] 73 ms
[3] [p] 90 ms, [t] 72 ms, [k] 70 ms

counterparts in spontaneous speech (Neuberger, 2015).[4] The geminate-to-singleton ratio was 1.5. In the last two studies, mean durations showed the same tendency with closures being longer for labials than for more posterior places of occlusion (velars). We can see that the PoA-effect on closure duration (CD) is universal in production. Hence, PoA is not assumed to be susceptible to language loss if L1 and L2 have the same PoAs.

To see if the English/German fake geminates are similar in (closure) duration to the true geminates (specifically, the geminate-to-singleton ratio is similar in both types of contrast), we enumerate some examples from other languages that possess phonemic consonant length contrast. For instance, a robust difference was confirmed in duration between Japanese singleton and geminate stop consonants (mean: 69 ms vs. 206 ms, respectively; Idemaru & Guion, 2008). The average G/S ratio was 2.14 in Japanese and 2.25 in Finnish (Ham, 2001), 1.6 in Maltese (Galea et al., 2014), 2.5 in Lebanese Arabic, and 1.82 in Lebanese Arabic spontaneous speech (Khattab, 2007).[5]

It is also shown that consonant duration is a significant marker of prosodic boundaries in English (Pickett & Decker, 1960; Repp, 1978). By manipulating the stop closure of /p/, listeners began to judge the word *topic* as *top pick* at a threshold (set at 60% of the judgments as *topic*) of approximately 175–200 ms (Pickett & Decker, 1960). Listeners tended to perceive CD under 150 ms as single, and CD above 250 ms as double; though, there was a bias toward rating all closure durations as single. Repp (1978) found that 200 ms of silence was needed to hear VCV as separate phonemic events (VC and CV), and for CD below this boundary was perceived as a single consonant.

1.4. Aims and hypotheses

The present research focuses on the influence of L2 on the phonology and phonetics of L1. We based our study on the following two statements: "L1 contrasts that are not found in the dominant language (L2) appear to be more susceptible to loss than those that are similar to contrasts found in the dominant language." (Ahn et al., 2017: 700), and "Geminates are also typologically considered marked (i.e., rare) sounds (Maddieson, 1984) and may therefore be particularly prone to attrition." (Alkhudidi et al., 2020: 2).

The present study aimed to investigate the perceptual processing of the stop consonant length distinction by Hungarian (L1) immigrants in English- and German-speaking communities (L2) and compare their results to Hungarian monolinguals as a control group. The main question of this experiment is whether long-term residence in a foreign language environment has affected geminate perception? In order to get closer to answering the question, a two-alternative

[4] [p] 79 ms, [t] 71 ms, [k] 63 ms; [pː] 115 ms, [tː] 122 ms, [kː] 106 ms

[5] Speech material used in the studies – unless otherwise indicated – was words read in isolation or embedded in carrier phrases.

forced-choice test was applied for stops with systematically manipulated closure duration in late bilinguals (Hungarian–English and Hungarian–German) and monolinguals.

We hypothesized that (H1) long-term exposure to L2 and reduced contact with L1 might affect the perceptual sensitivity to the durational correlates of consonant length contrast in L1, which may show up in less clearly defined category boundaries between Hungarian singletons and geminates in late bilinguals' perception.

The second hypothesis (H2) was that the base stimulus (originally singleton or geminate) may affect the listeners' responses to some extent due to probable secondary cues (e.g., preceding vowel duration, closure voicing, or combination of acoustic characteristics) in the acoustic signal that remained unaltered in the experiment.

2. Method

2.1. Participants

There were 45 participants in this study, separated into three groups. The "USA" group consisted of 15 Hungarian–English late bilinguals who learned American English as an L2 and immigrated to the U.S. after puberty. They had lived in the U.S. for at least seven years at the time of the experiment. The "Germany" group consisted of 15 adult-immigrant Hungarian–German bilinguals who learned German as an L2 and lived in Germany for at least seven years immediately before participating in the experiment. All late bilinguals started L2-learning in childhood and adolescence. The control group consisted of 15 adult Hungarian monolinguals living in Hungary (Budapest). They have never lived abroad for a more extended period. Their foreign language knowledge varies in terms of languages and levels, but they do not regularly use any language other than Hungarian. All participants were females, aged between 30 and 60 years. The maximum age was set at 60 years so that aging did not affect the data. The three groups did not differ significantly in terms of age and gender distribution. All participants had normal hearing based on self-report. In order to get information on participants' language background, they filled in a short online questionnaire about their language use and residence history. The questions were about the age of arrival (AoA) (also called age at emigration), length of residence (LoR), L2 level, and language choice in various situations. Table 1 illustrates the demographic data on the participants across the three groups.

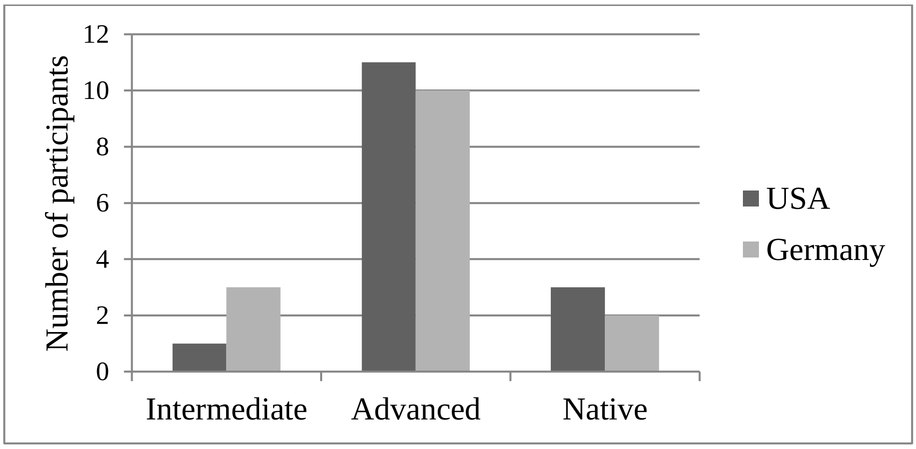
Table 1. General information about listener groups. Mean and standard deviation (in parentheses) are shown

	Monolingual controls (N = 15)	Hun-English late bilinguals (USA) (N = 15)	Hun-German late bilinguals (Germany) (N = 15)
Age (years)	43.2 (6.9)	51.0 (4.3)	41.5 (3.2)
AoA (years)	n/a	29.6 (9.0)	27.3 (3.4)
LoR (years)	n/a	21.4 (7.9)	14.1 (4.8)

All late bilinguals immigrated to the foreign country after puberty, at least 18 years old. Most female participants left their native country in their twenties or thirties. Median ages of emigration did not differ significantly between the USA and Germany groups by Kruskal–Wallis test by ranks ($p > 0.05$). The minimum length of residence (LoR) was set as a criterion for participation in this research following the sampling design of previous works (see Köpke & Schmid, 2004; Bátyi, 2020). The person who has been living in a foreign country for the longest time moved out 41 years ago (a USA group member). There was a negative correlation between AoA and LoR (Pearson: $r = -0.688$; $p < 0.001$). Overall, Hungarian–English bilinguals emigrated earlier and lived in an L2 environment for a longer period than Hungarian–German bilinguals. LoR did differ significantly between the USA and Germany groups by Kruskal–Wallis test by ranks ($\chi^2 = 4.676$; $p = 0.031$).

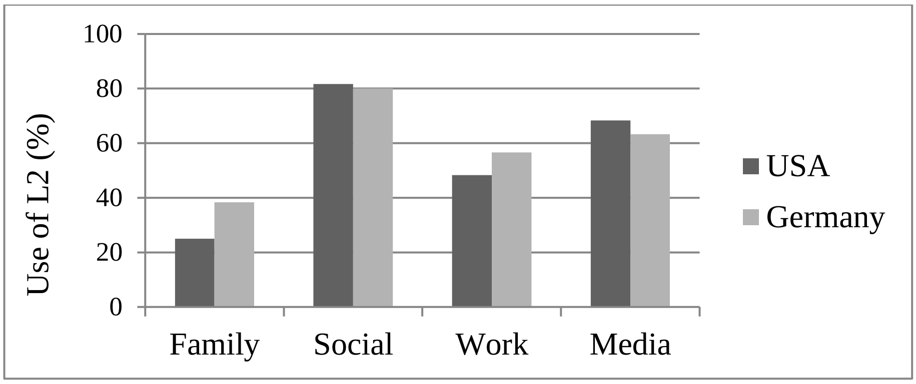
The distribution of the participants' language levels in L2 (English or German) is depicted in Figure 1. Participants could choose one category from a continuum divided into four proficiency levels: novice, intermediate, advanced, and native. As expected, none of them chose "novice." Most participants considered their language skills to be advanced, and some claimed to be equal to native speakers of the L2. Overall, the L2 is spoken at a very high level based on participants' self-reports.

Figure 1. Self-reported L2 proficiency level



Language use was measured on a four-point scale. Participants indicated how often they use L1 vs. L2 in different situations: in the family, in social relationships, at work, or during media usage. Answers are summarized in Figure 2. Hungarian (as L1) is used mainly with family members; however, in the other three situations, bilinguals seemed to prefer the country's official language, English or German (as L2).

Figure 2. Language use in different situations



2.2. Stimuli

The base stimuli of the present experiment were VC(:)V non-words read by a 27-year-old Hungarian native female speaker in a sound-proofed booth. The VC(:)V sequences contained Hungarian stops [p, t, k] and their geminate counterparts, preceding and following vowel [i]. The place of articulation (PoA) was varied to create diversity in the materials. Neuberger (2016) showed that the original non-words could be identified at an accuracy rate of 100%. Six tokens were selected for manipulation for the present study: two quantity categories (singleton and germinate) × three places of articulation (bilabial, alveolar, and velar). These tokens constituted the starting point for the construction of the continua. Two sets of stimuli were created by duration manipulation by PSOLA analysis-resynthesis method in Praat (Boersma & Weenink, 2020). Only stop closure duration was changed, i.e., the silent interval became shorter or longer, and temporal and spectral properties of the adjacent vowels, the voice onset time of voiceless stops, and the burst releases remained unaltered. There were no audible artifacts of the manipulation. In the first case, stimuli were made by artificially lengthening the closure duration (CD) of original singletons in 10 ms steps. CD of the original geminates was shortened likewise in 10 ms steps. Thus, for each stop, two continua were created with identical closure duration values ranging between 94 and 214 ms (13-step continua, which contain the base stimuli as well). Altogether, 78 tokens were created.

2.3. Procedure

The stimuli presentation and perception data collection were done on the GMS online platform (http://gms.hu) provided by Level Up Production. Participants were asked to listen to the recorded samples through earbuds or headphones. The listeners' task was to decide whether the medial consonant of the token was short/singleton or long/geminate and to make their responses by clicking on one of two buttons on the screen (short/long). The stimuli were played in random order (different order for each participant). The listeners were allowed to replay the stimulus tokens multiple times, but the task included that, if possible, they should rely on their first impression and repeat the item only if they thought it necessary. Once a choice was made, the listeners could not change their decision, and the following sample played automatically.

2.4. Analysis

The percentage of geminate ('long') responses at each closure duration were computed. Response curves (fitted logistic function) were plotted, and the perceptual boundaries between singletons and geminates, as well as boundary width, were computed using R (R Development Core Team, 2019). The placement and the steepness of two sigmoid functions related to singleton vs. geminate base token were also analysed.

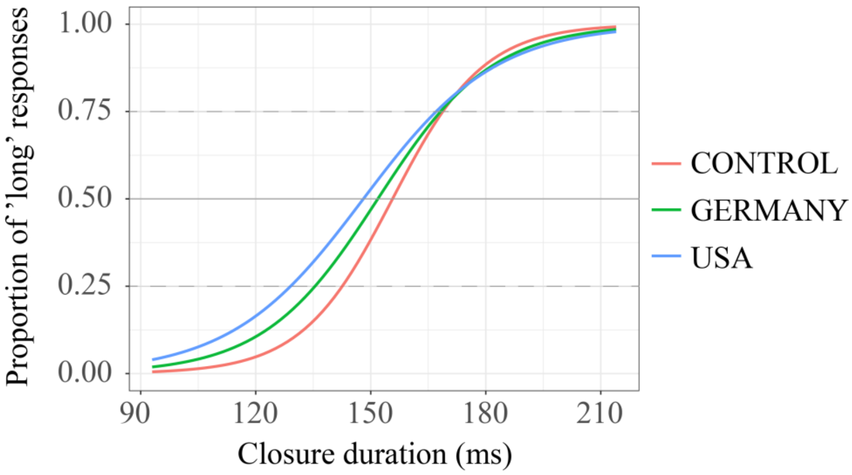
The perceptual boundary (cross-over point) was defined as the closure duration at 50% of 'long' responses (see van Heuven & Kirsner 2004 for a summary of response curves). At this point, half of the participants judged the consonant as 'short,' while the other half judged it as 'long.' It was measured in the overall data and for individual listeners as well.

Boundary width (uncertainty margin) was defined as the distance along the CD axis between the 25 and 75% identification scores. The wider this region, the shallower the slope in the sigmoid cross-over, which gives information about the well-definedness of the singleton-geminate contrast. It was measured in the overall data and for individual listeners as well.

3. Results

First, we analysed the data pooled over all consonants. A logistic function was fitted to the data points (Figure 3). Response curves represent the percentage of 'long' responses (y-axis) as a function of closure duration (x-axis). Different colours represent the response curves of different groups of participants. Listeners judged consonants with relatively long closure durations as 'long' and hardly judged consonants with relatively short closure durations as 'long.' Approximately 90 ms closure duration induced a total agreement of 'short' response among the participants in each group (in this case, the proportion of 'long' responses was close to zero). Closure durations approaching 210 ms triggered unanimous 'long' decisions in each group (in this case, the proportion of ‘long’ responses was close to 1). For statistical analysis, we set Responses as the target (or dependent) variable, Closure duration, (listener) Group, Base token and PoA as fixed effects, and (individual) Listener as a random effect. Their interactions were also analysed. Results of the logistic regression (generalized linear model with binomial (link = "logit") function) showed that closure duration had a significant effect on the overall responses: $Z = 6.525$; $p < 0.001$. A significant interaction between closure duration and listeners’ group was revealed: $Z = –3.396$; $p = 0.010$. Pairwise comparison (Tukey post hoc test) revealed that the responses of the USA group differed significantly from those of the control group ($p < 0.01$).

Figure 3. Proportion of ‘long C’ responses as a function of closure duration (ms) for L2 groups and control group



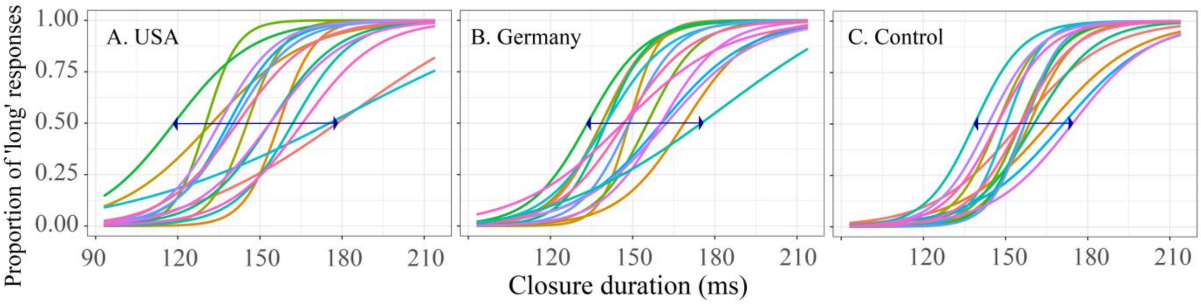
The shape of response curves is based on the average responses of a group of participants. S-shaped response curves were found in each group. However, it is seen in Figure 3 that the steepness of response curves differed among listeners’ groups. Therefore, in the next step of the analysis, we focused on the differences among groups.

Boundary width (i.e., distance along the CD axis between the 25 and 75% identification scores) was 38 ms for the USA group, 33 ms for the Germany group, and 26 ms for the control group. This indicates that the singleton-geminate contrast in monolinguals’ perception is well-defined, but more ambiguous boundaries were found in late bilinguals’ consonant length discrimination (when analysing the averaged data).

It can be noted that the sigmoid functions of the three groups of participants were asymmetrical; they showed greater differences at the singleton end of the continua than at the geminate end. Closure duration of 165 ms and up resulted in unanimous responses from the three groups. In contrast, at the low end of the continuum, the performance of the USA group was quite different from that of monolinguals. USA migrants became uncertain as soon as the CD exceeded 127 ms, while monolingual Hungarians considered CDs up to some 140 ms as convincing tokens of singletons. The question arises of what reason causes more uncertainty at the low end of the continuum rather than at the high end. To get closer to the answer, we examined the responses in detail.

It is known from earlier research that large between-listener variability in cross-overs may occur (especially in temporal phenomena, see Remijsen & van Heuven, 2003). In our research, the boundary between the categories varied substantially from one listener to the next (Figure 4). All listeners had a complete cross-over from 25 to 75%. The spread among the participants was relatively small at the low end of the continuum, larger around the 50% mark, while most varied around 75%. This asymmetry was characteristic of all three groups, and it formed a mirror image compared to what we found in the curves plotted for the means of the 15 listeners per group (i.e., Figure 3). This means that the performance at the group level showed a more considerable difference at the 'singleton' end of the continuum (shorter CD), but within the group, individuals' responses showed greater disagreement at the 'geminate' end.

Figure 4. Response curves for individual listeners



Between-listener variability was the largest in the USA group and the smallest in the control group. The mean and standard deviation of boundary width (CD range between 25–75% identification scores) and cross-over point (CD at 50% identification score) of individual listeners are shown in Table 2. Greater boundary width (shallower slope) measured in the overall data (Figure 3) compared to the mean of individual data (Table 2) reveals an effect of averaging. The same effect was found by Remijsen and van Heuven (2003). When comparing the three group means, neither boundary width nor CDs at the 50% cross-over point differed significantly between listener groups; however, the difference between the USA group and the control group approached the level of significance ($p = 0.089$). Hungarian–English bilinguals judged the stops as 'long,' even in case of shorter CDs, than the other two groups.

Next, we normalized the listener-individual curves to the mean value of the 15 listeners in the group so that all curves had their 50% cross-over at the group mean. A one-way ANOVA on the CDs at the 25% crossing points showed a significant difference among the groups: $F(2, 42) = 9.898$; $p < 0.001$. Tukey post hoc test showed that the difference was significant between the USA group and the control group ($p < 0.001$), and it was close to significant between the USA and the Germany groups ($p = 0.075$), as well as between the Germany group and the control group ($p = 0.083$). The CDs at the 75% crossing points did not differ between the groups.

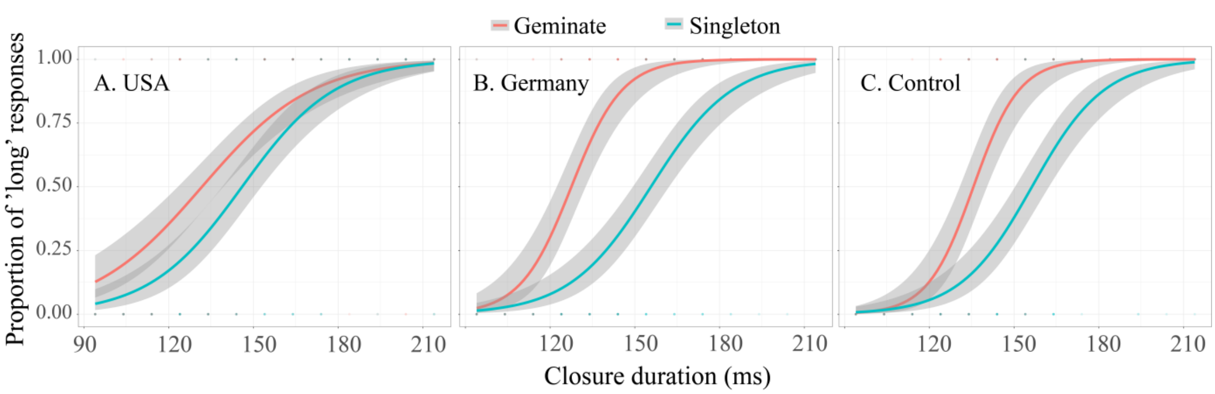
Table 2. Mean and standard deviation of boundary width and cross-over point based on individual listeners' response curves

	Hungarian–English bilinguals	Hungarian–German bilinguals	Control group	Overall
Boundary width	32 (20)	26 (11)	23 (8)	27 (14)
Cross-over point	148 (19)	152 (17)	156 (10)	152 (15)

The relationship between boundary width, 50% boundary, AoA, and LoR was examined using the Pearson correlation. No significant correlation was shown between the outcome and demographic variables.

The effect of the base stimulus (whether the original token was a singleton or a geminate) was proved to be significant: $Z = -2.106$; $p = 0.035$. According to PoA, only in the case of velar stops were original geminates identified as 'long' more frequently than original singletons (Figure 5). This was not the case in labial and alveolar stop, for which quasi-identical response curves were shown irrespective of the stimulus origin. In /k/, responses to originally geminated stimuli crossed over from 'short' to 'long' about 20 ms earlier than responses to stimuli created from singletons (at the 50% point). This kind of displacement was manifested in all listeners' groups (USA group: 14 ms; Germany group: 28 ms; control group: 20 ms). Moreover, a sharper sigmoid function was assigned to responses to original geminates than to original singletons in German-Hungarian bilinguals and monolinguals (but not in English-Hungarian bilinguals), with boundary width of 28-32 ms for singleton origin and 18-19 ms for geminate origin (USA 36 and 43 ms for singleton and geminate origin, respectively).

Figure 5. Response curves for /k/ stimuli according to the original quantity



4. Discussion and conclusion

Phonetics and phonology can be strongly involved in change under multilingual pressure, as shown by previous research and observations (Celata & Cancila, 2010; Rafat et al., 2017; Alkhudidi et al., 2020). The present research was based on the assumption that "production and perception of vowels and consonants *remain adaptive over the life span,* and that phonetic systems reorganize in response to sounds encountered in an L2 through the addition of new phonetic categories, or through the modification of old ones" (Flege, 1995: 233).

We investigated how monolingual and bilingual listeners discriminated quantity categories along a continuous duration scale. Our first hypothesis (H1) concerned changes in the perceptual sensitivity to the Hungarian consonant length contrast due to long-term exposure to L2 and reduced contact with L1. The data partially confirmed this hypothesis. On the one hand, perception data made evident that closure duration is a sufficient cue of the singleton-geminate contrast in Hungarian monolinguals and in late bilinguals whose L1 is Hungarian. S-shaped curves were found as a result of our two-alternative forced-choice test in each group of participants, which could make us assume that singletons and geminates are perceived categorically. Note that categorical perception would also require another condition to be met: a local peak in the discrimination function, i.e., easier discrimination of pairs of stimuli across the categorical boundary (van Heuven & Kirsner 2004). However, such an experiment was not conducted for the present research, so concluding categorical perception may be premature.

On the other hand, we found differences among groups concerning the time domain associated with perceptual boundaries between singletons and geminates, more precisely, the steepness of the cross-overs from singleton to geminate. Hungarian–German late bilinguals (Germany group) performed quite similarly to the control group. However, Hungarian–English late bilinguals' (USA group) performance was more distant than the control group. The statistical analysis confirmed a significant difference between the USA and the control groups, but it was not the case between the German and the control groups. Since the age of arrival was lower and the length of residence was longer in the USA group than in the Germany group, it is conceivable that socio-linguistic attrition might be responsible for shaping the perceptual performance of the L2 groups. However, there was no correlation between boundary width and AoA at the individual level. Concerning the explanation of the shallower slopes for the USA group, it can also be assumed that consonant geminate attrition should be less in the German group than in the USA group because the German language possesses a vowel length contrast, but English does not (but has tense-lax instead). Familiarity with any type of duration-based contrast (e.g., vowel length contrast) may have a positive effect (to varying degrees) on the processing of consonant length contrast.

The shallower response curves are possibly due to the fact that emigrants hear and use quantity contrasts less often in their speech perception and speech production than monolinguals. We do not claim that the shift towards a shorter value must be due to immersion in the L2 since no remarkable differences can be found in the average closure duration of voiceless stops between English/German and Hungarian (see literature in 1.3.). The same experiment with native English and German participants would make it possible to investigate whether the cause for the shift of the sigmoid function to a lower value could be assigned to cross-language differences.

We observed asymmetry in the response curves. Listener-individual differences were greater at the higher CD values, i.e., 'geminate' end. However, the between-group comparison showed a wider uncertain region for bilingual participants towards the lower end of the scale, especially between 120 and 140 ms. Why did listeners with different language backgrounds show less agreement at the 'singleton' end of the continuum than at the 'geminate' end? Possible explanations for the phenomenon could be related to between-listener variability in cross-overs or potential complementary information encoded in the (base) stimulus. Bilinguals' higher uncertainty level in this region may arise from giving greater weight to additional acoustic properties, such as relative duration (e.g., the ratio of consonant to preceding vowel duration, VOT proportion in the VCV sequence), release burst information (e.g., release amplitude), which contribute to various distinctions in English or German, for instance, place of articulation or voiced-voiceless distinction (Sharf, 1962; Ohde & Stevens, 1983; Mikuteit, 2007). Furthermore, cross-language differences in stop production (aspiration, VOT, see Lisker & Abramson, 1964; Mikuteit, 2007; Altmann et al., 2012) might also have influenced the bilinguals' judgments. However, in the present research, we do not have enough evidence which could help to understand the possible reasons behind the asymmetry.

The expectation (H2) regarding the effect of base stimuli was not entirely met. It is claimed that geminates are marked (i.e., rare) sounds compared to singletons (Maddieson, 1984) and may have more acoustically prominent features in addition to closure duration. The response curves for singleton and geminate base token were not identical in case of the velar stop, but such a difference was not seen in the other two places of articulation. Following Hankamer et al. (1989), it can be concluded that when the closure duration cue is ambiguous, listeners may rely on secondary cues when making a forced categorization. However, not every participant's perception was sensitive to these secondary cues, as indicated by the slight displacement of curves in the USA group compared to the other two groups. The displacement of the geminate-based curves to the lower values along the time axis reinforces the markedness of geminates. Further research is needed to investigate which acoustic properties play a role in the distinction (e.g., preceding vowel duration, closure voicing, or combination of acoustic characteristics) and why they were salient only in the stimuli containing velar stop (but not labial and alveolar).

Overall, our analysis concludes that there are no dramatic changes or significant weakening of L1 skills on the phonological language level concerning geminate perception. This result is in line with results from previous studies on L1 attrition in post-puberty migrants (Köpke & Schmid, 2004; Navracsics, 2015; Bátyi, 2020). We can assume that certain areas of language are more vulnerable to attrition than others; geminate attrition might be sooner manifested in production (pronunciation) than in perception.

It must be emphasized the difficulty of arguing about the causes of attrition. It seems to be indecisive that our findings (less clearly defined category boundaries in the original L1 in bilinguals) are because of the lack of exposure to the original L1 (i.e., a matter of forgetting), or is it that the original contrasts are adapted to the norms of the L2. We are unable to determine whether the difference in bilinguals' performance compared to that of monolinguals corresponds with a loss of linguistic information (the decline of competence) or impaired access to linguistic information (a performance/processing problem or retrieval slowdown) (see Ecke, 2004 for a review of analogies between forgetting and language attrition). Even though the present research was carried out with a limited number of participants, findings might contribute to understanding geminate perception in bilinguals.

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