

A feature-based phonological acquisition model: Behavioral and electrophysiological evidence from speakers of L1 Spanish – L2 English

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1.0 Introduction

The acquisition of a second language (L2) is clearly different from that of a first language. Adult L2 learners tend to demonstrate high amounts of variability in their L2 competence and production, rarely gaining the same command over a language that children do when acquiring their first language (L1). The most obvious factor that distinguishes child versus adult acquisition is the fact that the adult begins the L2 learning process already knowing a language, and naturally, the knowledge of the L1 grammar has an effect on the acquisition of the L2. This view is widely accepted in the field of second language acquisition (Flege 1981, Navarro 2010, Scovel 2000), but there is more debate over how the L1 grammar affects the L2 acquisition. Additionally, this failure to achieve native-like performance in the L2 is often times more apparent in the phonological domain, as opposed to the morphosyntactic domain (Long 1990, Moyer 1999).

The primary goal of this paper is to determine whether or not the structure the L1 phonological inventory and the distinguishing features that compose it has an effect on a speaker's ability to discern certain non-native contrasts. I aim to determine if one can predict a speaker's success in discriminating non-native phoneme contrasts in the L2 by examining if the distinguishing feature in the target contrast is present elsewhere in the L1.

2.0 Age-related approaches to second language acquisition

Many acquisitionists argue that age related effects or a critical period can account for the difficulties in fully acquiring an additional language, claiming that physiological maturation has a strong effect on the ability to achieve native-like competence in the L2 (Birdsong & Mollis 2001; Johnson & Newport 1989; Lightbown, Spada, Ranta, & Rand 2006). This is often

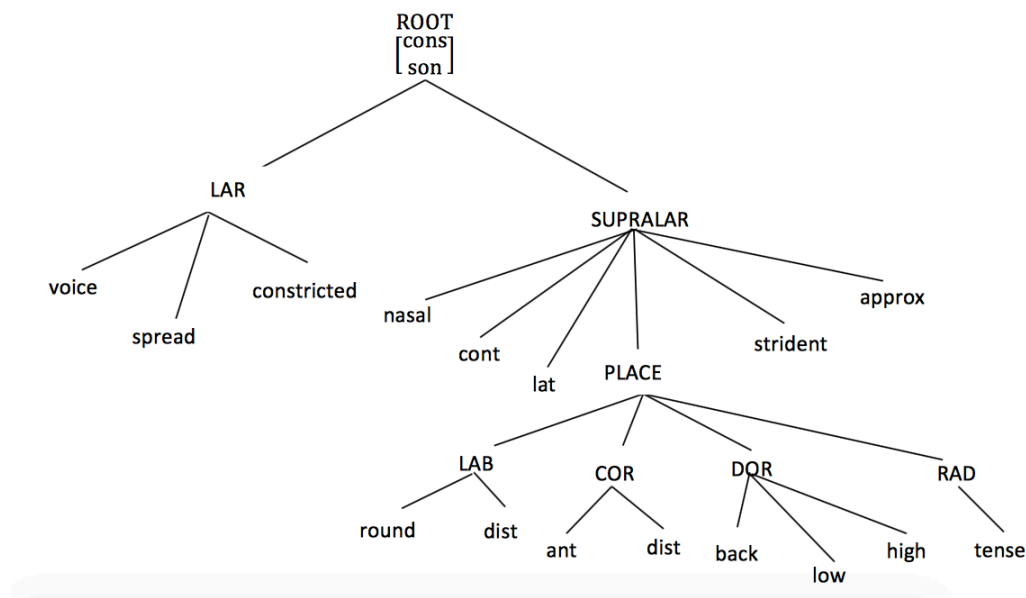
attributed to a loss of cerebral plasticity, caused by the lateralization of the language function and the myelination in Broca's area and throughout the cortex, which occurs after the onset of puberty. Lenneberg, Chomsky, & Marx (1967:176) argue that it is because of this, "automatic acquisition from mere exposure to a given language seems to disappear after this age [of puberty]". The end of the critical period implies a loss of direct access to universal grammar (UG), which is the innate, biological program for language that constrains the hypotheses that learners construct about any given grammar to which they have been exposed (Birdsong 1999; Juffs & Harrington 1995). When learners reach the end of the critical period at puberty, discovering the rules governed by UG, which are necessary for full attainment of any language, becomes more difficult, if not impossible, suggesting that maturation hinders L2 acquisition.

Another theory that accounts for age-related affects in second language learning without relying on physical maturation of the brain is the notion of L1 entrenchment: when adults begin learning their L2, they already have the L1 grammar entrenched in their minds, causing all L2 input to go through an L1 filter, hindering perception and, therefore, acquisition (Bylund, Abrahamsson, & Hyltenstam 2012). Therefore, the possibility exists that attaining native-like proficiency in an L2 becomes increasingly difficult with time not because of a loss of neural plasticity but because of L1 entrenchment. This is, however, still an age-related approach because the younger the age of exposure is to the L2, the less L1 entrenchment there is, which then decreases the potentially parasitic effects that the L1 will have on the L2.

2.1 L1 phonology and its acquisition

Current phonological theory within a generative framework assumes that any given phoneme has a structural representation composed of distinctive features. These features are

organized hierarchically to form a multi-tiered representation for each individual segment, also known as a feature geometry, which distinguishes a segment from all other segments in that language's phonemic inventory (Clements 1985, McCarthy 1988). The class nodes include place, along with its subsequent features, and manner. These are dominated by another set class nodes, the supralaryngeal and laryngeal tiers, which are then dominated by the root node that is attached to the segment.



Each segment will have its own specific feature geometry. However, following the theory of Minimally Contrastive Under Specification (Avery & Rice 1989), these segmental representations contain only the information that is necessary to phonemically contrast any given segment with all the other segments in its respective language, and additional specification is provided via phonetic implementation. Therefore, the representation of a segment depends entirely on the segments with which it is contrastive within the particular inventory. The feature geometry template is part of UG; syntactic information from UG constrains the acquisition, while the feature geometry contained in UG provides the template from which the child constructs the phonological segmental representations of the L1 grammar, ultimately resulting in

the possible phonemes of that language (Brown & Matthews 1997: 68). Additionally, UG provides a markedness theory that supplies the information to determine which features are underspecifiable; in the unmarked case, the features will be absent from the underlying representation. Avery & Rice (1989) also argue that this underspecification is inventory-driven and not rule-driven, and, therefore, rules must follow the representations provided by the feature geometry. For example, in English, the lateral and central approximants, /l, r/ respectively, are contrastive, and subsequently have feature geometries that differ at the lateral node on the supralaryngeal tier. In contrast, a language such as Japanese that does not contrast these two sounds at the phonemic level would have only one representation; even though these sounds are allophones of the same phoneme, they both have the unmarked [-lateral] feature in their structural representation. Any subsequent rule that determines the environment in which one sound is present versus another must be based on the underlying unmarked representation and then implemented at the phonetic level. Although no language is phonemically rich enough to have contrastive sounds for every possible representation on the feature geometry, all languages can accurately and adequately represent their phonemes in terms of features and structural relationships with this framework.

Children are able to contrast two phonemes in their native language once the internal feature geometries that distinguish the segments have been acquired. However, it is important to note that children only have access to the surface forms of the target language, so any properties of the grammar that are acquired must come from the innate acquisition apparatus, presumably UG. Following this, the Pruning Hypothesis (Brown & Matthews 1997), which relies on a child's sensitivity to negative evidence, claims that UG provides the learner's emerging grammar with a complete feature geometry that retracts or "is pruned" where the input does not support

the phonological contrasts. Therefore, any grammatical information that is unmarked or irrelevant as per the theory of Minimally Contrastive Underspecification, would be deleted to form the final structural representation of each segment.

The time-period in which learning these representations and native phoneme contrasts takes place has been shown to occur in infancy. Dehaene-Lambertz & Baillet (1998) demonstrated that by the age of three months, infants display phonological processing that is analogous to that of adults. Twenty-four French infants were tested in an event related potential (ERP) perception task, in which a stream of identical syllables was presented with various but equal acoustic deviants that crossed either a phonetic or phonological boundary in French. They found that ERP responses were larger for phonological changes, which mirrors the results found in adults. Another study, performed by Rivera-Gaxiola, Silva-Pereyra, & Kuhl (2005) investigated native versus non-native phonetic perception of infants in an ERP study. American monolingual infants at seven months old were followed longitudinally until 11 months to investigate native versus non-native phonetic contrasts. Their findings revealed that infants at seven months can discriminate both native and non-native phonetic contrasts, but by 11 months, the ERPs show increased sensitivity and responsiveness to native phonetic contrasts, failing to discriminate the non-native contrasts. Although Rivera-Gaxiola et al.'s study investigated phonetic discrimination, it can support the notion of infant phonological discrimination because the phonetic domain is even more sensitive than the phonological domain.

2.2 L2 phonological acquisition

In order to successfully acquire new phonological representations, one must correctly perceive these segments. Clearly, phonological discrimination and the construction of the

correct phonological representations for a particular grammar occurs at a very young age, leaving late L2 learners at a disadvantage. Because of this, a high degree of variability is present in L2 productive speech. However, it is possible that this variability does not originate in production but in perception.

One of the main models that addresses this salient issue in the field of acquisition is the Speech Learning Model (Flege 1995). The Speech Learning Model (SLM) aims to account for age-related limits on the ability to produce L2 sounds with a native-like accent. For correct realizations of any given L2 sound, the speaker must discern a phonetic difference between that sound and any similar sounds that are present in the L1. In discerning the sounds phonetic (or phonological) differences, the speaker forms a new phonetic category for this sound. If, however, the L2 segment is perceived as an allophone of an L1 sound, new phonetic category formation is blocked, ultimately resulting in a “compromise” feature. Furthermore, if the sound is perceived correctly and a new phonetic category is formed, the production of the L2 sound still may not resemble that of a monolingual, reflecting the speaker’s need to maintain phonetic contrast between the sounds in each respective language.

Brown (2000) proposes another model that aims to explain this difficulty in L2 phonological acquisition. She claims that an adult’s ability to discriminate L2 sounds that are not contrastive in the L1 is dependent on the structure of the L1 inventory and the structures (feature geometries) that compose it. If the L2 sound that is not contrastive in the L1 corresponds to a native segment, then the ability to discriminate these sounds and subsequent acquisition of their production is probable. Segments are said to correspond if the surface realization of the L2 segment could reasonably be assumed to be a surface realization corresponding to the underlying representation of an L2 phoneme. For clarification, she

provides an example: Japanese [Φ] (voiceless bilabial fricative) can be considered to correspond to the underlying representation of /f/. Therefore, a Japanese L1 speaker could perceive an English /p-f/ contrast because [p] will be perceived as /p/, a native Japanese segment, and [f] will be perceived as [Φ].

At a first glance, Brown's proposition seems to contradict that of the SLM. However, it is important to note that the SLM predicts that if the L2 sound is perceived as an allophone of an L1 sound, then discrimination between these two sounds is not likely, while Brown states that if the L2 sound is perceived as an allophone of a different L1 sound, then discrimination between this sound and another sound is likely. Therefore, these two models are not contradictory: the SLM would predict that a Japanese L1 speaker would not be able to perceive a [Φ-f] contrast, but, as Brown pointed out, this speaker should be able to perceive a [Φ-p] contrast.

2.3 Phonological inventories of Spanish and English

For this current study, I investigated phonological discrimination of English sounds by Spanish L1 speakers. Therefore, the respective inventories of these languages are important.

South American Spanish phonemic consonants

	Labial	Coronal	Palatal	Velar
Stop	p b	t d		k g
Fricative	f	s		x
Affricate			tʃ ʝ	
Nasal	m	n	ɲ	
Lateral		l		
Trill		r		

American English phonemic consonants

	Labial	Coronal	Palatal	Velar	Glottal
Stop	p b	t d		k g	
Fricative	f v	Dental θ ð Alveolar s z Post-alveolar ʃ ʒ			h
Affricate			tʃ dʒ		
Nasal	m	n		ŋ	
Lateral		l			
Approximant		r	j	w	

3.0 This study

Extensive work has been done on L2 acquisition in the phonological domain. More recent studies have implemented the cognitive neuroscience method of event related potentials (ERPs) to show that phonological differences between languages result in different neural responses to native versus non-native phoneme contrasts, indicating that exposure to particular speech sounds conditions language-specific neural responses. This study aims to add to this research by providing evidence that a speaker's L1 phonological inventory constrains the L2 acquisition of certain non-native contrasts, based on whether the distinguishing feature in the non-native contrast is present in other L1 contrasts with both behavioral and electrophysiological (ERP) evidence.

4.0 Methodology

4.1 Participants

The participants of this study included 67 monolingual speakers of Spanish who all had had little to no exposure to English at the time of the experiment. Their ages ranged from 18-37

with a mean age of 26.2. All participants were right handed, and none of them reported history of any hearing or neurological disorders.

4.2 Materials and Methods

The experiment took place in a sound proof chamber. Participants were asked to click a response button when they perceived a deviant sound. The hand in which the response button was held was counterbalanced between participants. ERP components were recorded with a 64-channel geodesic sensor net. The ERP component that was recorded was the MMN, which is automatically elicited by infrequent stimuli (deviants) that are embedded in a repeating stimulus (standards); this component was chosen because it has been proved to show neural activity that is related with phonemic discrimination in adults (Näätäneiv, Lehtokoski, Lennest, Luuki, Alliki, Sinkkonen, & Alho 1992)

4.3 Stimuli

The stimuli included 3 pairs of native and non-native CV syllable contrasts. The control (native contrast) pair was /s, f/, and the target (non-native contrast) pairs were /f, v/ and /s, θ/. For each pair, there were two blocks to counterbalance the deviant sound. For example, the first block would have /s/ as the standard and /f/ as the deviant sound, and the second block would have /f/ as the standard and /s/ as the deviant sound. The order in which the blocks were played was counterbalanced among participants. There was a 1:8 ratio of deviants to standards for each block. The deviants were not systematic, but there were at least three standards between every deviant. The inter-stimulus time was 500 milliseconds, with a one minute pause between blocks.

The CV stimuli were created from a woman's natural speech (age 20.4) and then manipulated in PRAAT in order to control for duration and pitch. All CV strings were 60 milliseconds long, with the target fricative lasting 17 milliseconds and the following vowel lasting 43 milliseconds. The pitch was neutralized to 230 Hertz for all sounds.

5.0 Hypotheses

For the /s, f/ L2 (English) contrast, all speakers will be able to accurately discriminate between these two sounds because both segments are contrastive in the L1 (Spanish).

For the /f, v/ L2 contrast, all speakers will be able to accurately discriminate between these two sounds. Although this contrast is not present in the L1, the distinguishing feature in the feature geometries of these sounds is [voice]. Because this feature [voice] is used contrastively in other parts of the L1 phonological inventory, it is expected that this feature contrast will be used for non-native contrasts as well, ultimately allowing the speakers to discriminate this non-native L2 contrast.

For the /s, θ/ L2 contrast, the speakers will not be able to accurately discriminate between these two sounds. This contrast is not present in the L1. The distinguishing feature of these two sounds is [distributed], which, in the feature geometry, is a subordinate node under the coronal node, which is dominated by the place node, which is further dominated by the supralaryngeal node. Because this feature [distributed] is not present in the L1 phonology, it is expected that this contrast will not be perceived. As per the SLM (Flege 1995) and Brown (2000), I predicted that the /θ/ will be perceived as an allophone of /s/, hindering the speakers' abilities to correctly perceive the distinction.

I expected that the above predictions would be evident in both the behavioral and ERP results, with the latter potentially revealing more sensitive, subconscious discriminations that the former did not show. The ERP results should also show faster reaction times than the behavioral results. Additionally, I expected that the MMN components would be stronger for the native contrast /s, f/ than the non-native contrast /f, v/.

6.0 Possible results and discussion

Both the behavioral and ERP measures support the hypotheses: the /s, f/ contrast was detected by all speakers, the /f, v/ contrast was detected by all speakers, and the /s, θ/ contrast was not detected by most speakers. The ERP MMN waveforms yielded weaker results for the non-native yet discernable contrast /f, v/ as compared to the native contrast /s, f/, as expected. All of these results are significant. The small amounts of reported variability in the non-native contrasts can be attributed to exposure to the L2. Although all participants reported that they had little to no exposure to English, some exposure is virtually inevitable.

The results found in this study give substantial evidence that the structure of the L1 phonology can aid and hinder the acquisition of certain non-native contrasts, depending on what the distinguishing feature is and if it is present elsewhere in the L1. Additionally, this supports the theory of Minimally Contrastive Underspecification for L1 phonology. If the underlying representations of native phonemic segments that speakers have included more than what was needed to be minimally contrastive with the other native phonemes in that language, then the results would have shown either that Spanish speakers can discriminate the /s, θ/ contrast, or there would have been a high degree of variability, ultimately yielding insignificant results. As this was not the case, the results did support this theoretical model. Furthermore, these results

add support in favor of the SLM. Because the speakers were not able to discriminate /s/ from /θ/, they must have perceived the latter (non-native) sound as an allophone of /s/ (native), as Flege predicted.

7.0 Conclusions

In the present study, 67 monolingual speakers of Spanish were tested in an aural discrimination task of native and non-native phoneme contrasts to determine if the L1 phonological structure affects the perception and subsequent acquisition of L2 non-native contrasts. The hypothesis that the contrasts in which the distinguishing feature was present elsewhere in the L1 grammar would be perceived correctly and others would not be was supported. The results from both the behavioral and ERP tasks ultimately provide support for models of both L1 phonological acquisition (Minimally Contrastive Underspecification) and L2 phonological acquisition (Speech Learning Model).

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