Orthographic and perceptual cue integration in cross-language categorisation of two Romance languages

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L2 phonological development is subject to orthographic influences (see Bassetti et al. 2015 for an overview). In particular, if the grapheme-to-phoneme mappings are incongruent in L1 and L2, as e.g. Portuguese <r>/ɾ/ - Chinese Pinyin <r>/ɻ/, the L1 orthographic mapping often determines the L2 output: though the Portuguese tap is not perceived as Mandarin /ɻ/, learners use [ɻ] for the L2 tap after being exposed to the written form (Zhou & Hamann 2020). Recent experimental evidence, however, indicates that orthographic effects on L2 phonology go beyond such incongruent letter-to-sound mappings, as perceptual cues and structural restrictions also play a role.

In this study, we consider **two such cases of cross-modal**, **cross-language** (L2 orthographic and L1 perceptual) **cue integration**. We provide a formalisation of these cases with a generative model that allows for cross-modal interaction, namely *Bidirectional Phonology and Phonetics* (BiPhon; Boersma 2007) with the extension of a reading grammar (Hamann & Colombo 2017), where the cross-modal cue integration is formalised as an additive effect in Harmonic Grammar (HG) with constraint satisfaction.

Case 1 (experimental results by Rafat & Stevenson 2018): When provided with input from Mexican Spanish, naïve Canadian English-speaking subjects use an innovative form /lj/, integrating auditory form [j] and written input <ll>, while sole reliance on L1 English grapheme-to-phoneme mapping predicts /l/. This cue integration occurs much more frequently in word-medial intervocalic position than word-initially. A formalisation of this position-sensitive cue integration is given in (1) and (2). When receiving only auditory input, L1-English learners categorise the glide accurately, regardless of position, cf. (1a) and (2a). When having both auditory and orthographic forms, due to their reliance on orthography, learners choose the integrated form /lj/ over /j/ in word-medial (2b) but not in word-initial position (1b). This is because the sequence /lj/ is not allowed word-initially by Canadian English phonotactics. The orthographic influence could have also led to the integrated form /jl/, which occurs more prevalently than /lj/ in the English lexicon. We postulate that the choice between /lj/ and /jl/ is determined again by Canadian English phonotactics, formalised with the umbrella constraint *English Phono*, which is satisfied by the forms /.lj/ and /j.l/, but not */l.j/ and */.jl/ (Duanmu 2002). The cue knowledge is captured by two transition-sensitive cue constraints: [jV]/jV/ applies to input glide cues with following vowel transitions, which holds for both initial (1) and medial position (2) and is satisfied if the glide is parsed as being followed by a vowel. [Vj]/Vj/ applies to those glide cues with preceding vowel transitions, which holds only for medial position (2a) and (2b), and is satisfied if the glide is parsed as being preceded by a vowel. As following vowel transitions are stronger perceptual cues (Steriade 2001), the first constraint has a higher weight. The grapheme-phoneme mapping is expressed with the orthographic constraint <ll>/l/, which is satisfied if the input <ll> corresponds to an /l/ in the surface output form.

Case 2 (experimental results by Zhou & Hamann 2020): The Portuguese tap is perceptually categorised as /t/ by some naïve Mandarin speakers due to the presence of a short closure phase. Exposure to written input <r> leads many of these listeners to modify the categorisation of the

Portuguese tap to /l/ (while the Mandarin grapheme-to-phoneme convention would lead to /ɻ/). Again, an integration of L2 cues and L1 orthography happens, as will be illustrated in our presentation.

(1) Word-initial position, as e.g., in *janeiro*

a) Perceptual input only

	0.8	1.2	1.5	1.0	*H*
[jV]	[Vj] /Vj/	[jV] /jV/	English Phono	<ll> /l/	
☞ /.jV/		1	1		2.7
/.lV/			1		1.5
/.ljV/		1			1.2
/.jlV/					0

b) Perceptual and orthographic input only

	0.8	1.2	1.5	1.0	*H*
[jV] <ll>	[Vj] /Vj/	[jV] /jV/	English Phono	<ll> /l/	
☞ /.jV/		1	1		2.7
/.lV/			1	1	2.5
/.ljV/		1		1	2.2
/.jlV/				1	1.0

(2) Word-medial position, as e.g., in *pojo*

a) Perceptual input only

	0.8	1.2	1.5	1.0	*H*
[VjV]	[Vj] /Vj/	[jV] /jV/	English Phono	<ll> /l/	
☞ /V.jV/	1	1	1		3.5
/V.lV/			1		1.5
/V.ljV/		1	1		2.7
/V.jlV/	1				0.8
/Vl.jV/		1			1.2
/Vj.lV/	1		1		2.3

b) Perceptual and orthographic input only

	0.8	1.2	1.5	1.0	*H*
[VjV] <ll>	[Vj] /Vj/	[jV] /jV/	English Phono	<ll> /l/	
/V.jV/	1	1	1		3.5
/V.lV/			1	1	2.5
☞ /V.ljV/		1	1	1	3.7
/V.jlV/	1			1	1.8
/Vl.jV/		1		1	2.2
/Vj.lV/	1		1	1	3.3

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