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TABLE OF CONTENTS

PRESENTATION 7

[SECTION: LEARNING AND ACQUISITION]

ENRÍQUEZ, NÚRIA AND LOURDES DÍAZ
Politeness in the oral discourse of L1 Spanish, L2 Spanish and heritage Spanish speakers 9

FERNÁNDEZ, AMAIA; NAGORE IPIÑA AND M.ª PILAR SAGASTA
How do bilingual children use their linguistic repertoire to communicate in English as an L3? 21

SÁNCHEZ-HERNÁNDEZ, ARIADNA AND EMILIA ALONSO-MARKS
Factors affecting the acquisition of Spanish pragmatic routines during study abroad 33

SUN, YULIANG; MARIONA TAULÉ AND LOURDES DÍAZ
A writing based study of the acquisition of aspect in Spanish by Mandarin Chinese learners 51

[SECTION: LANGUAGE TEACHING AND CURRICULAR DESIGN]

RAMOS ORDÓÑEZ, MARÍA DEL CARMEN
Interaction and integration in CLIL: a study on project-based cooperative learning 63

[SECTION: LANGUAGE FOR SPECIFIC PURPOSES]

FIELDEN BURNS, LAURA V.
Portfolio use for raising confidence and combatting level differences in English for specific purposes courses 75

PEREA BARBERÁ, MARÍA DOLORES
An Exploratory Study of Maritime English Corpora 85

RUBIO CUENCA, FRANCISCO
Using CLIL strategies for lesson planning in an English for aerospace engineering course 97

TORREGROSA BENAVENT, GABRIELA AND SONSOLES SÁNCHEZ-REYES PEÑAMARÍA
The police report as a genre in an ESP (English for law enforcement) curriculum..... 113

[SECTION: LANGUAGE PSYCHOLOGY, CHILDHOOD LANGUAGE AND PSYCHOLINGUISTICS]

CARRETERO GUZMÁN, ISABEL MARÍA
Psycholinguistics and Affective Learning: The Role of Motivation in L2 acquisition..... 123

MARTÍNEZ-GARCÍA, MARÍA TERESA
Tracking bilingual activation in the processing of Lexical Stress 133

[SECTION: SOCIOLINGUISTICS]

ARBOLEDA GUIRAO, INMACULADA DE JESÚS
Social and cognitive factors in the perception of English forenames: Antonia or Antonella? Judy or Judith? 145

NÚÑEZ NOGUEROLES, EUGENIA ESPERANZA
The impact of the English language on Spanish society..... 155

[SECTION**:** DISCOURSE ANALYSIS]

ALBALAT-MASCARELL, ANA
Worst trade deal maybe ever signed? A contrastive analysis of hedges in campaign debates..... 165

BOCANEGRA-VALLE, ANA
Promotional discourse at internationalised universities: a critical discourse analysis approach 175

FERNÁNDEZ POLO, FRANCISCO JAVIER AND MARIO CAL VARELA
A structural analysis of student online forum discussions..... 189

MORENO ALONSO, ANA
Metaphor in political speeches: An analysis of George W. Bush and Barack Obama's discourse..... 201

[SECTION: CORPUS LINGUISTICS, COMPUTACIONAL LINGUISTICS AND LINGUISTIC ENGINEERING]

GERSTENBERGER, CIPRIAN-VIRGIL
A grammar for Romanian weak pronoun generation 215

JIMÉNEZ-YÁÑEZ, RICARDO-MARÍA; HUGO SANJURJO-GONZÁLEZ; PAUL RAYSON AND SCOTT PIAO
Building a Spanish Lexicon for Corpus Analysis..... 227

[SECTION: LEXICOLOGY AND LEXICOGRAPHY]

PALMA GUTIÉRREZ, MACARENA
Internal constraints on the English middle construction: verb semantics and process types 237

[SECTION: TRANSLATION AND INTERPRETATION]

LÓPEZ-RODRÍGUEZ, CLARA INÉS
Conventionality and creativity in English into Spanish medical translation..... 251

MARTÍNEZ SERRANO, LEONOR MARÍA
Poets as translators: Seamus Heaney, Robert Hass and Mark Strand on the art of translating poetry 263

NEGRO ALOUSQUE, ISABEL
A comparative analysis of body movement verbs in English, Spanish and French..... 273

TRACKING BILINGUAL ACTIVATION IN THE PROCESSING OF LEXICAL STRESS

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ABSTRACT
This study investigates the effect of stress placement on the processing of English-Spanish cognates by native Spanish speakers and intermediate-to-advanced English-speaking second-language learners of Spanish using a visual-world eye-tracking experiment in Spanish. Growth-curve analyses on competitor fixations reveal cognate-status and stress-mismatch effects for native Spanish speakers, and they reveal cognate-status and stress-mismatch effects, and an interaction between the two for Spanish learners. This suggests that both groups use stress as a cue for word recognition, and that the English stress pattern affects the processing of Spanish words only for the native speakers of English.
Palabras clave: Bilingualism, Bilingual Activation, Lexical Stress

1. INTRODUCTION

Bilingual activation has been attested even in contexts in which bilinguals intend to use only one of their languages (e.g., Blumenfeld & Marian, 2011; Canseco-Gonzalez *et al.*, 2010; Desmet & Duyck, 2007; Dijkstra, 2005; Marian & Spivey, 2003; Schulpen, Dijkstra, Schriefers, & Hasper, 2003; Weber & Cutler, 2004). This finding is

consistent with the nonselective hypothesis of bilingual activation: Lexical representations in both language systems are automatically activated, even in circumstances where the unintended language is not explicitly used (for a review, see Kroll *et al.* (2012)).

This experiment has two main purposes: (1) determine whether intermediate-to-advanced English-speaking second-language (L2) learners of Spanish can use stress as a cue for word-recognition online, and (2) examine whether lexical stress modulates the degree of cross-language activation in an online task. The study compares native speakers of Spanish with English as their L2 and native speakers of English with Spanish as their L2 in a monolingual language mode experience, to further explore how proficiency and language dominance (L1 vs L2) affect bilingual activation. This study sought to confirm, then, that bilingual activation would be observed even in a situation where bilinguals are expected to function in one of their two languages (in a Spanish monolingual mode), in line with the nonselective hypothesis of bilingual activation. Furthermore, it sought to confirm that intermediate-to-advanced English-speaking L2 learners of Spanish could indeed use suprasegmental cues to stress during online word recognition, at least when the competitor word is not a Spanish-English cognate (Martínez-García *et al.*, n.d.), which is when they do not experience the potential interference from their native language.

This experiment uses the visual-world eye-tracking paradigm to assess the degree of cross-language interference caused by Spanish-English cognates in the recognition of Spanish target words.

2. EXPERIMENT

2.1. Participants

Two groups of participants were tested: a group of 48 native speakers of Spanish with a mid-proficiency level in English, tested in Spain, and a group of 40 mid-to-high-proficiency English-speaking L2

learners of Spanish tested in a Midwestern university in the US. The main purpose of having these two groups was to determine how bilingual activation may depend on whether the unintended language is the L1 or the L2. Table 1 provides some more detailed information about these two groups.

Table 1. Participants' background information

	Age of Acquisition	Years of L2 Instruction	Proficiency in L2 (cloze test + Lextale)
L1 Spanish	9.9 (1.4)	13.1 (4.1)	59.0% (9.8%)
L1 English	14.1 (3.4)	8.1 (3.8)	73.5% (14.1%)

Note. Mean (SD)

2.2. Materials

32 Spanish trisyllabic nouns with regular stress placement in one of two competitor conditions were recorded by a native speaker of Spanish. The target was always a word with stress on the penultimate syllable (e.g., *asado* 'roasted', or *materia* 'matter/subject'), and this target was presented on the screen together with a competitor. In the stress-mismatch condition, the competitor was a word in which the first two syllables were segmentally identical to but suprasegmentally different from the target word, with the competitor word having word-final stress (e.g., *asador* 'rotisserie', or *material* 'material'). In this stress-match condition, the target and competitor words also differed in the last segment (e.g., *asados* 'roasted (pl)', or *materias* 'matter/subject (pl)') but had the same stress pattern (penultimate). Comparing the levels of competition between these two conditions would allow us to examine the moment-by-moment processing of Spanish stress.

To test for the effect of stress on bilingual activation, 16 of the experimental items belonged to a non-cognate condition, in which none of the words on the screen was a Spanish-English cognate. The remaining 16 belonged to the Spanish-English cognate condition, with

the English stress of the critical competitor (e.g., *material*, with third syllable in Spanish, second syllable in English) word matching that of the Spanish target (e.g., *materia*). It was expected that these orthographic cognates would activate both Spanish and English phonological representations, with participants needing to inhibit the English stress pattern to recognize the Spanish target word as early as in the second syllable. Competitor words within and between conditions did not differ in either frequency or length, neither did the target words in both conditions. An example test item for the non-cognate condition is shown in Table 2 and for the cognate condition in Table 3.

Table 2. Example stimuli in the non-cognate condition

	Stress-mismatch condition		**Stress-match condition**	
Auditory Stimulus	Visually Presented Words		Visually Presented Words	
asado 'roast'	**Target**	**Competitor**	**Target**	**Competitor**
	"asado" 'roast'	"asador" 'rotisserie'	"asado" 'roast'	"asados" 'roast (pl)'
	Distracters		**Distracters**	
	"camisas" 'shirt (pl)'	"camisones" 'nightshirt (pl)'	"camisón" 'nightshirt'	"camisones" 'nightshirt (pl)'

Table 3. Example stimuli in the cognate condition

	Stress-mismatch condition		**Stress-match condition**	
Auditory Stimulus	Visually Presented Words		Visually Presented Words	
asado 'roast'	**Target**	**Competitor**	**Target**	**Competitor**
	"materia" 'matter/subject'	"material"	"materia" 'matter/subject'	"materias" 'matter/subject (pl)'
	Distracters		**Distracters**	
	"parados" 'unemployed (pl)	"paradores" 'inn (pl)'	"parador" 'inn'	"paradores" 'inn (pl)'

The target and competitor words were presented orthographically on the screen, together with two distracter items. These distracter words were created following the same structure as the experimental items, making sure that parameters such as the number of plural and singular nouns and the number of heavy vs. light final syllables in the singular form would be balanced. This experiment also included 96 filler trials, following the same design as that described for the experimental items. Two different lists were used such that each participant would see each target with only one competitor type.

2.3. Procedure

Participants had their eye movements recorded by a head-mounted Eyelink II at a sampling rate of 250 Hz. In each trial: Participants first saw the four orthographic words for 4,000 ms, which they were instructed to silently read. The words then disappeared, and a fixation cross appeared and stayed on the screen for 500 ms. As the fixation point disappeared, the same four words reappeared on the screen and participants simultaneously heard the target word through

headphones. Participants were asked to click on the word that matched the acoustic input as quickly and accurately as possible.

The experiment consisted of 132 trials presented in four different blocks. The position of the target and competitor words in the display and the order of the test items (experimental, filler) were randomized across trials.

2.4. Data Analysis

Growth curve analysis (GCA) was used to model listeners' differential proportions of fixations (Mirman, Dixon, & Magnuson, 2008), which allows to model the curvilinear relationship between proportions of eye fixations over time. To conclude that stress of the English cognate competitor word had an effect on participants' fixations, the GCA outcome results must reveal an interaction between this variable and at least one time polynomial.

The GCAs were run on participants' differential proportions of fixations using the lme4 package in R (Bates, Mächler, Bolker, & Walker, 2015) from 0 to 1,500 ms, with a delay of 200 ms. The analysis included group (L1 Spanish vs. L1 English, with L1 Spanish as the baseline), cognate status (cognate condition vs. non-cognate condition, with the non-cognate condition as the baseline), and stress (match vs. mismatch, with the match as the baseline) as fixed effects, as well as all two- and three-way interactions. A backward-fitting function from the package LMERConvenienceFunctions (Tremblay & Ransijn, 2015) was used to identify the model that accounted for significantly more of the variance than all simpler models, as determined by log-likelihood ratio tests. *P* values were calculated using the lmerTest package in R (Kuznetsova, Brockhoff, & Christensen, 2016) and only the significant results of the model with the best fit are reported. Analyses yielding significant interactions between cognate status and stress were followed up by subsequent GCAs conducted on the two cognate conditions separately, with the alpha level being adjusted. All analyses included

participant and item as random intercepts, and the time polynomials as random slopes for the participant variable, thus modeling a different line shape for each participant.

2.4. Results

Figure 1 shows the predicted values for the two cognate conditions separately, in red representing the stress-match and black representing the stress-mismatch conditions. The two groups are also represented, with native speakers of Spanish in the first row and native speakers of English in the second one. A four way interaction between time, stress, cognate status and group emerged (*Estimate* = -0.058, *SE* = 0.019, $p < 0.01$), indicating that both groups patterned differently. Follow-up analyses were done on the groups separately.

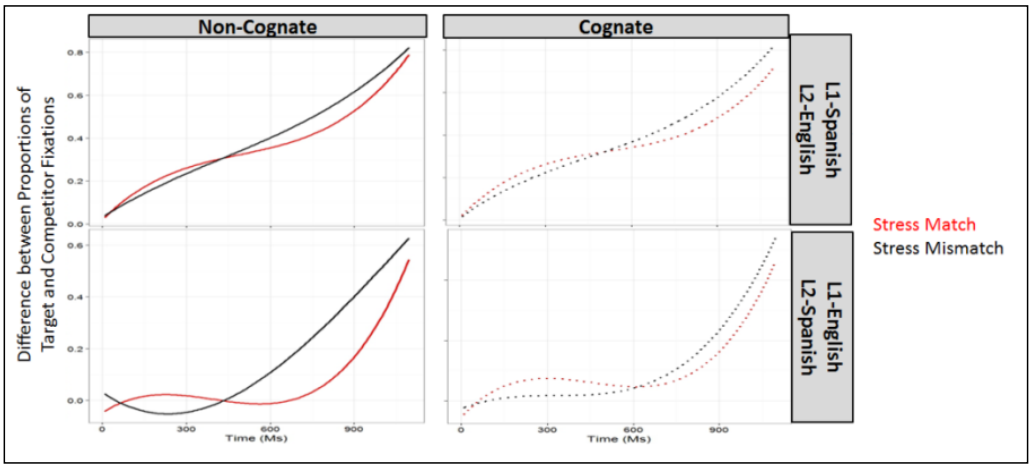

Figure 1. Predicted values for the two cognate conditions and groups separately.

The results of the GCA with the best fit on native Spanish participants' differential proportions of fixations in all conditions showed a three-way interaction between stress, cognate status and the linear polynomial (*Estimate* = -0.163, *SE* = 0.059, $p < 0.01$) as well as

a three-way interaction between stress, cognate status and the quadratic polynomial (*Estimate* = -0.176, *SE* = 0.059, $p < 0.01$), so follow-up analyses were run on the two cognate conditions separately. The main difference between both emerged with respect to the cubic polynomial. Only the interaction between stress and the cubic polynomial was significant in the cognate condition (*Estimate* = -0.171, *SE* = 0.039, $p < 0.001$). This pattern indicates that, equally in both conditions, the stress-match line is more s-shaped than the stress-mismatch line, with lower differential proportions of fixations in the stress-match condition than in the stress-mismatch condition.

The results of the GCA with the best fit on native-English L2-Spanish bilinguals' differential proportions of fixations in all conditions showed a three-way interaction between stress, cognate status and the three time coefficient (linear: *Estimate* = 0.603, *SE* = 0.063, $p < 0.001$; quadratic: *Estimate* = -0.272, *SE* = 0.063, $p < 0.001$; and cubic: *Estimate* = -0.509, *SE* = 0.063, $p < 0.001$), so follow-up analyses were run on the two cognate conditions separately. The follow-up analyses indicate that the stress-match line is more s-shaped than the stress-mismatch line, with lower differential proportions of fixations in the stress-match condition than in the stress-mismatch condition in both conditions. However, the difference between match and mismatch lines is larger in the no-cognate condition, as evidenced by the fact that only the interaction between stress and the quadratic term is significant in the cognate condition (*Estimate* = 0.241, *SE* = 0.038, $p < 0.001$). This difference between the two conditions can only be attributed to the presence of a cognate word with interference stress pattern.

3. DISCUSSION

This experiment investigated the degree of cross-language interference caused by Spanish-English cognates in the recognition of Spanish target words. It examined whether the recognition of Spanish

words would indeed be influenced by competition from English words that differ from Spanish in their stress placement, while analyzing how English-speaking L2 learners of English use suprasegmental segmental cues to stress in an online task.

Results indicated that stress constrains lexical access for native speakers of Spanish, similarly in the two cognate conditions, which indicates that they were not influenced by the English stress pattern of the cognate words. Some explanations may account for this lack of an effect. First, it could be argued that L2 into L1 processing influence is not strong enough to be captured. Second, it could also be the case that the participants tested in this study may not have been proficient enough in English for us to capture this cognate effect. Finally, it could be that participants may be better at inhibiting the interference from their non-dominant unintended language.

Results of the native speakers of English showed an initial advantage for cognate words, indicating that the overlap between Spanish and English facilitates the processing of these words. However, the cognate mismatch items do not constrain lexical access as well as the non-cognate mismatch items, indicating more competition (interference) in the cognate condition (stress-mismatch). This is clear evidence of cross-language interference, at least when the unintended language is participants' native language, which provide further support for the Nonselective Hypothesis (e.g., Canseco-Gonzalez *et al.*, 2010; Marian & Spivey, 2003; Schulpen *et al.*, 2003; Weber & Cutler, 2004). This study also showed that lexical stress can modulate the degree of cross-language activation that bilingual listeners experience, emphasizing how sensitive the bilingual system is.

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