NUCLEAR CONTOURS OF SPANISH ECHO QUESTIONS PRODUCED BY PROFICIENT CHINESE LEARNERS OF SPANISH: A DYNAMIC ANALYSIS

Peng Li [1], Xiaotong Xi [2]
[1] Center for Multilingualism in Society across the Lifespan (MultiLing), University of Oslo, Norway
[2] Department of Translation and Language Sciences, Universitat Pompeu Fabra, Spain
[1]*peng.li@iln.uio.no*, [2]*xiaotong.xi@upf.edu*

ABSTRACT

This study investigates Spanish nuclear contours produced by Chinese students and the influence of lexical stress position on these contours. In a Discourse Completion Task, 16 Chinese students and nine Spanish natives produced 450 Spanish yn- and wh- questions with various pragmatic functions (information seeking, clarification echo, and counter expectation echo). The nuclear words were stressed in initial, medial, or final positions. Dynamic analyses using Generalized Additive Mixed Models revealed that (a) clarification echo questions were the most challenging for Chinese students, who tended to produce a high boundary tone (H%) instead of the native pattern (L%), and (b) word-final stress was the least favorable position for producing L2 nuclear contours, especially for the clarification echo questions. These results provide direct evidence of cross-linguistic influence on prosody and support the L2 Intonation Learning Theory, emphasizing the importance of prosody in L2 teaching practice.

Keywords: Nuclear contour, dynamic analysis, L2 prosody acquisition, Spanish, Chinese students

1. INTRODUCTION

Compared to second language (L2) speech sound learning, relatively fewer studies focused on L2 speech prosody, such as intonation, due to its abstract and dynamic nature. Only a few models have tackled L2 prosody learning. For instance, the L2 Intonational Learning Theory (LILt) [1] predicts that the first language (L1) prosody is the key to predicting the learning outcome. Some empirical studies supporting LILt found that tone language speakers showed general advantages in learning L2 prosody [2], [3]. However, others suggest that the positive transfer is domain-specific and conditioned by individual differences [4], [5]. This study thus further explores L2 prosodic learning with Spanish prosody produced by Chinese learners and Spanish natives.

As an "intonation language", Spanish varies pitch at sentence level to shape intonation. By contrast, "tone languages", like Chinese, vary pitch on lexical level to distinguish words [6]. Therefore, Chinese speakers use multiple prosodic cues for intonational meanings [7], resulting in a more complex tone-intonation interaction than Spanish [8]. Previous research showed that Chinese students realized Spanish lexical stress as Tone 2 (rising tone) [9], manipulated pitch more than Spanish natives to contrast stress [10], and tended to replace the low nuclear accent (L) with high (H) or rising (L+H) tones on intonational level [8]. Therefore, the complex interplay between lexical stress and intonation should be considered in L2 prosody research. A stressed syllable may trigger unexpected high boundary tones or rising pitch accents for Chinese students.

Turning to specific sentence types, Spanish questions are said to be more challenging than statements for Chinese learners [11]. Recent research has investigated the Chinese students' production of Spanish *yn*- and *wh*- questions varied in pragmatic functions (i.e., information-seeking vs. confirmation-seeking) and disjunctive questions [8]. However, many other question types were left out in previous research, for example, echo questions. Compared to information-seeking (INF) questions, echo questions are biased towards the proposition *p* as conveying pragmatic meanings of either clarification (CLA, i.e., *Did you say p?*) or counter expectation (EXP, i.e., *Are you saying p?*) [12], and are thus more difficult than neutral questions. Within echo questions, CLA would be more difficult than EXP for Chinese learners for the following reasons. Spanish CLA bears a low boundary tone [12], but the underlying form of Chinese CLA is a *yn*-question with a high boundary tone [13]. By contrast, EXP shows a high boundary tone in both Spanish [12] and Chinese [14].

Therefore, this study selected six question types produced by Chinese students and Spanish natives from a large corpus: CLA-*yn*, EXP-*yn*, CLA-*wh*, EXP-*wh*, INF-*yn*, and INF-*wh*. Since nuclear configurations are key for intonation types [15] and the stress position of the sentence-final words largely affects the surface nuclear curves [8], we mainly focused on the nuclear contours while considering the stress position of the sentence-final nuclear words.

Furthermore, traditional analytic frameworks on prosody (e.g., ToBI systems for Spanish [16] and Chinese [17]) categorized intonation elements on phonological level [18]. However, when comparing intonation curves produced by L2 learners and native speakers, a dynamic approach is necessary to estimate the exact locations of differences. To this end, we used Generalized Additive Mixed Models (GAMM) to compare the estimated intonation curves at group level (e.g., Chinese students vs. Spanish natives) and the traditional Sp_ToBI [16] to phonologically label the intonation curves.

We hypothesized that:

- Spanish CLA would be the most challenging sentence type for Chinese students since the low boundary tone is contrary to Chinese CLA.
- The stress position of nuclear words would affect the surface nuclear contours, with sentence-final stress being the least favorable since it would trigger unexpected high or rising boundary tones.

2. METHOD

2.1. Participants

We recruited 16 Chinese learners of Spanish (female = 12, aged 22-33 years) and 9 monolingual speakers of peninsular Spanish (female = 6, aged 18-28 years) from Spain. They signed consent forms to allow the researchers to process their data. The Chinese students started learning Spanish in their early adulthood (M = 19.3 years old, SD = 1.9). They had learned Spanish with formal instructions for 4.1 years (SD = 1.3) in China, had lived in Spanish-speaking countries for 5.4 years (SD = 3.3), and had studied various subjects instructed in Spanish for 2.4 years (SD =2.2) in Spain. They all had passed the DELE test (Diplomas of Spanish as a Foreign Language). Five of them were qualified as B2/advanced level and the rest (11), C1/high advanced level. Therefore, the Chinese students were proficient late adult learners with extensive exposure to the target L2.

2.2. Materials and procedure

The experiment was a Discourse Completion Task. We designed 54 scenarios to elicit Spanish utterances with different prosodic structures. The scenarios were organized in a PowerPoint presentation, with each slide containing one scenario followed by a prompt of the target sentence. The participants had to read each scenario carefully and orally read the prompts in Spanish. The participants' speech outcomes were recorded with a Zoom H4n Pro in a soundproof room. The current study targeted 18 scenarios (6 sentence types × 3 stress positions). That is, for each sentence type, we designed three scenarios, with each eliciting a sentence ending with one of the three target words, varied in stress positions: ***vi**no* 'wine' (word-initial), *Ma**ri**na* (word-medial), and *Mi**lán*** 'Milan' (word-final). In total, we analyzed 450 utterances (25 participants × 18 scenarios). See (1)-(3) for English-translated examples of the scenarios for each pragmatic type, with the target sentences in Spanish and English translation. The target word is "vino".

(1) In a noisy party you seemed to hear Lola drinks wine. But you didn't understand well, so you asked: *¿Lola bebe vino?* 'Lola drinks wine?' [CLA-*yn*]

(2) You're told that Elena, who's allergic to alcohol drinks wine. You were surprized and asked: *¿Elena bebe vino?* 'Elena drinks wine?' [EXP-*yn*]

(3) In a store, you want to ask if they have wine: *¿Tienes vino?* 'Do you have wine?' [INF-*yn*]

2.3. Data coding and analysis

We manually segmented the target words at the syllable level using Praat [19] and extracted 10 regularly spaced F0 samples from each syllable to generate a time-normalized pitch contour. The raw values were transformed into z-scores.

To estimate and compare the pitch contours of the target words across groups and functions, we built six GAMMs using the *bam()* function from the *mgcv* package [20] in R for the two structures (*yn*- vs. *wh*-questions) across the three target words ("vino", "Marina", "Milán"). For all the GAMMs, the fixed factors were time (the normalized time point), gender (m vs. f), function (CLA vs. EXP vs. INF), group (Chinese students vs. Spanish natives), and a two-way interaction of Function × Group. The smooth terms included a smooth curve for the Function × Group interaction and a by participant (id) random smooth to account for individual differences. The data distribution was specified as "scaled-t".

Finally, as we are interested in the differences in nuclear pitch contours as a function of speaker group and pragmatic meanings, we only report the findings on smooth terms. Figs 1-2 visualize the groupwise comparisons of pitch contours.

3. RESULTS

Table 1 summarizes the GAMM results for smoothed nuclear pitch contours with initial, medial, and final stress. A boldfaced smooth term means that the estimated curve significantly differs from a straight line as measured by the estimated degree of freedom (*edf*), where *edf* =1 means a straight line. Since only a few cases showed non-significant results, we will mainly interpret the post-hoc comparisons of the estimated pitch curves between groups.

Table 1: Smooth terms of the GAMMs for the z-scored nuclear F0 of Spanish *yn*- and *wh*-questions produced by Chinese students (ch) and Spanish

natives (sp) with various pragmatic functions (CLA, EXP, and INF) divided by the word stress positions (initial, medial, and final).

	Vino (initial)		Ma**ri**na (medial)		Mi**lán** (final)	
	edf	*F*	*edf*	*F*	*edf*	*F*
***Yn* questions**						
s(time): interaction (group, function)						
ch.CLA-*yn*	**4.6**	**66.4**	**6.0**	**81.9**	**5.3**	**32.5**
sp.CLA-*yn*	1.0	1.0	**5.5**	**28.5**	**2.0**	**8.0**
ch.EXP-*yn*	**4.8**	**95.9**	**6.1**	**81.9**	**6.3**	**58.0**
sp.EXP-*yn*	**4.8**	**24.8**	**5.9**	**28.8**	**5.6**	**16.9**
ch.INF-*yn*	**4.6**	**71.7**	**6.0**	**79.8**	**5.8**	**52.8**
sp.INF-*yn*	**4.6**	**38.7**	**5.8**	**55.2**	**5.5**	**18.7**
s(id, time)	**22.5**	**67.4**	**22.7**	**118.2**	**22.6**	**96.1**
***Wh*-questions**						
s(time): interaction (group, function)						
ch.CLA-*wh*	**1.0**	**4.1**	**5.6**	**48.5**	**5.1**	**40.8**
sp.CLA-*wh*	2.5	2.4	**3.4**	**8.4**	**5.1**	**21.0**
ch.EXP-*wh*	**3.2**	**5.1**	**5.9**	**113.4**	**5.2**	**45.8**
sp.EXP-*wh*	**4.8**	**10.5**	**5.1**	**44.5**	**5.6**	**37.9**
ch.INF-*wh*	1.0	2.1	**4.2**	**4.8**	**3.1**	**3.7**
sp.INF-*wh*	1.9	1.1	**2.6**	**2.6**	2.1	2.3
s(id, time)	**22.5**	**68.7**	**22.5**	**55.2**	**22.6**	**97.2**

3.1. Results of yn-questions

For the initial stressed "vino" (Fig. 1), Chinese students produced significantly higher pitch than Spanish natives on the second syllable. In terms of pitch contours, both groups showed similar patterns in INF-*yn* and EXP-*yn* (L* H%), but in CLA-*yn*, Chinese students produced a L* H% pattern in contrast with the native L* L% pattern.

As for the medial stressed "Marina" (Fig. 1), the significant contrasts in pitch height between groups were mainly on the first syllable, "ma" in CLA-*yn* and EXP-*yn*. The two groups produced similar contour patterns for all three functions (L* H%).

Regarding the final stressed "Milán" (Fig. 1), the most important difference lay in the contours of CLA-*yn,* with Chinese learners showing a L* H% and Spanish natives showing a L* L%. As for EXP-*yn*, Spanish natives showed a L* H% pattern, but Chinese students had a significantly higher boundary tone (L* ¡H%). No significant contrast was found for INF-*yn*, with both groups showing a L* H%.

3.2. Results of wh-questions

First, the initial stressed "vino" (Fig. 2) revealed no significant difference in pitch height between Chinese learners and Spanish natives in any of the three functions. Noteworthily, although Chinese students seemed to show a different pitch contour from Spanish natives, the difference observed in Fig. 2 was not meaningful since no significant contrast was found. Therefore, both groups produced INF-*wh* and CLA-*wh* as L* L% and EXP-*wh* as L* HL%.

Second, the medial stressed "Marina" (Fig. 2) revealed a significant difference in CLA-*wh,* with Spanish natives showing a L* L% while Chinese students showing a L* H%. However, in EXP-*wh*, although Spanish natives produced "ma" with a significantly higher pitch than Chinese students, the

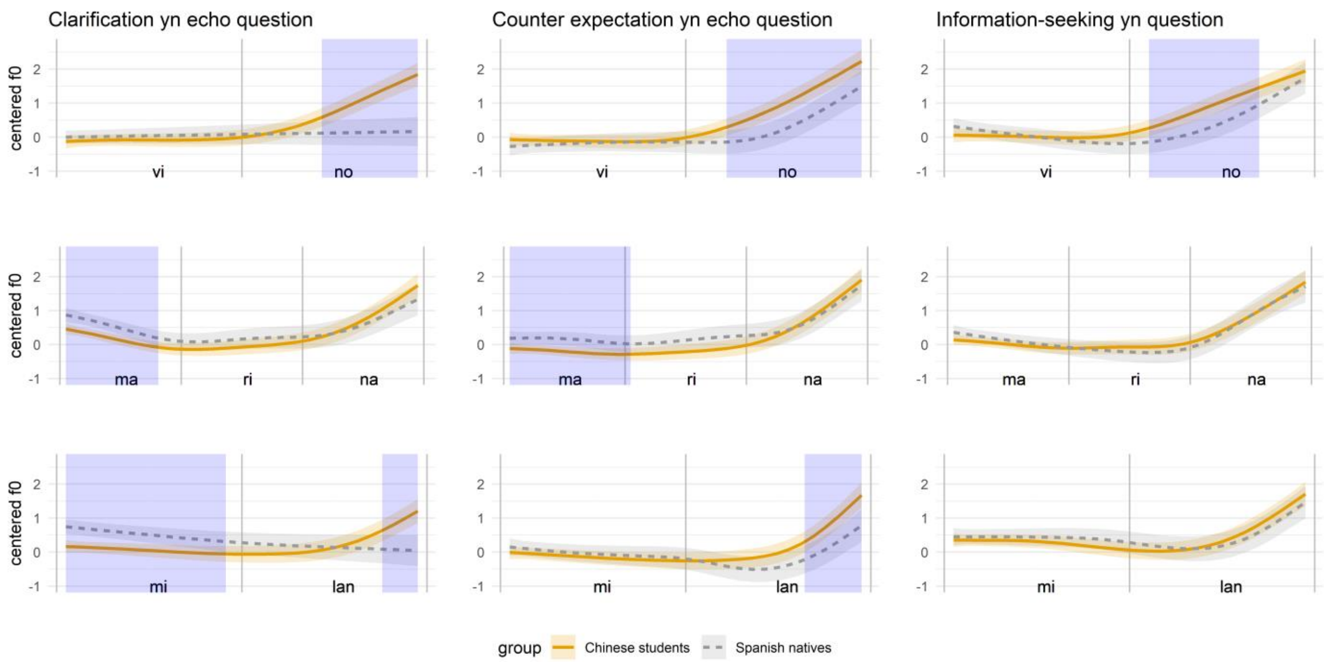

Fig. 1. Groupwise comparisons of F0 contour of the nuclear words estimated by GAMM for each pragmatic function of *yn*-questions, from left to right: CLA-*yn*, EXP-*yn*, and INF-*yn*, varied across stress patterns, from top to bottom, initial stressed, medial stressed, and final stressed. The shaded area of each contour paints the 95% Confidence Interval. The purple squared shades illustrate significant contrasts between the intonation contours produced by Chinese students and Spanish natives.

pitch contours of both groups were L* H%. Again, no significant contrast was found for INF-*wh* (L* L%).

Finally, the final stressed "Milán" (Fig. 2) revealed significant differences in CLA-*wh*, with the Chinese students producing a L+H* H% while Spanish natives showed a H+L* L%. No significant group difference was found in INF-*wh* (L* L%) and EXP-*wh* (L* H%).

4. DISCUSSION AND CONCLUSION

This study compared the nuclear contours produced by proficient Chinese learners of Spanish and Spanish natives for six Spanish question types (INF-*yn*, INF-*wh*, CLA-*yn*, CLA-*wh*, EXP-*yn*, and EXP-*wh*) in a Discourse Completion Task. The target nuclear words varied in stress position (initial, medial, and final).

Our first hypothesis, that CLA would be the most challenging for Chinese students, was confirmed. In INF and EXP, Chinese students showed on-target contours in most cases, but they tended to produce high boundary tones (H%) for CLA-*yn* ending with "vino" and "Milán", and CLA-*wh* with "Marina" and "Milán", which was inconsistent with Spanish natives (L%). That is, Chinese students could not prosodically mark the clarification echo questions.

Our second hypothesis, that the word-final stress would be the least favorable for producing L2 nuclear contours, was also confirmed. In INF and EXP, "vino" and "Marina" showed subtle differences in pitch height but not many in contour shapes between groups. However, the word-final stressed "Milán showed an unexpected high boundary tone (H%) in CLA produced by Chinese students. Especially in CLA-*wh*, they showed a rising nuclear accent (L+H*), which contrasted with the native speakers' falling pattern (H+L*). Also, in EXP-*yn*, even though the contours of "Milán" were similar between groups, Chinese students had a higher boundary tone (¡H%) than Spanish natives (H%).

Importantly, Chinese students performed well in EXP, which suggested a positive cross-linguistic influence since EXP is also marked by a high boundary tone in Chinese [14], [21]. By contrast, Chinese students failed to produce on-target prosodic patterns for CLA because Chinese CLA resembles the intonation of *yn*-question, which bears a high boundary tone [13]. Our results thus support the predictions by LILt [1] that the interaction between L1 and L2 prosodic categories is driven by the (dis)similarities of the two languages. In addition, the dynamic analysis revealed pitch height differences between groups even though the overall pitch contours were similar (e.g., EXP-*yn* with "vino"). This suggests a need for dynamic approaches in L2 prosodic research.

To conclude, this study, for the first time, dynamically modeled Chinese students' nuclear contours of Spanish. For the six question types in our corpus, the clarification echo question seemed to be the most challenging for Chinese students. Also, stress position affected nuclear pitch contours, with the word-final position being the most problematic. The findings thus call for attention to prosody in L2 teaching practice.

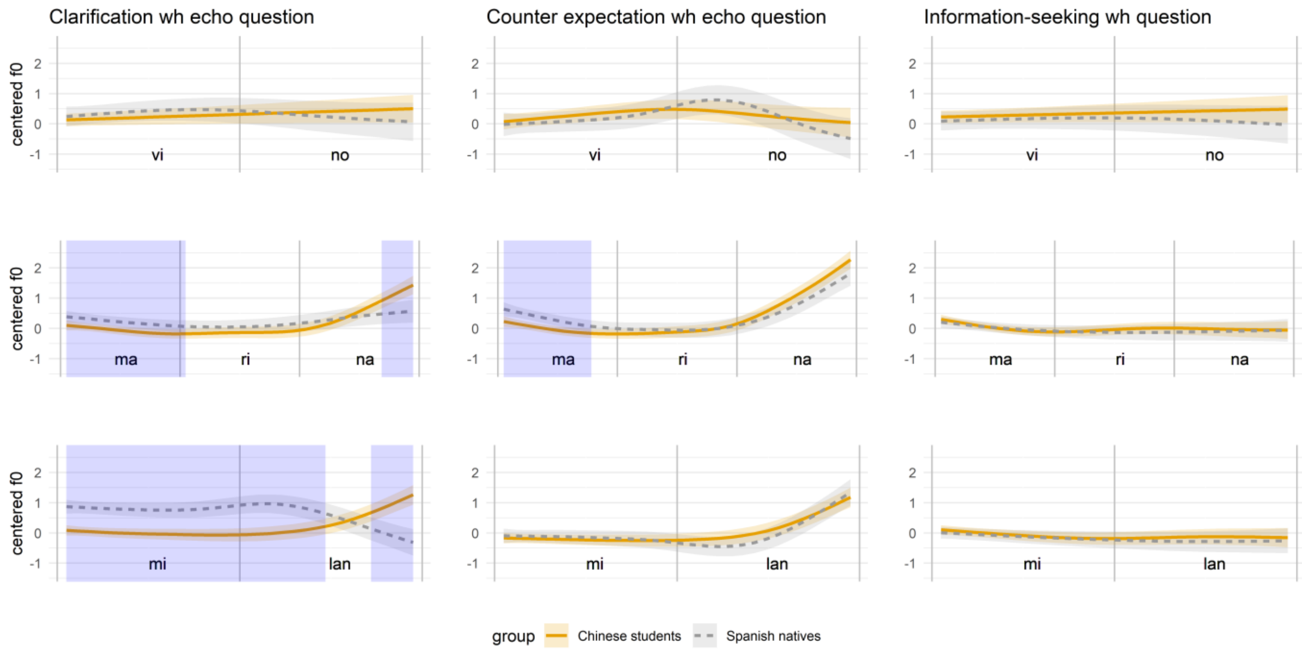

Fig. 2. Groupwise comparisons of F0 contour of the nuclear words estimated by GAMM for each pragmatic function of *wh*-questions, from left to right: CLA-*wh*, EXP-*wh*, and INF-*wh*, varied across stress patterns, from upper to bottom, initial stressed, medial stressed, and final stressed. The shaded area of each contour paints the 95% Confidence Interval. The purple squared shades illustrate significant contrasts between the intonation contours produced by Chinese students and Spanish natives.

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