Empathy Conditions ERP Responses in High Empathy Bilinguals

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# Author note

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# Abstract

This is where the abstract will go.

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# Introduction

Recent behavioral research in both monolingual Esteve-Gibert et al. (2020) and bilingual (Casillas et al., 2023) populations has investigated the role of pragmatic skills, such as empathy (Baron-Cohen & Wheelwright, 2004), in the processing of intonation. However, little research has explored the neurophysiological correlates that reveal *how* empathy modulates intonation processing (Aziz-Zadeh et al., 2010). The current study aims to address this gap by investigating Event-Related Potential (ERP) correlates of higher empathy L1 English L2 Spanish late bilinguals when explicitly deciding if a spoken Spanish sentence is a declarative or interrogative. By identifying the neurophysiological mechanisms underlying empathy’s role in L2 intonation processing, this study will contribute to the growing literature on the role of individual differences and pragmatic skills in L2 acquisition, as well as identify specific ERP components – such as the N400 and P600 – that are modulated by pragmatic skills during intonation processing.

# Background and Motivation

## Individual Differences and Empathy

Proficiency has long been the focus of L2 processing literature (Reichle et al., 2016), but recent studies have turned to investigating the impact of other individual differences, such as working memory (WM), language use, and empathy. The expansion to include other factors into L2 language processing models has been fruitful. Many researchers find that higher WM, for example, acts as a reliable predictor of L2 learners’ sensitivity to agreement violations (Sagarra & Herschensohn, 2013), morphosyntactic violations (McDonald, 2006), and relative clause disambiguation via verbal agreement (Havik et al., 2009). Likewise, language use has been found to condition specific brain structure and function adaptations (DeLuca et al., 2019; Hervais-Adelman & Babcock, 2020) and greater resting state alpha power (Bice et al., 2020). These studies demonstrate that bilingual language processing should not be viewed as a monolith that is solely determined by proficiency, but that it is conditioned by a variety of individual factors.

Empathy is yet another individual difference measure that is typically described in the literature as having an *affective* and *cognitive* component (Baron-Cohen & Wheelwright, 2004). Affective empathy describes an observer’s emotional response to another’s emotions; cognitive empathy is the ability to set aside one’s own mental state to consider or infer another’s, which can lead to predicting another’s behavior or mental state. Empathy is an important pragmatic skill that allows individuals to effectively mobilize in the social world. Baron-Cohen & Wheelwright (2004) introduces the Empathy Quotient (EQ), a self-report questionnaire that maps an individual’s empathy on a scale of zero to 80. This instrument has been used in the extant literature investigating empathy and linguistic perception (Casillas et al., 2023; e.g., Esteve-Gibert et al., 2020; Orrico & D’imperio, 2020).

Researchers have investigated the effects of bilingualism on the development and modulation of empathy (Javor & Javor, 2016; Rodriguez, 2022), but there is scarce research of empathy’s role in second language acquisition. Guiora et al. (1972), for instance, tried to link empathy to “authentic pronunciation” of an L2, but no strong associations have been found. In contemporary research, the few studies that do exist are reviewed below.

Although empathy has received little attention as a factor modulating L2 acquisition or development, there is empirical (Aziz-Zadeh et al., 2010; Casillas et al., 2023; Esteve-Gibert et al., 2020; Orrico & D’imperio, 2020) and theoretical motivation to investigate a possible link. Empathy is directly linked with pragmatic skills, such as establishing and updating common ground (Stalnaker, 2002) or accurately interpreting sarcasm (Filik et al., 2019). The Shallow Structure Hypothesis (SSH) (Clahsen & Felser, 2006b, 2006a, 2018) posits that L2 learners must parse L2 sentences shallowly due to underdeveloped grammar, which fails to provide the detailed structural information needed for L1-like processing. Thus, L2 learners rely more on lexical, semantic, and, relevant here, *pragmatic* information when their L2 grammar cannot provide the necessary structural information.

## Intonation and the Autosegmental Metrical Framework

Since empathy is linked with pragmatic skill, it makes sense that one of the most influential areas of empathy on language would be in intonation. Within the Autosegmental Metrical (AM) model of intonation (Ladd, 2008; Pierrehumbert, 1980), the continuous intonation contour is mapped to discrete, sequential tone targets that are compositional in nature (although this last point is debated (Orrico & D’imperio, 2020)). The Tones and Break Indices tool, originally developed for English (Silverman et al., 1992) and later expanded to Spanish (Beckman et al., 2002), is used within AM to annotate intonation. Discrete pitch targets can be H, L, or a combination of such to represent rises (e.g., LH) or falls (e.g., HL). Focused on in the present study are boundary tones, marked by a percentage sign (e.g., H% would be a high boundary tone target; HL% could be a final rise-fall, although the amount of phonetic detail included in these representations is dependent on the researcher). Boundary tones are associated with the right edge of largest prosodic unit, the Intonation Phrase (IP). Typically, boundary tones for absolute interrogatives are rising (e.g., H%) in Spanish (Prieto & Roseano (2010)), but some dialects, such as Puerto Rican Spanish (Armstrong, 2010), use a fall (e.g., L%). Partial wh- questions, broad focus declaratives, and narrow focus declaratives are typically produced with a fall.

However, boundary tones are not the only cue that indicates if something is of a specific sentence type, and is in fact temporally the final cue amongst many, all of which contribute to sentence-type identification for L1 Spanish speakers (Face, 2007). Despite that, as it is the final cue, it may be the most salient and accessible for L2 Spanish speakers. The present study investigates the boundary tone as a locus for deciding sentence modality in L2 Spanish.

## LILT Model

*NOTE: COPIED FROM SOCIO PAPER, NEED TO REVIEW, CUT DOWN, AND ADD RELEVANCE*

AM has been primarily developed to investigate L1 intonation, but there have been recent attempts to expand intonation investigation into the L2 domain. For example, (**mennen2015beyond?**) has proposed the theoretical model L2 Intonation Learning Theory (LILt). Four dimensions of intonation are recognized under this model with the goal of characterizing the similarities and differences between the intonation inventories between two languages:

1. The inventory and distribution of categorical phonological elements (“systemic” dimension)
2. The phonetic implementation of these categorical elements (“realizational” dimension)
3. The functionality of the categorical elements of tunes (“semantic” dimension)
4. The frequency of use of the categorical elements (“frequency” dimension)

The LILt model, as demonstrated by the specified dimensions, are primarily concerned with L1-L2 transfer effects. That is, it is predicted that a language learner acquiring an L2 will experience positive transfer effects when the intonation systems align along one or more dimensions, whereas they will experience negative transfer when they do not align. For example, English and Spanish differ in how they express polite responses to wh-questions. Where English uses a broad pitch range in its rises, represented with by the nuclear configuration L+¡H\* (where **¡** represents an extra high tone), Spanish uses a narrow pitch range, represented by L+H\* (**estebas2014evaluation?**).

The differences here have a significant impact on the acquisition of Spanish by L1 English speakers. English speakers have available to them L+H\* (**dilley2013role?**), the expected contour in Spanish (“systemtic” dimension). It is realized phonetically similarly, although the English L+H\* typically has a broader pitch range (for English: **beckman1997guidelines?**; for Spanish: Prieto & Roseano, 2010) (“realizational” dimension”). The “frequency” dimension is defined at a more general level by (**mennen2015beyond?**) and would require more space than attributed here to investigate the frequency differences of tone primitives in English and Spanish. However, crucially, there is a mismatch in the *semantic* dimension. Where English uses L+¡H\* as an appropriate, polite response to a wh-question, Spanish does not pattern in this way; instead, it is mapped to an “over-excited” response, which could give rise to misinterpretation when learners interact with monolingual L1 Spanish speakers.

## Empathy and Intonation

It is clear that intonation plays a strong role in the expression of pragmatic meaning, thus associating it with empathy. Of note for the current study is the role that intonation plays in sentence modality. In languages like English and Spanish, identical strings of words can be produced with different intonation contours to distinguish it as a declarative and an interrogative. It has already been shown that higher empathy late bilinguals are more sensitive to intonation for distinguishing sentence modality (Casillas et al., 2023), but the specific mechanisms have yet to be elucidated.

Recent behavioral studies have investigated the role of empathy in the perception of intonation in both monolingual and bilingual populations. In monolingual populations, for example, Orrico & D’imperio (2020) found that higher empathy Italian monolinguals have access to finer-grain distinctions in intonation-meaning mapping. Also in a monolingual population, Esteve-Gibert et al. (2020) used a visual world paradigm eye-tracking task with French monolinguals that resembled a card guessing game in which target items were homophones. Only after the target item was the homophone lexically disambiguated. Importantly, the temporary lexical ambiguity caused by the target items could be resolved with an intonational cue. Esteve-Gibert et al. (2020) found that only higher empathy individuals varied their looking behavior, conditioned by the intonational cue. Interestingly, their looking behavior actually focused on the distractor image, not the correct image. Due to the unexpected results, Esteve-Gibert et al. (2020) completed a post hoc off-line behavioral task in which participants listened to the sentence only up to the target homophone (and thus, the homophone is never lexically disambiguated) and had to match the homophone to the correct image. Higher empathy individuals were significantly more accurate than lower empathy individuals. Esteve-Gibert et al. (2020) explain the unexpected eye-tracking results by proposing that higher empathy are more sensitive to all possible alternative interpretations, but still map intonation to the most plausible. This proposal is in line with what Baron-Cohen & Wheelwright (2004) describes as the cognitive component of empathy, and has correspondences with Theory of Mind (Frith & Frith, 2003).

In the first study that investigates interactions of empathy and intonation in a bilingual population, Casillas et al. (2023) conceptually replicates Brandl et al. (2020). L1 English L2 Spanish participants listened to sentences and had to explicitly decide if it was a question or not. Casillas et al. (2023) found an interaction between empathy and Spanish proficiency, measured by vocabulary size via the LexTALE (Izura et al., 2014), such that lower proficiency individuals with higher empathy were more accurate. Interestingly, they found that these same individuals were also slower than their low empathy counterparts. However, Casillas et al. (2023) did not control for the specific intonational contours present in the stimuli, such that there was variety within and across speakers of different varieties. The present study controls for the intonational contour, specifically boundary tones.

Empathy has remained largely uninvestigated using neurolinguistic methodologies, such as electroencephalogram (EEG) or fMRI, despite the growing behavioral evidence indicating that it impacts both monolingual and bilingual language processing. Aziz-Zadeh et al. (2010) performed an fMRI study to investigate if production and perception of intonation was modulated by empathy. Unlike the previously mentioned studies, Aziz-Zadeh et al. (2010) used the Interpersonal Reactivity Index (Davis, 1983) and the Psychopathic Personality Inventory-Revised (Lilienfeld et al., 2005) as measurements of empathy, as well as an off-line prosodic ability test.

In the on-line production task, participants were asked to produce the nonsense phrase “da da da da da” with varying intonation that matched a presented image of a smiling, sad, questioning or neutral face. In the on-line perception task, they were presented no image, but listened to the phrase “da da da da da”. Aziz-Zadeh et al. (2010) found that higher empathy individuals showed more activity during the perception of emotional, but not neutral, intonation in premotor areas, including the bilateral inferior frontal gyrus and premotor cortex. They propose that the increased activity is related to simulation processes in the motor-related areas. That is, higher empathy individuals, in the vein of *cognitive empathy*, simulate how they would produce the given intonation to understand someone else’s.

In sum, there is clear evidence that empathy impacts both monolingual and bilingual processes, but in exactly what ways are still unclear. Esteve-Gibert et al. (2020) propose that higher empathy monolinguals compute more possible interpretations, which seems to imply longer processing time. This prediction is borne out by Casillas et al. (2023), where higher empathy bilinguals had slower reaction times (although overall more accurate responses) than their lower empathy counterparts. This study attempts to elucidate which part of sentence processing is responsible for the slower reaction times.

# Research Questions and Hypotheses

1. Is reaction time to identifying sentence modality in Spanish by L1 English L2 Spanish late bilinguals modulated by empathy?

This is expected to be the case, based off of research conducted by Casillas et al. (2023).

1. Are high empathy bilinguals more sensitive to intonation when identifying sentence modality?

This is expected to be the case, based off of research conducted by Casillas et al. (2023).

1. In mismatch conditions, are greater N400 components associated with high empathy individuals?

It is expected that high empathy individuals are more sensitive to intonation, which will present itself as a greater violation of expectations in mismatch conditions, eliciting larger a larger N400.

1. In match conditions, do high empathy individuals exhibit more broadly distributed late positivity components (e.g. P600) than their low empathy counterparts?

High empathy individuals take longer to decide if an utterance is an interrogative or declarative (Casillas et al., 2023), and it is predicted that the longer processing time is associated with late components. This prediction is based on the proposal by Esteve-Gibert et al. (2020), who posited that high empathy individuals take into account all possible interpretations. This is expected to be seen as a late, broadly distributed ERP component.

1. Where Spanish and English do not coincide in the marking of sentence type with boundary tone (e.g., Puerto Rican fall for absolute interrogatives, where English would have a rise), do high empathy individuals exhibit lower N400s?

High empathy individuals were found to be more accurate at identifying sentence modality (Casillas et al., 2023). This study will investigate if the boundary tone is perhaps the main cue for identifying sentence modality. It is expected that in low empathy individuals, their main cue will be the boundary tone. When it does not coincide with the boundary tone expected in English, they will exhibit larger N400s, whereas high empathy individuals will exhibit a smaller, if any, N400 (**mennen2015beyond?**).

# Methodology

Match/Mismatch design.

Participants will see fixation cross. See image of person with speech bubble. Inside speech bubble is a period or question mark. Image disappears. Listen to sentence (which will have a rising or falling boundary tone, coinciding with natural intonation across Spanish varieties). Text appears on screen: “¿La frase coincide con la imagen?” Participants clicks keyboard key for yes or no.

Area of interest: start of final syllable.

Independent variables: empathy proficiency (lextale) boundary tone (H, L) match with English sentence type EN boundary tone ES boundary tone match? y-n Q H% H% or L% meh wh- Q H% L% no declaratives L% L% yes

# Scraps

Maybe just single, three-syllable penultimate stressed words? control for syllable structure e.g., CV.CV.CV CVC.CVC.CVC CV.CVC.CV CV.CVC.CVC CV.CV.CVC.

Closure Positivity needs to be addressed.

Empathy/Proficiency only interacted for wh- questions, broad focus statements, and narrow focus statements for accuracy. Response times for all conditions were impacted by empathy/proficiency interaction. Higher empathy individuals took longer to respond (Casillas).

Empathy (Baron-Cohen & Wheelwright, 2004) has been found to modulate perception of intonation in the L1 (Esteve-Gibert et al., 2020; Orrico & D’imperio, 2020), as well as the L2 (Casillas et al., 2023), but the specific neurophysiological correlates that underlie empathy’s role in intonation processing remain uninvestigated. In the L1, higher empathy individuals have been found to show more granular interpretations of epistemic bias (Orrico & D’imperio, 2020) and to be more sensitive to intonational cues when developing a set of possible interpretations and selecting the most likely one (Esteve-Gibert et al., 2020). In the L2, higher empathy individuals have been found to respond more accurately, albeit slower, when determining if a spoken sentence is a declarative or interrogative (Casillas et al., 2023). The current research aims to contribute to the growing body of literature on the role of pragmatic skills and individual differences on L2 acquisition by investigating L1 English L2 Spanish late bilinguals by investigating Event-Related Potential (ERP) correlates of empathy in intonation processing. Specifically, continuing the line of research began by Casillas et al. (2023), are there

The extant research on language processing has identified that individual differences is a consequential factors for the L2 acquisition process.

For example, experience-based factors in bilingual language use impacts brain structure and functional connectivity (DeLuca et al., 2019);

Although there exists research investigating the effects of bilingualism on the development or modulation of empathy (Javor & Javor, 2016; Rodriguez, 2022), empathy has received little attention in contemporary research as a modulating factor of linguistic processing. Researchers from the 60s and 70s (e.g., Guiora et al., 1972) have tried to link empathy to “authentic pronunciation” of an L2, but no strong associations have been found.

Empathy is responsible for allowing individuals to infer another’s mental state, which is critical for establishing and updating common ground (Stalnaker, 2002). Furthermore, empathy is critical in understanding an interlocutor’s sarcasm or insincere utterance (Filik et al., 2019).

# References

Armstrong, M. E. (2010). Puerto rican spanish intonation. *Transcription of Intonation of the Spanish Language*, 155–189.

Aziz-Zadeh, L., Sheng, T., & Gheytanchi, A. (2010). Common premotor regions for the perception and production of prosody and correlations with empathy and prosodic ability. *PloS One*, *5*(1), e8759.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *34*, 163–175.

Beckman, M. E., Dı́az-Campos, M., McGory, J. T., & Morgan, T. A. (2002). *Intonation across spanish, in the tones and break indices framework*.

Bice, K., Yamasaki, B. L., & Prat, C. S. (2020). Bilingual language experience shapes resting-state brain rhythms. *Neurobiology of Language*, *1*(3), 288–318.

Brandl, A., González, C., & Bustin, A. (2020). The development of intonation in L2 spanish. *Hispanic Linguistics: Current Issues and New Directions*, *26*, 11.

Casillas, J. V., Garrido-Pozú, J. J., Parrish, K., Arroyo, L. F., Rodrı́guez, N., Esposito, R., Chang, I., Gómez, K., Constantin-Dureci, G., Shao, J., et al. (2023). Using intonation to disambiguate meaning: The role of empathy and proficiency in L2 perceptual development. *Applied Psycholinguistics*, *44*(5), 913–940.

Clahsen, H., & Felser, C. (2006a). Grammatical processing in language learners. *Applied Psycholinguistics*, *27*(1), 3–42.

Clahsen, H., & Felser, C. (2006b). How native-like is non-native language processing? *Trends in Cognitive Sciences*, *10*(12), 564–570.

Clahsen, H., & Felser, C. (2018). Some notes on the shallow structure hypothesis. *Studies in Second Language Acquisition*, *40*(3), 693–706.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113.

DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. (2019). Redefining bilingualism as a spectrum of experiences that differentially affects brain structure and function. *Proceedings of the National Academy of Sciences*, *116*(15), 7565–7574.

Esteve-Gibert, N., Schafer, A. J., Hemforth, B., Portes, C., Pozniak, C., & D’Imperio, M. (2020). Empathy influences how listeners interpret intonation and meaning when words are ambiguous. *Memory & Cognition*, *48*, 566–580.

Face, T. L. (2007). The role of intonational cues in the perception of declaratives and absolute interrogatives in castilian spanish. *Journal of Experimental Phonetics*, *16*, 185–225.

Filik, R., Ţurcan, A., Ralph-Nearman, C., & Pitiot, A. (2019). What is the difference between irony and sarcasm? An fMRI study. *Cortex*, *115*, 112–122.

Frith, U., & Frith, C. D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *358*(1431), 459–473.

Guiora, A. Z., Brannon, R. C., & Dull, C. Y. (1972). Empathy and second language learning 1. *Language Learning*, *22*(1), 111–130.

Havik, E., Roberts, L., Van Hout, R., Schreuder, R., & Haverkort, M. (2009). Processing subject-object ambiguities in the L2: A self-paced reading study with german L2 learners of dutch. *Language Learning*, *59*(1), 73–112.

Hervais-Adelman, A., & Babcock, L. (2020). The neurobiology of simultaneous interpreting: Where extreme language control and cognitive control intersect. *Bilingualism: Language and Cognition*, *23*(4), 740–751.

Izura, C., Cuetos, F., & Brysbaert, M. (2014). Lextale-esp: A test to rapidly and efficiently assess the spanish vocabulary size. *Psicológica*, *35*(1), 49–66.

Javor, R., & Javor, R. (2016). Bilingualism, theory of mind and perspective-taking: The effect of early bilingual exposure. *Psychology and Behavioral Sciences*, *5*(6), 143–148.

Ladd, D. R. (2008). *Intonational phonology*. Cambridge University Press.

Lilienfeld, S. O., Widows, M. R., & Staff, P. (2005). Psychopathic personality inventory TM-revised. *Social Influence (SOI)*, *61*(65), 97.

McDonald, J. L. (2006). Beyond the critical period: Processing-based explanations for poor grammaticality judgment performance by late second language learners. *Journal of Memory and Language*, *55*(3), 381–401.

Orrico, R., & D’imperio, M. (2020). Individual empathy levels affect gradual intonation-meaning mapping: The case of biased questions in salerno italian. *Laboratory Phonology: Journal of the Association for Laboratory Phonology*, *11*(1), 1–39.

Pierrehumbert, J. B. (1980). *Submitted to the department of linguistics and philosophy on 9 september 1980 in partial fulfill ment of the requirements for the degree of doctor of philosophy* [PhD thesis]. MASSACHUSETTS INSTITUTE (OF TECHNOLOGY.

Prieto, P., & Roseano, P. (2010). *Transcription of intonation of the spanish language*. Lincom Europa Munich.

Reichle, R. V., Tremblay, A., & Coughlin, C. (2016). Working memory capacity in L2 processing. *Probus*, *28*(1), 29–55.

Rodriguez, E. (2022). *Language learning and empathy*.

Sagarra, N., & Herschensohn, J. (2013). Processing of gender and number agreement in late spanish bilinguals. *International Journal of Bilingualism*, *17*(5), 607–627.

Silverman, K. E., Beckman, M. E., Pitrelli, J. F., Ostendorf, M., Wightman, C. W., Price, P., Pierrehumbert, J. B., & Hirschberg, J. (1992). ToBI: A standard for labeling english prosody. *ICSLP*, *2*, 867–870.

Stalnaker, R. (2002). Common ground. *Linguistics and Philosophy*, *25*(5/6), 701–721.