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Child Comprehension of Intonationally-Encoded Disbelief

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1. Introduction

It is difficult to talk holistically about children's "prosodic comprehension" since prosody is at work in so many parts of the grammar. Prosody can be used to demarcate intonational phrases, to highlight a discourse entity (focus), to mark sentence modality, convey emotion, sarcasm, irony, etc. The list goes on and continues to grow as we learn more about the nuances of the role of prosody in adult grammars. Many languages like Spanish, English or Catalan use prosody, specifically intonation, to encode information about the speaker's epistemic stance (belief states, attribution of thoughts) (Escandell Vidal 1998; Armstrong 2010, 2012; Gravano et al. 2008; Crespo-Sendra et al. 2013; Vanrell et al. 2013). Yet there is no work (to the author's knowledge) assessing children's ability to use prosody as a window to a speaker's belief state. There is a good deal of work, however, examining children's ability to infer belief states using the lexicon, e.g. mental state verbs (Shatz et al. 1983; Bartsch & Wellman 1985) or modal verbs (Papafragou 1998; Papafragou & Ozturk 2007).

Recent work shows evidence that belief state prosody, specifically intonation, presents an interesting acquisition challenge for children. Armstrong (2012) studied the acquisition of yes-no question intonation in Puerto Rican Spanish (henceforth PRS). In this variety of Spanish, the speaker has the option to encode his/her belief state about the propositional content of a question through intonation (Armstrong 2010, 2012, submitted). For instance, in a confirmation question, a PRS speaker can mark the utterance as a question *without* encoding belief state information using the ¡H*L% contour. Another

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alternative is for the speaker to use L*HL%, which in addition to marking questionhood conveys the speaker's disbelief about the proposition. Felicitous contexts for each contour type are shown in (1) and (2).

(1) Context: A and B live in a rural area in Western Massachusetts.
A: I had to run to the store to get some food for the goats.
B: *You have goats*? How many? I've got six but we should be getting one more soon.

(2) Context: A and B live in Manhattan.
A: I had to run to the store to get some food for the goats.
B: *You have goats*?! Where in the world do you keep them?

In (1), the speaker confirms a proposition that she inferred from A's previous utterance, that A has goats. For a context like this in PRS, a default question contour that does not convey information about belief state would be used. In a context like (2), in addition to confirming that A has goats, B is able to express her state of disbelief about the proposition, since Manhattan is not the sort of place we expect people to be raising farm animals. Here the PRS disbelief question contour (henceforth L*HL%) would be appropriate/felicitous.

In a longitudinal study of two PRS-acquiring female toddlers between the ages of 1;9 and 3;6, Armstrong (2012) found that while the PRS default question contour ¡H*L% is acquired as early as 1;9, L*HL% is never used felicitously by the toddlers in the study. Five percent of all caretaker questions, however, were produced with L*HL% (versus 93% produced with the default contour ¡H*L%). It is possible that L*HL% poses an acquisition challenge to children that the default question contour does not, perhaps because L*HL% 1.) encodes not just sentence modality (marking a question), but also a speaker's state of disbelief about a proposition and 2.) it is only felicitous for questioning propositions that were activated just prior to the time of utterance (either linguistically or extra-linguistically). Specific child-directed speech (CDS) uses for L*HL% were also found in Armstrong's longitudinal data. Caretakers often used L*HL% to encourage the child to reformulate a response that may not be true or satisfactory for the caretaker, as in (3). A caretaker may also use the contour to show interest or excitement about something the child has just said, as in (4).

(3) Context: A mother points to a green chair and asks her 3-yr-old son what color it is.
Mother: What color is this?
Child: Red.
Mother: Red? (L*HL%)

(4) Context: The child's mother welcomes her home from school.
Mother: What did you do today in school?
Child: I drew a picture.

Mother: You drew a picture? (L*HL%) That's great! Can I see?

Both of these specialized CDS uses relate to a core disbelief meaning – with the first use the caretaker expresses 'disbelief' that the child responded with the incorrect answer, implicating that the caretaker knows that the child knows (or should know) the right answer (i.e. the child *should* know her colors, etc.). In (3) disbelief is used to make a child aware of her inaccuracy (negative valence), while in (4) disbelief is used as a positive reaction to something the child has done. These context-dependent, pragmatic uses of L*HL% are a potential confound to the child. When, then, are children able to comprehend the core disbelief meaning of L*HL% questions? The objective of this research was to understand when children can reliably comprehend L*HL% meaning. Below I review the various pieces to this acquisition puzzle and present results from a linguistic comprehension experiment designed to assess 4-, 5- and 6-year-olds' comprehension of L*HL% in PRS. I discuss these results and their implications for the study of L1 prosodic development.

1.1. Sp_ToBI and PRS questions

In this work, I use the Sp_ToBI (*Spanish Tones and Breaks Indices*) labeling system (Beckman et al. 2002; Estebas-Vilaplana & Prieto 2009; Prieto & Roseano 2010; Hualde & Prieto to appear) to describe the intonation contours used for PRS questions. The Sp_ToBI system assumes the Autosegmental Metrical (AM) framework (Pierrehumbert, 1980; Ladd, 1996/2008; Gussenhoven 2004). Within this framework, the fundamental frequency (F0) contour is understood as a sequence of high (H) and low (L) tonal targets throughout an utterance. Some languages, like Spanish or Catalan, show evidence for three levels of contrastiveness in terms of pitch height (Borràs Comes, Vanrell & Prieto, in press). Two types of tones are assumed in the AM framework. The first type is *pitch accents,* tonal events associated with metrically prominent syllables within the utterance. Pitch accents are monotonal (e.g. H*, L*) or bitonal (e.g. L+H*, L*+H, H+L*, H*+L). For the case of PRS, we find low (L) tones, high (H) tones and extra-high (¡H) monotonal pitch accents (Armstrong, 2010). The asterisk is used just after the tone that is associated with the metrically strong syllable. In bitonal pitch accents, if there is a tone preceding this starred tone, the preceding tone is referred to as the leading tone. For example, in a H+L* pitch accent the leading tone is a high (H) tone. If the starred tone is followed by a tone, it is referred to as the trailing tone. Thus for the L*+H pitch accent, the trailing tone is a high (H) tone. The second type of tones is boundary tones, which are tonal events associated with the edges of prosodic phrases. These can be of varying pitch heights as well, but in more general terms will be high (H) or low (L). Boundary tones are associated with right edges of intermediate phrases (ip) or intonational phrases (IP).

Within one IP it is possible to find more than one pitch accent. The final pitch accent in an utterance, which is quite often the most prominent pitch

accent, is referred to as the *nuclear pitch accent*. Pitch accents preceding the nuclear pitch accent are known as *prenuclear pitch accents*. The combination of a nuclear pitch accent and the subsequent boundary tone is commonly referred to as a *nuclear configuration* in many ToBI systems. In PRS, the default intonation contour for yes-no questions is the ¡H*L% nuclear configuration, (Armstrong 2012; submitted). This refers to an extra-high nuclear pitch accent with a subsequent fall to a low boundary tone, and can be seen in the schematic in Figure 1. As stated earlier, should the speaker choose to convey his or her disbelief with respect to the propositional content of the question, s/he can indicate this intonationally with the L*HL% nuclear configuration. This is characterized by a low, flat tone in the nuclear stressed syllable with a subsequent rise and fall, as shown in Figure 2. The white area on each schematic indicates the pre-tonic syllable, the dark grey area indicates the nuclear stressed syllable and the light grey areas indicate the post nuclear syllable(s).

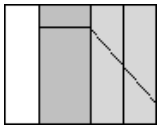

Figure 1. ¡H*L%

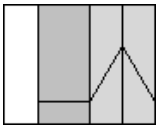

Figure 2. L*HL%

1.2. Prosodic comprehension

As I have noted, it has become clear that 'prosodic comprehension' cannot be considered holistically, since age of acquisition and the extent of variability found within different age groups depends on the specific function of prosody that is being acquired (Cutler & Swinney, 1987; Wells et al. 2004; Martínez-Castilla & Peppé 2008). Wells et al. (2004) used a battery of prosodic tasks examining both children's production and perception of different aspects of prosody - namely prosodic phrasing, affective/attitudinal meaning, sentence type and focus. This study used the child version of the Profiling Elements of Prosodic Systems procedure (PEPS-C). Wells et al. investigated children between the ages of 5;6 and 13;9[2]. These authors' results reveal a great deal of variation in children's performance. They found that children's prosodic comprehension (as well as production) depends largely on the function of prosody. For instance, 5-year-olds were better at discriminating sentence type (declarative versus question) through prosody than they were for comprehending focus, or for 'chunking' of prosodic constituents. In a more recent study using

[2] This battery has also been used for atypical populations of children such as children with high-functioning autism or Asperger's Syndrome (see Peppé et al. 2011; Martínez-Castilla et al. 2012, among others). The PEPS test is the adult version (Peppé, 1998; Peppé et al. 2000).

eyetracking, Zhou et al. (2012) found that 4- and 5-year-old speakers of Mandarin Chinese are quite similar to adults in their comprehension of declarative versus question prosody. An offline task also showed that children were sensitive to the intonational difference between these two speech acts. Ito et al. (2012) highlight the importance of providing children with context in comprehension tasks testing children's prosodic knowledge. They found that both visual and discourse contexts were important for determining whether or not children were able to inhibit a recent referent and attend to a new one based on prosody. Other recent work has shown discourse context to be quite important to children. Both Armstrong et al. (submitted) for Central Catalan speaking children (ages 4-6), and Aguert et al. (2010) for French-speaking children (ages 5-9) have shown that children give considerable weight to situational context when processing meaning. Taken together, these studies confirm that prosodic comprehension depends on prosody's specific role. Including appropriate discourse contexts for children is also critical. For this specific acquisition problem, then, it is important to consider which challenges the acquisition of a particular form-meaning pair might present. For children to successfully comprehend the meaning of L*HL% in PRS, they must not only understand how intonation is used to mark sentence modality (i.e. questions), but they must also recognize that this specific contour provides them with belief state information (namely the speaker's disbelief). It is therefore helpful to consider other parts of the grammar apart from intonation that provide listeners with mental state-related information.

1.3. Child comprehension of belief states

Mental state verbs and epistemic modal verbs are lexical items that convey information about the mental states of individuals. Papafragou et al. (2007) note that for mental state verbs, there is a lack of an ostensible action for the child to observe visually and relate with the lexical item when acquiring it. It is much easier to observe that a jumper is performing the action of jumping versus observing that a thinker is thinking. We could expect a similar difficulty for the acquisition of L*HL% to convey disbelief meaning in questions. In general, 4-year-olds appear to be making important strides in terms of their comprehension of both mental state and modal verbs, a behavior that has been claimed to be related to their emerging metacognitive abilities/developing Theory of Mind (Papafragou 1998; Miller 2004). For instance, whereas verbs like *think* and *know* are known to appear in production around the first year (Bretherton & Beeghly, 1982; Shatz, Wellman & Silber, 1983), they are not known to be distinguished in comprehension until some time around age four (Papafragou et al. 2007; Moore, Bryant & Furrow 1989; Moore & Furrow 1991; Naigles 2000). Papafragou & Ozturk (2007) observed that while children may start to use modal vocabulary very early on, it is not until age four that they are able to differentiate between modal expressions. This is also the age that children have been shown to distinguish between mental state verbs like *know*/*be sure*,

think/*guess* (Moore, Bryant & Furrow, 1989; Moore & Davidge, 1989). While 4- and 5-year-olds show evidence for progress in terms of modal verb comprehension, Papafragou (1998) claims that it is not until the sixth year that the child has a full understanding of the underpinnings of the modal system. Given the developmental paths previously identified for modal and mental state verbs, children between the ages of 4 and 6 were of interest in the present study since comprehending L*HL% involves an awareness of the speaker's mental state (i.e. disbelief).

1.4. Hypotheses

Based on the literature on modal and mental state verbs mentioned above, we can hypothesize that children between the ages of 4 and 6 might show competence in L*HL% comprehension. Given Papafragou's claim (1998) that it is in the sixth year that children are aware of the underpinnings of the modal system, we might also expect that 6-year-olds would be particularly skilled in comprehending the full meaning of L*HL%. The experiment detailed below was designed to test these hypotheses.

2. Methods

2.1. Participants

A total of 36 Puerto Rican Spanish-speaking children participated in the experiment: 8 4-year-olds (mean age: 4;6, ranging from 4;0 to 4;8), 16 5-year-olds (mean age: 5;6, ranging from 5;0 to 5;11) and 12 6-year-olds (mean age: 6;4, ranging from 6;0 to 6;8). The children came from lower, middle and middle-class families. They were recruited from several schools in San Juan, Bayamón, Levittown and Guaynabo City, Puerto Rico and were tested individually in a quiet room outside their classrooms. In order to validate the stimuli and the procedure, a group of 10 Puerto Rican Spanish-speaking adults living in the same area also participated.

2.2. Linguistic comprehension task

2.2.1. Visual materials

Visual materials were presented on a PowerPoint presentation by the experimenter. Participants always saw a set of twins, Verónica and Marisol, and their friend Jeni, in addition to pictures of different animals (i.e. the animals that Jeni told the twins she saw). An example slide is shown in Figure 3.

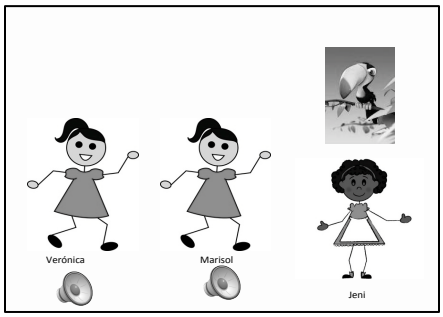

Figure 3. Example of PowerPoint slide presented to participants

2.2.2. Audio materials

In order to avoid a voice bias, all audio stimuli were produced by one 33-year-old female speaker of PRS. For familiarization and filler trials, the speaker produced an utterance with a proposition that was either affirmed *(Pues sí, yo te creo que viste un tigre*. 'Well, yes, I believe you that you saw a tiger.') or negated (*Ay no, yo no te creo que viste un tigre*. 'Oh no, I don't believe you that you saw a tiger.') These stimuli were produced with appropriate declarative contours in PRS, and therefore never overlapped with the intonation used for the test stimuli. For the test trials, the speaker recorded short echo questions (i.e., one prosodic word) produced with either (¡H*L%) or (L*HL%). Each question was made up of an indefinite determiner (*un* or *una* 'a') plus the name of the animal (e.g. *Una vaca?* 'A cow?'). Hence, participants heard either a contour that marks the utterance for questionhood only (¡H*L%), versus a contour that marks an utterance for questionhood in addition to disbelief (L*HL%). Figures 4 and 5 show typical phonetic implementations of the ¡H*L% contour (Figure 4) and the L*HL% contour (Figure 5) that were used in the study.

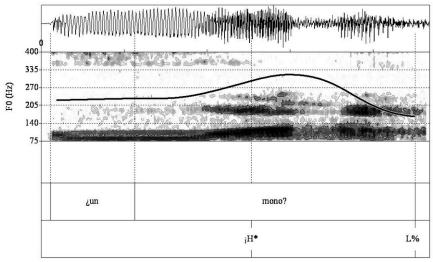

Figure 4. Typical realization of ¡H*L% used in stimuli for the question *¿Un mono?* 'A monkey?'

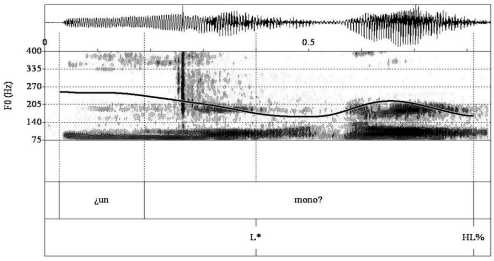

Figure 5. Typical realization of L*HL% used in stimuli for the question *¿¡Un mono?!* 'A monkey?!'

2.3. Procedure

Each child was introduced to the two characters, Verónica and Marisol, and was told that they were twins. The experimenter confirmed that the child understood what a twin was. They were then told that the twins had a friend named Jeni. Jeni had just returned from vacation with her family and was telling the twins about the animals she saw. The child was told that there was always one twin that did not believe Jeni, and that s/he needed identify which twin that was by listening closely to what each twin said. For example, the experimenter said to the participant *Jeni les dice que vio un tucán*. 'Jeni tells them that she saw a toucan', and an image of a toucan appeared. The child then heard each twin 'say' a pre-recorded echo question as a reponse, produced with either ¡H*L% (neutral echo) or L*HL% (disbelief echo). If the child heard ¡H*L% first, s/he heard L*HL% second, and vice versa. The twin on the lefthand side always spoke first, and the twin on the righthand side always spoke second. Two lists were presented to the participants, counterbalancing for the side on which each twin appeared (left or right; Marisol or Verónica), and which contour was played first (¡H*L% or L*HL%). After listening to each twin produce an echo question, the experimenter asked the child *¿Quién no le cree? Enséñame.* "Who doesn't believe her? Show me." The child then pointed to the twin s/he thought did not believe Jeni. Participants received two familiarization trials (see Audio Materials), for which they received feedback. The process lasted about 12-15 minutes per child. There were 12 targets and 6 fillers presented to each child, for a total of 18 trials. The fillers were exactly like the training trials, with affirming and negating statements. Additionally, each participant's session was recorded on the laptop's built-in camera. A total of 432 target trials were analyzed for child participants, and 120 trials for adults.

3. Results

The control group of PRS-speaking adults performed at 100% on all trials in the task, i.e. they always decided that the twin asking a L*HL% question was

the one that did not believe Jeni. We now turn to the child results. Figure 6 shows the percentage of correct answers for each of the age groups.

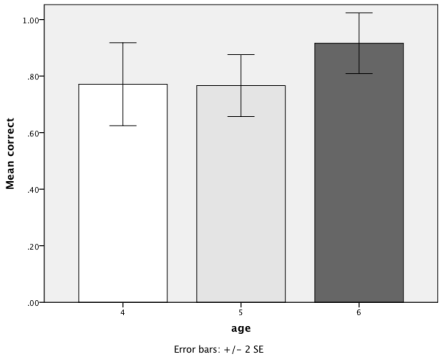

Figure 6. Percent correct responses for each age group with error bars

4- and 5-year-olds showed very similar performance on the task (77% vs. 76.66% correct, respectively). 6-year-olds performed best, with 92% accuracy. A one-sample t-test was used to test each age group against chance performance (50% correct). All groups performed significantly above chance: 4-year-olds ($t(7) = 3.70$, $p = 0.008$); 5-year-olds ($t(14) = 4.88$, $p<0.001$) and 6-year-olds ($t(12) = 7.81$, $p <0.01$). While 4- and 5-year-olds performed in similar ways, the error bars indicate that there was less variance for 5-year-olds.

To test whether age was a significant predictor of performance on the task, the data were then analyzed using a mixed-model logistic regression, which was fit to the data using the statistical tool R (R Development Core Team, 2009). For the model presented here, the dependent variable was CORRECT RESPONSE (i.e. whether the child identified the twin who used disbelief intonation as the one that did not believe Jeni). AGE was tested as a potential predictor (a fixed effect), and PARTICIPANT was included as a random effect. The lmer function in the lme4 package of the R statistical package was used (Bates, Maechler & Bolker, 2011). The model's fixed effects are presented in Table 1, alongside the factors' estimated coefficients and their predictive significance. In order to understand differences between all three groups, I present the results first with Age 4 as the reference level, and then results from the same model with Age 5 as the reference level.

	Estimate	*SE*	*z* value	Pr(>|z|)
(Intercept)	1.87	0.72	2.57	p<0.01
Age (reference level is Age 4)				
Age 5	-0.03	0.85	-0.40	0.97
Age 6	2.04	1.00	2.03	0.04
(Intercept)	1.84	0.55	3.33	p<0.01
Age (reference level is Age 5)				
Age 4	0.03	0.85	0.40	0.97
Age 6	2.07	0.88	2.35	0.02

Table 1. Coefficients of fixed effects

Age was a significant predictor of correct response choice. There was no significant difference between 4- and 5-year-olds' performance, but 6-year-olds performed significantly better than 4-year-olds (3.91/1.87). They also performed significantly better on the task when compared to 5-year-olds (3.91/1.84). The pattern shown here is not unlike the one described by Papafragou (1998) for comprehension of modal verbs. All age groups perform significantly above chance, but 6-year-olds appear to be more refined in their performance.

3.1. Qualitative observations

While the study was not designed to test children's implicit reactions to the stimuli, the video recordings yielded some unexpected observations. Three of the twelve 6-year-olds reacted to the linguistic stimuli in a way that none of the other groups did – as they listened to the stimuli, they produced facial gestures known to be associated with the two types of questions. Brow furrowing was often produced prior to the offset of the L*HL% nuclear configuration, while raising was often produced just after hearing the ¡H* nuclear pitch accent. The photos in the upper and lower left panels in Figure 8 show neutral expressions for two of the children, before they listened to the target stimuli. The photo of the female child in the upper right panel shows a typical reaction to stimuli produced with ¡H*L% (brow raising), and the photo of the male child in the lower right panel shows a typical reaction to stimuli produced with L*HL% (brow furrowing). Two of the participants (the same two shown in Figure 8), when asked by the experimenter how they knew which twin did not believe Jeni after the very last trial, replied *Porque ella dice* '¡¿*un lagarto*?!' (Because she says 'a lizard!?') producing both the L*HL% nuclear configuration in addition to moving the head back and down, accompanied by eyebrow furrowing.

Figure 8. Child facial gestures. Photos on left indicate neutral faces, upper right produced during/after questions with ¡H*L%, lower right produced during/after questions with L*HL%

In a production study examining the relationship between facial gesture and intonation in Catalan and Dutch, Crespo-Sendra et al. (2013) showed that speakers of both languages tended to produce upward eyebrow movements for 'information-seeking' yes-no questions, while for 'counter-expectation' questions speakers from both languages produced downward eyebrow movements (or furrowing), eye-squinting and head movements described as 'down and back'. Srinivasan and Massaro (2003) also found that questions can be discriminated from statements by American English speakers by attending to brow-raising. The gestures produced by the older children in the present study as they listened to the stimuli were never produced by the 4- or 5-year-olds. It is also worth noting that some 5- and 6-year-olds told the experimenter they knew which twin did not believe Jeni *porque lo dijo más fuerte* 'because she said it stronger/louder' or *porque lo dijo más alto* 'because she said it louder'. These behaviors indicate some metalinguistic knowledge about the use of intonation and its linguistic use for differing meanings that should be explored in future work.

4. Discussion & Conclusions

This experiment was carried out based on the hypothesis that 4-6 year-olds should show sensitivity to L*HL% meaning, since children this age are known to be developing comprehension skills for other mental-state related forms - namely mental state and modal verbs. All three age groups performed at above-chance levels on the task, showing evidence that 4-6-year-olds can make use of prosodic cues to guide them to information about a speaker's belief state. The 4- and 5-year olds did not show any significant differences when compared to each other, whereas 6-year-olds were significantly more accurate on the task when compared to the younger participants. These findings are compatible with Papafragou's (1998) observations about the development of the modal system –

with 4- and 5-year-olds making initial strides, and 6-year-olds showing a more advanced understanding of the system's underpinnings. Additionally, it is noteworthy that some 6-year-olds produced meaningful facial gestures as a reaction to the target stimuli. These same facial gestures have been shown to be related to questioning and disbelief meanings in other languages. While this behavior should be explored in a more controlled way in a future study, it is interesting that only 6-year-olds demonstrated the behavior. The role of facial gesture in intonational development merits further investigation. In any case, even though all three age groups examined perfomed at above-chance levels on the task, 6-year-olds were the most adult-like. The PRS-speaking children assessed here show sensitivity to intonationally-encoded belief state information around the same age that children are known to comprehend modal and mental state verbs. One limitation of this study, however, is that it did not examine the correlation between children's ability to infer belief states through intonation and their ability to make modal verb/mental state verb distinctions, and future research should take this into account.

Differently from Zhou et al.'s results, the results reported here show that 4- and 5-year-olds do not perform in a completely adult-like way. This highlights the fact that all prosodic comprehension is not equal. Zhou et al.'s work showed that younger children are successful at comprehending broad sentence-modality distinctions (declaratives versus questions). But in the present study, we find 4- and 5-year-olds still developing the ability to comprehend more nuanced meaning about a speaker's assessment of propositional content within the question domain. This could vary based on the type of assessment the speaker is making. For instance, L*HL% encodes speaker disbelief, but PRS has yet another intonation contour, H+L*L%, that conveys positive epistemic bias (Armstrong, 2012) for yes-no questions. Whether comprehension of PRS H+L*L% develops differently from L*HL% remains to be seen. As a final note, I point out that at least for Spanish, there is a paucity of studies that present detailed accounts of intonational meaning, even for adults. Accurate accounts of intonational meaning in the adult grammar are needed in order to study a child's intonational development in a precise manner. Such an understanding of both intonational form and meaning are paramount if we are to advance our knowledge of prosodic acquisition.

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