Intonational Grammar in Ibero-Romance

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Issues in Hispanic and Lusophone Linguistics (IHLL)

ISSN 2213-3887

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Volume 6

Intonational Grammar in Ibero-Romance. Approaches across linguistic subfields
Edited by Meghan E. Armstrong, Nicholas C. Henriksen and Maria del Mar Vanrell

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Prosodic and gestural features distinguish the intention of pointing gestures in child-directed communication

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Previous literature had found that infants rely on the social-contextual information to understand the pragmatic meaning of a pointing gesture. Our study investigates the prosodic and gesture features accompanying a pointing gesture that infants may also use to infer its meaning. Nine caregiver-infant dyads played three games designed to elicit pointing acts with either an expressive, imperative, or informative pragmatic meaning. Results show that in all pragmatic situations caregivers mostly combine pointing gestures with speech to direct the infants attention to an object, and that in child-directed communication specific prosodic (intonation contour, pitch range, and mean syllable duration) and gesture features (hand shape, gesture duration, and the gesture's lexical affiliate) indicate the pragmatic meaning of a pointing gesture.

Keywords: child-directed communication; pointing gestures; prosody; intention understanding

1. Introduction

One of the gestures that received more attention in the developmental literature is the pointing gesture. Pointing gestures are the first communicative gestures that infants produce (e.g., Bates, Camaioni, & Volterra, 1975; Tomasello, Carpenter, & Liszkowski, 2007) and a reliable measure of the infants' later lexical development (e.g., Colonnesi, Stams, Koster, & Noom, 2010; Iverson & Goldin-Meadow, 2005). Several studies have found that as early as one year of age infants are able to understand the pragmatic meaning behind a pointing gesture, i.e. the reason why the interlocutor is pointing (Aureli, Perucchini, & Genco, 2009; Behne, Liszkowski, Carpenter, & Tomasello,

DOI 10.1075/ihll.6.12est
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2012; Camaioni, Perucchini, Bellagamba, & Colonnesi, 2004), which can be that of requesting an object that is out of reach (an *imperative* motive), that of sharing the interest in an event (an *expressive* motive), or that of providing information to others when they need it (an *informative* motive) (Bates et al., 1975; Tomasello et al., 2007). Research on early comprehension of pointing gestures has found that infants rely on common ground and social contextual information. Very young infants manage to comprehend the imperative, expressive, or informative motives of an attention-directing act if they are given enough social contextual information (Aureli et al., 2009; Behne et al., 2012; Camaioni et al., 2004). Importantly, these findings can be interpreted as a sign for an early development of the Theory of Mind[1] (Liszkowski, 2013). The importance of inferring the social intention of the interlocutor is based on the assumption that human motivations for communicating are cooperative (Grice, 1975; Searle, 1999) and that the shared intentionally and common ground is a requisite for a successful communication between interlocutors (Clark, 1996; Grice, 1957; Tomasello, 2008).

However, recent studies show that when the common ground is ambiguous and thus not helpful for infants to interpret the meaning of the pointing gesture, prosodic and gestural features accompanying the gestures are crucial for infants to understand the adult's intention. Esteve-Gibert, Prieto, and Lizskowski (2013) tested 12-month-olds in two tasks in which infants had to infer the imperative, the expressive, or the informative meaning of a pointing gesture. In these tasks the social common ground and the lexical information that infants received was the same across the three pragmatic meanings. Results revealed that infants could anyway manage to assign the expected pragmatic meaning to the pointing gesture, suggesting that when the common ground and the lexical cues are not helpful to them, infants might process the prosodic and gesture signals as indicators of the adult's intention. However, no research has determined the nature of these prosodic and gestures features accompanying pointing gestures that might help infants inferring the pragmatic meaning behind a pointing gesture.

Prosody is crucial in first language development. During the first months of life infants detect the rhythmic pattern of languages (e.g., Nazzi, Bertoncini, & Mehler, 1998), an ability that helps them learning to segment the speech stream into words (e.g., Thiessen, Hill, & Saffran, 2005). Pre-lexical infants use phonetic cues of prosody (pitch range and duration) to signal the intentional value of vocalizations (Esteve-Gibert & Prieto, 2013; Papaeliou & Trevarthen, 2006). Some months later, at the onset

1. The classical definition of the ToM is the ability to reason about mental states, such as beliefs, desires, and intentions, and to understand how mental states feature in everyday explanations and predictions of people's behavior (e.g., Premack & Woodruff, 1978).

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of combinatorial speech, infants develop adult-like intonation and phrasing patterns (Frota, Matos, Cruz, Vigário, this volume), although the mastering of intonation patterns continues until the pre-school stages (Armstrong, 2012; Lleó, this volume).

The importance of the adults' use of prosodic features in the infants' language development is extensively accepted in the literature. It is widely known that adults modify the prosodic cues of their speech when talking to infants in the so-called 'child-directed speech' (henceforth CDS). Adults use higher pitch and wider pitch excursions when talking to infants, and they also produce longer pauses, longer vowels, longer words, and shorter utterances (Fernald & Mazzie, 1991; Fernald & Simon, 1984; Ko & Soderstrom, 2013). In a cross-linguistic comparison Payne, Post, Astruc, Prieto, and Vanrell (2009) found that CDS displays less global variability in both consonant and vowel interval duration, has a higher proportion of vowels, and thus is more *syllable-timed* than adult-directed speech (henceforth ADS), particularly in Catalan and English, but also in Spanish. Armstrong (2012) found that caregivers use intonation contours that serve CDS-specific functions, such as that of encouraging children to reformulate a mistaken answer, or to signal that the new information introduced in the common ground is very interesting or novel.

But communication is multimodal and infants receive relevant discourse information from other modalities like gesture. Several studies have investigated how caregivers modify not only verbal but also gestural strategies when interacting with infants. They found that mothers showing novel objects to their children are more interactive, enthusiastic, and proximal to the infant, and that they use a greater range of motions (Brand, Baldwin, & Ashburn, 2002). Interestingly, other studies have demonstrated that infants' attention is greater when they look at actions with more amplitude and repetition (Brand & Shallcross, 2008; Koterba & Iverson, 2009; Masataka, 1992), and that they learn words faster if the labels are presented while moving the object or while accompanying them with a pointing gesture (Gogate, Bahrick, & Watson, 2000; Matatyaho-Bullaro, Gogate, Mason, Cadavid, & Abdel-Mottaleb, 2014).

The present study aims at contributing to this research by investigating the prosodic and gesture strategies that caregivers might use to signal the pragmatic meaning behind their child-directed pointing gestures. Previous literature showed that pointing gestures acquire their meaning in context, but our hypothesis is that act-accompanying features also carry important information for the encoding of the pragmatic meaning of pointing gestures. In order to do it, we tested nine caregiver-infant dyads in three semi-structured games designed to elicit child-directed communicative acts with three specific intentions: an expressive game (sharing the interest about an object), an imperative game (requesting an object to the child), and an informative game (informing the child about the hidden location of an object). The communicative acts were analyzed prosodically (caregivers' use of intonation contour, pitch range, and syllable duration) and g (hand shape, duration, and lexical affiliate of the

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pointing gesture). If the prosodic and gesture cues differ across pragmatic situations, this would mean that the pragmatic meaning of the pointing gesture is also conveyed by other aspects of the communicative act apart from common ground and social contextual information.

2. Methodology

2.1 Participants

Nine caregiver-infant dyads participated in the study. Infants were aged between 11 and 14 months old (mean age 13;05) and were 6 girls and 3 boys. All caregivers were native Central Catalan speakers and spoke exclusively Catalan to their child and with their partner. Caregivers were asked about their linguistic habits through a questionnaire, and results showed that they all had Catalan-speaking parents and Catalan was their first language (L1). All dyads lived close to Barcelona, in small villages where Catalan is spoken by 83.19% of the population (Generalitat de Catalunya. Institut d'Estadística de Catalunya, 2013).

2.2 Set-up and materials

Three games were designed to elicit child-directed pointing acts with three differing pragmatic meanings: an expressive game (i.e. sharing with the child their interest in an object), an imperative game (i.e. asking the child to give them an object), and an informative game (i.e. informing the child about the location of a hidden object). The set-up, materials and procedure of each game established enough social contextual information to enable infants understanding the caregivers' intent when directing their attention towards an object.

2.2.1 *Expressive game*

The caregiver sat on a chair near the dining table in the dining room. The infant was seated on the caregiver's lap. A laptop was placed at a distance of one meter from the caregiver (Figure 1). This distance prevented both caregiver and infant from touching the laptop, and favored the production of pointing gestures. A PowerPoint presentation consisting of twenty slides was displayed on the laptop. The first two slides had an attention-getting video of a toy moving around the screen and saying twice *Hola! Hola!* 'Hello! Hello!'. Thereafter, each slide showed a picture of an object that infants typically know at that age: a pear, a cake, a strawberry, a car, a sun, a ball, a moon, a tree, an airplane, a clown, a devil, a flower, a fish, a bee, a zebra, a cow, a cat, a dog, some ants, and a hen. The transition from one slide to the other was automatic and occurred 7 seconds after the object was displayed.

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2.2.2 *Imperative game*

The caregiver sat on the floor beside a rectangular table, typically a sofa coffee table in the living room. The infant stood next to the caregiver and they both played with a toy that consisted of two pieces that the infant had to match together. Another toy was ready to be used in case the child showed signs of being bored.

2.2.3 *Informative game*

The caregiver sat on the floor at a distance of one meter from the sofa, facing it. The infant sat on the caregiver's lap. The caregiver and child were playing with a toy that consisted of two pieces and the infant had to match them together. Another toy was ready to be used in case the child showed signs of being bored with playing with the first toy. On the sofa four cushions were displayed horizontally.

2.3 Procedure

The dyads were video-recorded using a SONY HDR-CX410VE camera. No additional microphone was used. All caregiver-infant dyads participated in the three games.

2.3.1 *Expressive game*

The procedure to elicit expressive pointing gestures was similar to that in Camaioni et al. (2004) but adapted to be suitable for a semi-spontaneous situation. The aim of the game was that the caregiver shared his/her interest with the child about the images appearing on the laptop screen. To do it, the Experimenter (henceforth E) instructed the caregiver to watch the PowerPoint presentation displayed on the laptop screen. The caregiver was asked to share with the child his/her interest in the things they would see on the screen (see Figure 1). Crucially, E did not give any further instructions about what to say or whether to gesture. The PowerPoint presentation was displayed twice.

Figure 1. Setting and procedure in the expressive game. Left, dyads sitting in front of the laptop presentation; center, when the attention-getter was presented; right, caregiver producing an expressive pointing gesture

2.3.2 *Imperative game*

The procedure to elicit imperative pointing gestures was again similar to that in Camaioni et al. (2004) but adapted to be suitable for a semi-spontaneous situation.

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The aim of the study was that the caregiver requested an object from the child. To do it, E instructed the caregiver to play together with the child with a two-piece toy. When the child was involved in the game, the caregiver was asked to pretend that one piece had slipped from his/her hands and then throw it to the end of the table. The thrown piece was what the child and caregiver needed to keep on playing. The caregiver then asked the child to give him/her the piece so they could continue playing (Figure 2). No instructions were given regarding what to say or whether to gesture. This sequence of events was repeated 8–10 times.

Figure 2. Setting and procedure in the imperative game. Left, dyads playing together; center, the caregiver having thrown away one piece and then the child looking for it; right, caregiver requesting the object to the child

2.3.3 *Informative game*

The procedure to elicit informative pointing gestures was similar to that in Aureli et al. (2009) and Behne et al. (2012) but again adapted for a semi-spontaneous situation. The aim of the game was that the caregiver informed the child about the hidden location of an object. To do it, E instructed the caregiver to play with a two-piece toy. When E saw that the child was involved in the game and holding one of the two pieces, E suddenly entered the scene and took the piece from the infant's hands. E hid the piece under one of the cushions on the sofa. E then said to the child *[Child's name]! On* és*, la peça? On* és*?* '[Child's name]! Where is the piece? Where is it?', while shrugging her shoulders and opening her hands with a palm-up gesture. The caregiver then informed the child about the location of the hidden piece (Figure 3). This game was repeated 8–10 times.

Figure 3. Setting and procedure in the informative game. Left, dyads playing together; center, the experimenter hiding one of the pieces under the pillow; right, caregiver informing the child about the location of the hidden piece

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2.4 Data coding

From the recordings of the expressive game, the first author of the study selected the caregivers' communicative acts directed to infants with the specific intention of sharing their interest with the child about the objects appearing in the laptop screen (for a total of 351 acts). From the recordings of the imperative game, we selected those acts that consisted on requesting the object to the child (for a total of 388 acts). And from the recordings of the informative game, we selected those acts that had the aim of informing the child about the location of the hidden object (for a total of 309 acts). Thus, only those communicative acts that directed the infants' attention towards the object with the specific intention that the particular game was eliciting were taken into account. For instance, if during the informative game the child did not return to the caregiver's lap after finding the hidden location of the object, the caregiver tended to utter a sentence like *Porta-ho cap aquí, va, que continuarem jugant* 'Bring the toy back here, come on, we'll keep on playing with it'. This sentence has an imperative meaning (that of requesting the object and the event), not an informative meaning (informing about the hidden location), so it was not selected from the recordings of the informative game for further analysis nor used for the analysis of imperative strategies.

The selected expressive, imperative, and informative acts were coded in terms of prosodic features (intonation contour, pitch range, and mean syllable duration), and gesture features (hand shape, gesture stroke duration, and lexical affiliate that accompanied the pointing gesture). Also, caregiver-infant interaction features (modalities that caregivers used to convey the intended meaning and response that the acts triggered from the infant) were coded in order to see whether caregivers behaved naturally, whether the games triggered the observation of pointing-speech combinations, and whether infants understood the game and got involved in it.

2.4.1 *Caregiver-infant interaction features*

First, the caregivers' communicative acts were classified in terms of the modalities used to convey the intended meaning. Three categories were used: 'speech-only act' (when the caregiver's act consisted of speech), 'pointing-only act' (when the caregiver's act consisted of only a deictic manual gesture), and 'pointing-speech combination' (when the caregiver's act consisted of a deictic manual gesture accompanied by speech). Second, we coded the child's reaction after the caregiver's act, with four possibilities: *attending object,* if the child was looking, pointing, or vocalizing towards the object that the caregiver was directing his/her attention (the expected behavior in the expressive game); *offering object*, if the child offered the target object to the adult (the expected behavior in the imperative game); *attending the hidden location*, if the child looked for the target object in a hidden location (the expected behavior in the informative game), and *no reaction,* if the child was not involved in the game.

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Inter-rater reliability was conducted with 10% of the data by two independent coders who were unaware of the purpose of the study. The agreement in coding the modalities used to convey the intended meaning (speech-only, pointing-only, pointing-speech combination) was 100%, Cohen's Kappa = 1.00, indicating perfect agreement among raters. The agreement in coding the child's reaction after the caregivers' act (attending object, offering object, attending hidden location, no reaction) was 87%, Cohen's Kappa = 0.82, indicating almost perfect agreement among raters.

2.4.2 *Prosodic features*

Caregivers' speech acts (accompanied by gesture or not) were coded in terms of intonation contour, pitch range, and mean syllable duration (Figure 4). For the intonation analysis, the nuclear configuration of the intonation phrase (nuclear pitch accent and final boundary tone) was annotated in Praat (Boersma & Weenink, 2012) using the Cat_ToBI system for the transcription of Catalan intonation (Prieto, 2014). For pitch range, the minimum and maximum fundamental frequency points were located at the phrase-level automatically in Praat and later checked manually. For mean syllable duration, the total duration of the intonation phrase (in milliseconds) was automatically extracted from Praat and later divided into the number of syllables in the prosodic phrase.

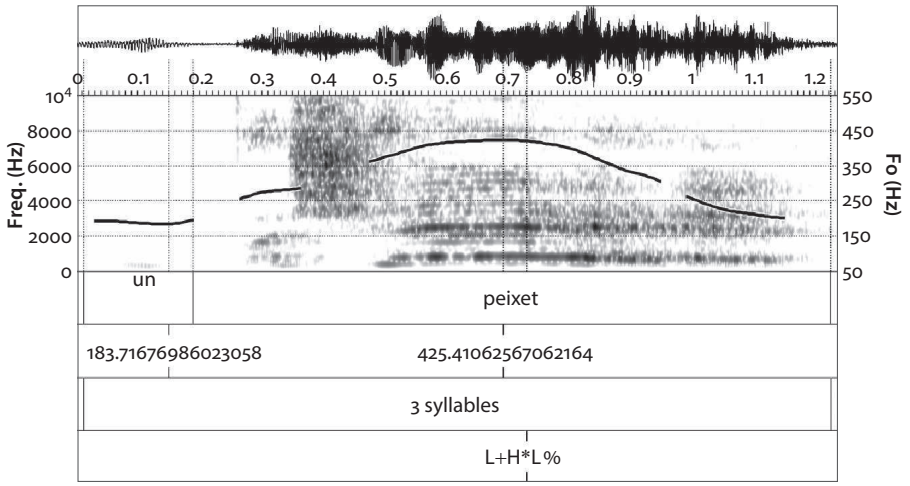

Figure 4. Prosodic annotation of the sentence *Un peixet* 'A little fish'. Second tier, maximum and minimum F0 values in Hz. Third tier, total duration and number of syllables in it. Fourth tier, intonation contour in Cat_ToBI

Inter-rater reliability was conducted with 10% of the data by two independent coders who were unaware of the purpose of the study. The agreement in coding the intonation contour was 82%, Cohen's Kappa = 0.79, indicating substantial agreement among raters.

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2.4.3 *Gesture features*

Caregivers' pointing gestures (accompanied by speech or not) were coded in terms of gesture hand shape (three possibilities: index finger, hand-open palm-up, or hand-open palm-down), the duration of the gesture stroke, and the grammatical category of the gesture's lexical affiliate. The gesture stroke is the interval of time in which the dynamics of 'effort' and 'shape' are expressed with most clarity (Kendon, 2004; McNeill, 2005), i.e. those video frames in which the arm is well extended with no blurring of the image, the fingertip being fully extended or not. The lexical affiliate is the word or words that correspond most closely in meaning to the gesture (McNeill, 2005; Schegloff, 1984). Four grammatical categories were used to classify the lexical affiliate: *noun*, when the stroke of the gesture coincided with a noun in speech; *verb*, when the stroke of the gesture coincided with a verb in speech; *locative expression*, when the stroke coincided with a lexical expression such as 'here', 'there', or 'down there'; and *pronoun*, when the stroke coincided with phrases like 'me' or 'to me'. If the gesture stroke was produced in combination with more than one of the previous categories, it was coded as *noun+verb*, *verb+pronoun*, etc.

Inter-rater reliability was conducted with 10% of the data by two independent coders who were unaware of the purpose of the study. The agreement in coding the hand shape (index finger, hand-open palm-up, hand-open palm-down) was 100%, Cohen's Kappa = 1.00, indicating perfect agreement among raters.

3. Results

A total of 1,048 child-directed acts were analyzed. Of these, 351 had an expressive meaning (sharing interest about an object with the infant), 388 had an imperative meaning (requesting an object from the infant), and 309 had an informative meaning (informing the infant about the hidden location of an object).

3.1 Caregiver-infant interaction features

Of the total number of caregiver acts, 27% (N = 283) were speech-only acts, 1.8% were pointing-only acts (N = 19), and 71.2% (N = 746) were pointing-speech combinations. Thus, even though caregivers were not given any instructions about having to gesture, most of their child-directed acts were a combination of a deictic manual gesture and speech. A chi-squared test for assessing goodness of fit revealed that the number of gesture-speech combinations varied across pragmatic situations ($\chi^2(2, N = 746) = 7.772, p < .05$). Gesture-speech combinations were significantly less frequent in the expressive than in the imperative ($\chi^2(1, N = 483) = 6.727, p < .01$) or informative situations ($\chi^2(1, N = 476) = 5.252, p < .05$), while equally frequent when comparing the

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imperative and informative situations ($\chi^2(1, N = 476) = 0.092$, $p = .76$) (60.7% in the expressive, 69.6% in the imperative, and 85.1% in the informative situations).

The child's reaction was also coded to ensure that the games worked and that infants were engaged in them. Results show that in the expressive situation infants were engaged in the game because they mostly attended the object (92.6% of the acts), and only scarcely did not show any reaction (7.4% of the cases). In the imperative situation infants were also engaged in the task because they attended the requested object 46.6% of the times and they actually offered it to the adult 32.5% of the times (only they did not show any reaction 20.9% of the times). In the informative situation, infants were also engaged in the game because they looked at the referred place in 30.4% of the times and they actually crawled or walked towards the hidden location in 54% of the cases (only in 15.5% of the times they did not show any reaction).

3.2 Prosodic features

A total of 1,029 child-directed acts contained speech, but 21 cases were excluded because the prosodic features could not be identified in Praat (due to poor sound quality or because the caregiver was whispering).

Table 1 displays the distribution of the intonation contours across pragmatic situations and shows that (1) most of the contours were observed in all three pragmatic situations, (2) some contours were a lot more frequent than others, and that (3) two contours seem to dominate over the others in each pragmatic situation (see items in boldface, Table 1). Statistical analyses were run to see whether pragmatic conditions are distinguishable by means of intonation contour. Five contours were excluded from the statistical analyses because they represented less than 2% of the total occurrences (Table 1): L* H% (0.8%), L* HL% (1.9%), H* L% (1.4%), L+H* LHL% (0.3%), and L+H* LH% (0.5%).

A chi-squared test of independence revealed that choice of intonation contour was significantly affected by the pragmatic condition (χ^2 (10, N = 959) = 352.744, p <.001), and that all conditions were different to each other: intonation contours were different when comparing the expressive with the imperative condition (χ^2 (5, N = 688) = 174.092, p <.001), the expressive with the informative condition (χ^2 (5, N = 601) = 131.017, p <.001), and the imperative with the informative condition (χ^2 (4, N = 629 = 144.318, p <.001).

In the expressive condition, the most frequent intonation contour was the rising-falling L+H* L% contour (exemplified in the sentence *I aquest* és *el sol solet!,* 'And this is the sun, little sun!', top panel in Figure 5). The L* L% nuclear contour was also found, frequently observed after a rising L+H* prenuclear pitch accent, such as

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Table 1. Distribution of intonation contours across the three pragmatic situations. In boldface, the two most frequent intonation contours per condition. Symbol '†' accompanies contours that were excluded due to very low occurrence

	Expressive		Imperative		Informative		TOTAL	
Cat_ToBI pitch contour	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
L L%*	**89**	**26.1**	**205**	**55.6**	**121**	**40.6**	415	41.2
H+L L%*	66	19.4	**122**	**33.1**	23	7.7	211	20.9
L H%* (†)	5	1.5	1	0.3	2	0.7	8	0.8
L HL%* (†)	2	0.6	2	0.5	15	5.0	19	1.9
H L%* (†)	3	0.9	4	1.1	7	2.3	14	1.4
L+H !H%*	23	6.7	2	0.5	6	2.0	31	3.1
L+H L%*	**124**	**36.4**	24	6.5	**62**	**20.8**	210	20.8
L+H HL%*	26	7.6	0	0	0	0	26	2.6
L+H H%*	2	0.6	5	1.4	59	19.8	66	6.5
L+H LHL%* (†)	1	0.3	1	0.3	1	0.3	3	0.3
L+H LH%* (†)	0	0	3	0.8	2	0.7	5	0.5
TOTAL	341	100	369	100	298	100	1,008	100

in the sentence *Mira* [L+H*] *quina pilota* [L* L%]! 'Look at that ball!'. Interestingly, two intonation contours were observed almost exclusively in the expressive condition: the calling contour L+H* !H% (exemplified in the sentence *La maduixeta!,* 'The little strawberry!', middle panel in Figure 5) and the rising-falling configuration L+H* HL% (exemplified in the sentence *Mira una abella*!, 'Look, a bee!', bottom panel in Figure 5). This is of interest because thus far these two contours have been reported in ADS only in vocatives, not in declarative expressive sentences (Prieto, 2014).

In the imperative condition the most frequent nuclear contour was the low pitch contour L* L%, typically found in sentences with two or more accents (exemplified in the sentence *Corre vés a buscar el garatge!,* 'Come on, go get the garage', top panel in Figure 6). In sentences with only one pitch accent, the contour was the rising-falling L+H* L% (exemplified in the sentence *Dóna'm,* 'Give it to me', bottom panel in Figure 6). Interestingly, our data show a relatively low incidence of this contour despite the fact that it has been described as one of the most frequent contours in adult-directed imperatives (Prieto, 2014). The second most frequent nuclear contour in imperatives was the falling nuclear configuration H+L* L% (exemplified in the sentence *Que me'l dónes?,* 'Will you give it to me?', middle panel in Figure 6), which is

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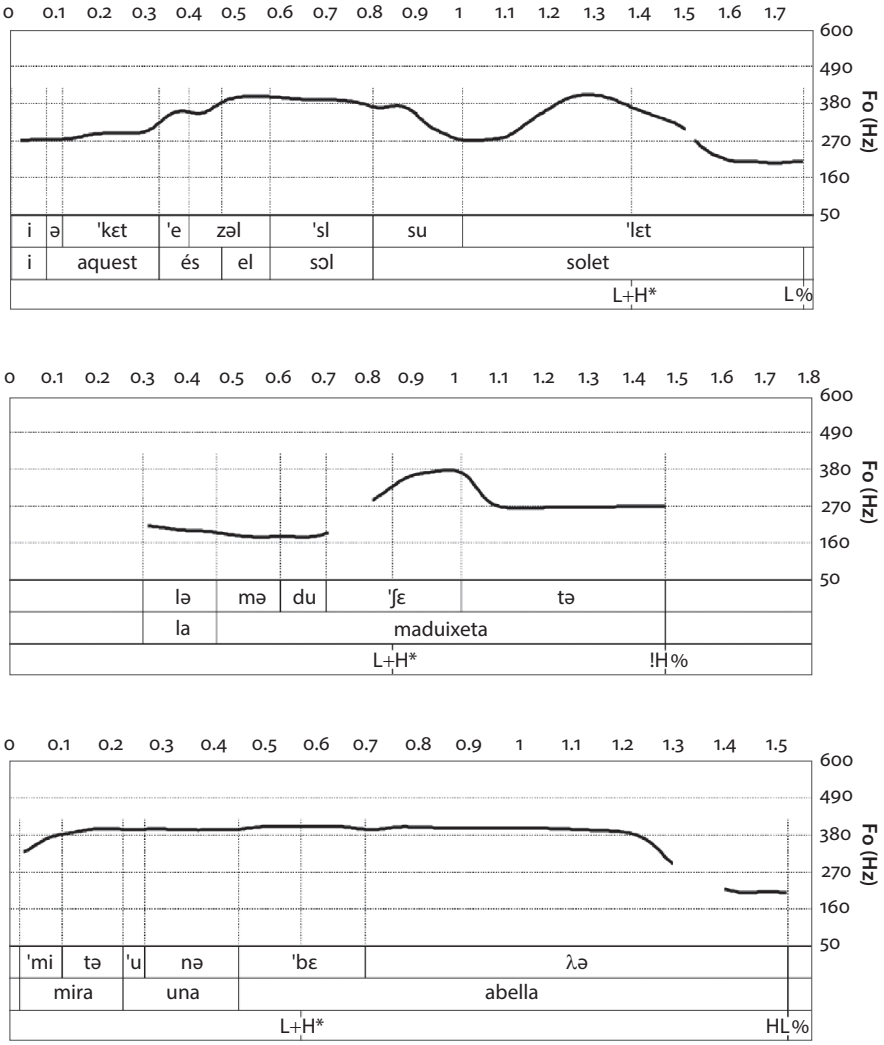

Figure 5. Contours in the expressive condition: top, the most frequent contour, L+H* L%; middle, calling contour L+H* !H% exclusive of this condition; bottom, contour L+H* HL%, exclusive of this condition

used in Catalan for information-seeking yes-no questions headed by the particle *que* 'that'. In our data we found only two instances of the L* HL% contour, which has been typically associated with requests in ADS.

In the informative condition, the most frequent nuclear configuration was L* L%, like in the imperative condition (exemplified in the sentence *Mira què hi ha allà sota,* 'Look what is under there', top panel in Figure 7). The second most frequent was the

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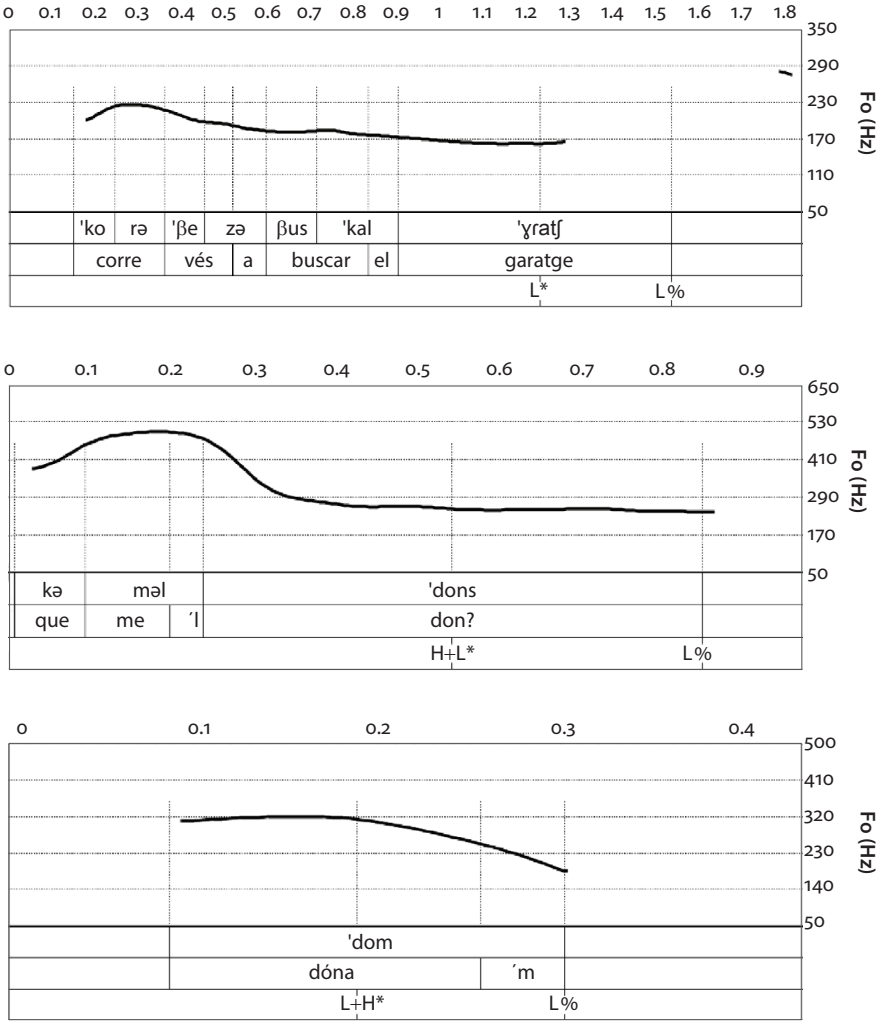

Figure 6. Contours in the imperative condition: top, the most frequent contour, L* L%; middle, contour H+L* L%, typical of yes-no questions headed by the particle *que* 'that'; bottom, contour L+H* L%, found occasionally

rising-falling contour L+H* L%, typical of the expressive condition (exemplified in the sentence *Allà,* 'There', middle panel in Figure 7). Interestingly, the rising L+H* H% intonation contour (exemplified in the sentence *Mira!,* 'Look!', bottom panel in Figure 7) was observed exclusively in the informative condition with a declarative function, and not an interrogative function which is the typical use of this contour in ADS (see Prieto 2014).

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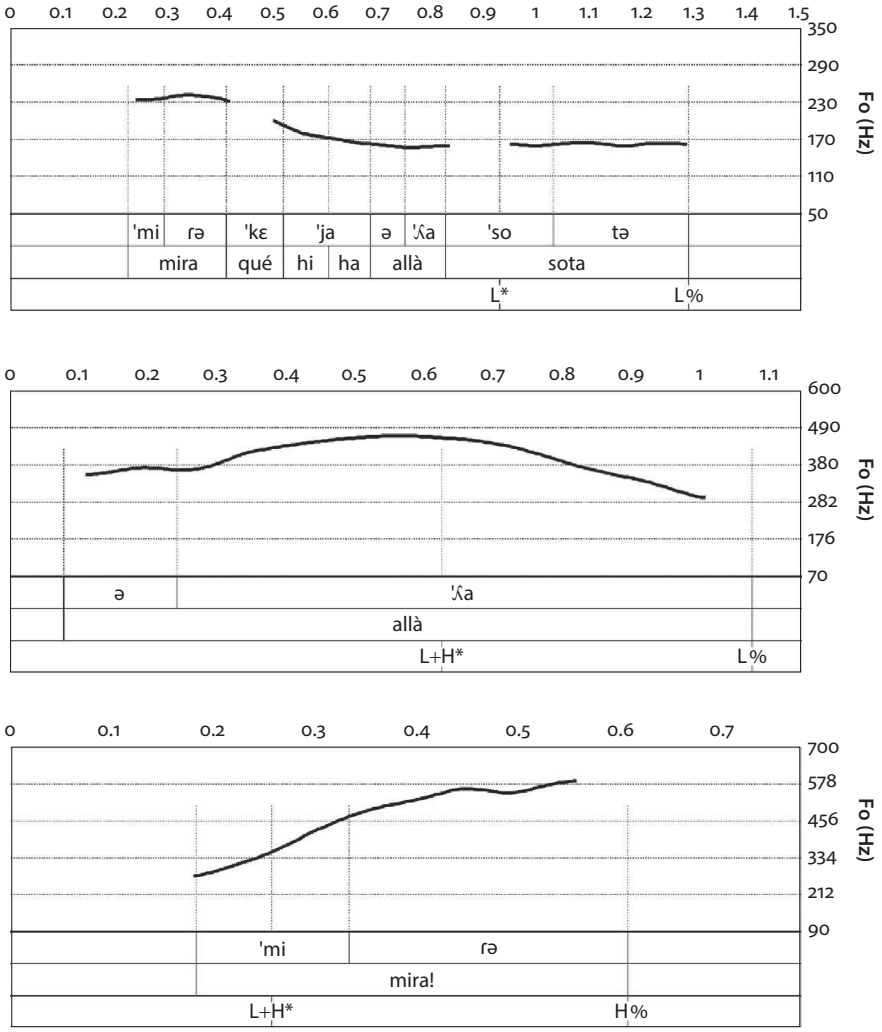

Figure 7. Contours in the informative condition: top, the most frequent contour, L* L%; middle, contour L+H* L%, the second most frequent in this condition; bottom, contour L+H* H%, found almost exclusively in this condition

For the analysis of phrasal pitch range we excluded the outliers from the total number of cases (23 out of 1,008). We ran a Generalized Linear Mixed Model (henceforth GLMM) analysis with pitch range (in semitones) as the dependent variable, pragmatic condition as the independent variable (three levels: expressive, imperative, informative), and subject as the random factor. The GLMM analysis

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revealed that pragmatic condition had a significant effect on the pitch range ($F(2,980) = 5{,}744$, $p < .01$). Bonferroni pair-wise comparisons showed a significant difference between expressive and informative conditions ($p < .01$), only a marginally significant difference between expressive and imperative conditions ($p = .054$), and no significant difference between imperative and informative conditions ($p = .214$). Figure 8 shows that the pitch range was wider in the expressive condition than in the other conditions, and the narrowest pitch range was produced during the informative game (expressive: $M = 12.27$ st, $SD = 5.77$; imperative: $M = 11.31$ st, $SD = 5.39$; informative: $M = 10.76$ st, $SD = 5.70$).

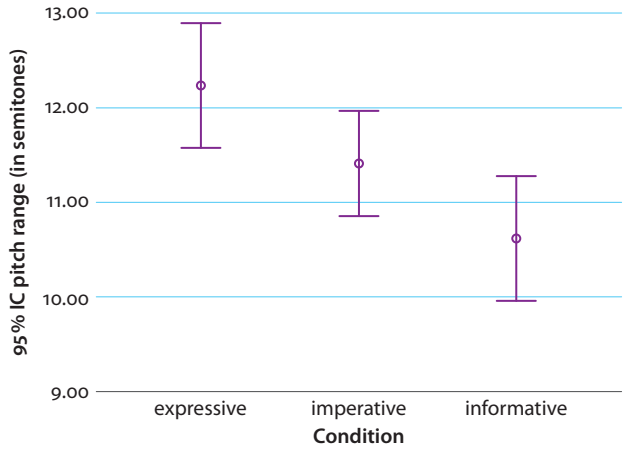

Figure 8. Mean pitch range (in semitones) across the three pragmatic conditions

In the analysis of mean syllable duration, a total of 63 outliers out of 1,008 were excluded. A GLMM analysis with mean syllable duration (in milliseconds) as the dependent variable, pragmatic condition as the independent variable (three levels: expressive, imperative, informative), and subject as the random factor revealed that condition had a significant effect on mean syllable duration ($F(2,939) = 66{,}042$, $p < .001$). Bonferroni pair-wise comparisons showed that the mean syllable duration differed significantly between expressive and imperative condition ($p < .001$), between expressive and informative conditions ($p < .001$), and between imperative and informative conditions ($p < .001$). As Figure 9 shows, the longest syllables were found in the expressive condition ($M = 217.68$ ms, $SD = 53.94$), the shortest syllables in the imperative condition ($M = 173.56$ ms, $SD = 45.34$), and the middle values in the informative condition ($M = 190.14$ ms, $SD = 47.72$).

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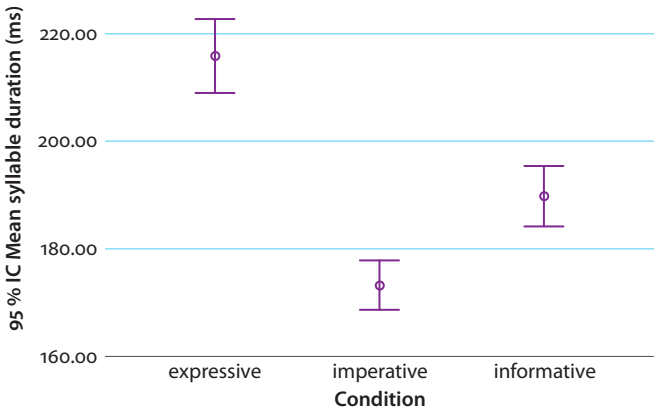

Figure 9. Mean syllable duration (in ms) across the three pragmatic conditions

3.3 Gesture features

This analysis included all child-directed acts containing gesture (accompanied by speech or not). Table 2 shows the type of hand shapes as a function of the condition, both in absolute numbers and in percentages. Caregivers used an index finger deictic gesture in 98.6% of the acts with an expressive intention, in 31% of the acts with an imperative intention, and in 99.2% of the acts with an informative intention. The hand-open palm-up deictic gesture was found in more than half of the imperative acts (66.9%) and only rarely in the expressive (1.4%) and informative (0.4%) acts. The hand-open palm-down deictic gesture was found only a few times in the imperative (2.1%) and informative conditions (0.4%).

Table 2. Hand shapes as a function of the condition, both in absolute numbers and in percentages

	Expressive		Imperative		Informative		TOTAL	
	N	%	N	%	N	%	N	%
Index finger	212	98.6	88	31.0	264	99.2	564	73.7
Hand-open palm-up	3	1.4	190	66.9	1	0.4	194	25.4
Hand-open palm-down	0	0	6	2.1	1	0.4	7	0.9
TOTAL	215	100	284	100	266	100	765	100

Regarding the duration of the gesture stroke, a GLMM analysis with stroke duration (in milliseconds) as the dependent variable, condition as the independent variable, and subject as the random factor revealed that the duration of the stroke varied significantly depending on the pragmatic condition ($F(2,713) = 5.387$, $p < .01$) (see Figure 10).

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Bonferroni pair-wise comparisons revealed that the stroke duration did not differ significantly between expressive and imperative (p = .210) or informative conditions (p = .141), while it differed significantly between imperative and informative conditions (p < .01) (expressive: M = 1,210 ms, SD = 821.72; imperative: M = 1,311 ms, SD = 976.5; informative: M = 1,062 ms, SD = 890.11).

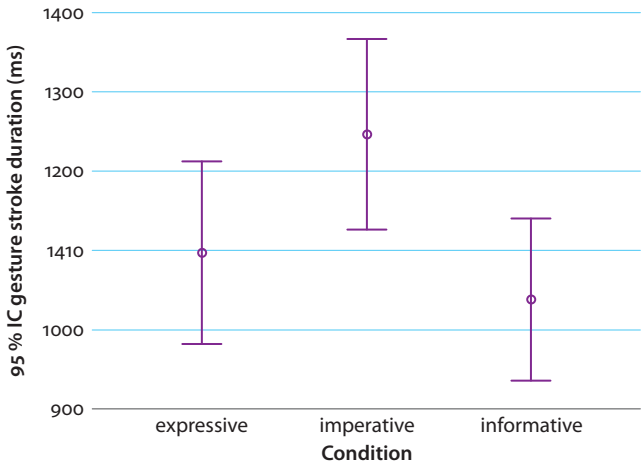

Figure 10. Mean duration (in milliseconds) of the gesture stroke across the three pragmatic conditions

Table 3 summarizes the grammatical categories of the lexical affiliate accompanying pointing gesture (across conditions). In the expressive condition, pointing gestures

Table 3. Lexical affiliate as a function of condition, in both absolute numbers and percentages

Lexical affiliate	Expressive		Imperative		Informative		TOTAL	
	N	%	N	%	N	%	N	%
Noun	140	67.6	24	8.9	13	5.5	177	24.8
Verb	18	8.7	154	57.2	11	4.6	183	25.7
Locative expression	26	17.4	37	13.8	174	73.4	247	34.6
Pronoun	0	0	13	4.8	0	0	13	1.8
Noun + verb	10	4.8	34	12.6	0	0	44	6.2
Noun + deictic word	1	0.5	0	0	16	6.8	17	2.4
Verb + deictic word	2	1	5	1.9	23	9.7	30	4.2
Verb + pronoun	0	0	2	0.7	0	0	2	0.3
TOTAL	207	100	269	100	237	100	713	100

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were mostly coordinated with a noun (67.6%) or in fewer cases with a locative expression (17.4%). In the imperative condition the most frequent lexical affiliate was a verb (57.2%), and in fewer cases a locative expression (13.8%) or a verb combined with a noun (12.6%). In informative condition the deictic gestures were mostly accompanied by locative expressions (73.4%) and less frequently by the other categories.

4. Discussion and conclusions

The aim of this study was to explore whether caregivers interacting with infants use prosodic and gesture cues to signal the pragmatic meaning of pointing gestures. Traditionally it has been said that pointing gestures acquire their meaning in context, but we proposed that prosodic and gesture features accompanying the pointing gestures also carry important information for the encoding of its pragmatic meaning. To test this hypothesis, a total of 9 caregiver-infant dyads were recorded while playing three semi-spontaneous games at their respective homes. Each game was designed to elicit child-directed pointing acts with a different pragmatic meaning: an expressive meaning (caregivers had to share with the infant their interest in an object), an imperative meaning (caregivers asked the infants to give them an object), and an informative meaning (caregivers informed the infants about the hidden location of an object). Our main attempt was to obtain child-directed acts as naturalistic as possible, so we adapted methodologies that other studies had used before in controlled laboratory settings (Aureli et al., 2009; Behne et al., 2012; Camaioni et al., 2004). In the laboratory settings these studies could control very precisely some variables such as the distance between object and child, the distance between object and caregiver, or the distance between caregiver and child. In our semi-spontaneous games we lost this tight control but on the other hand we gained on naturalness from the participants.

The analysis of the prosodic features assessed intonation, pitch range, and speech rate differences across pragmatic situations. In the expressive situation, caregivers produced sentences with the widest pitch range and the longest syllables. As for intonation, the most frequent nuclear pitch accent was the rising-falling L+H* L% nuclear pitch configuration. These results are consistent with the general intonation pattern found for exclamative sentences in Central Catalan ADS (Prieto, 2002, 2014). The second most frequent nuclear pitch configuration was L* L%. The expressivity in these sentences is conveyed not by the nuclear pitch accent but by a rising prenuclear pitch accent L+H*. Interestingly, two intonation contours were found in the expressive condition which occurred very rarely in the other conditions, namely the chant L+H* !H% and L+H* HL%. In ADS these two contours have been described in vocative sentences (Prieto, 2014), and our results show that in CDS they are also used for an

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expressive purpose. Other languages like German and Friulian use the vocative chant with a phatic function (Barker, 2005; Gibbon, 1998; Roseano, Vanrell, & Prieto, 2015), i.e. for establishing communication or prolonging it, or in narrow focus statements, exclamatives, and imperatives, or asking questions.

In an imperative situation, caregivers produced sentences with a narrow pitch range and the shortest syllables. In terms of intonation, the most frequent nuclear pitch configuration was the L* L% that is typical for the nuclear pitch accent in imperatives with more than one pitch accent (Prieto, 2014). Interestingly, the contour L+H* H%, common in interrogative sentences with an imperative purpose (Prieto, 2014), is found hardly at all in our data. Instead, the falling interrogative contour H+L* L% was observed very frequently. The preference for a falling interrogative pattern in child-directed speech had been previously documented in studies on Catalan intonation. Prieto and Rigau (2007), for instance, state that polar questions with a falling intonation pattern and optionally headed by *que* are used in contexts where the speaker wants to convey mutual understanding or emotional attachment with the hearer, and that this is very frequent in child-directed speech. Also, Thorson, Borràs-Comes, Crespo-Sendra, Vanrell, and Prieto (2014) found that the falling interrogative contour is the most frequently found in confirmation-seeking sentences in child-directed speech.

In an informative situation, caregivers produced sentences with a narrow pitch range and syllables that were shorter than in the expressive intention but longer than in the imperative intention. As for intonation, the most frequent contour was L* L%, which was also found in the imperative condition. Two other contours were the second most frequent ones: L+H* L% and L+H* H%. The use of L+H* L% in CDS parallels its usage in ADS, since in Central Catalan this contour is used in narrow contrastive focus sentences (Prieto, 2014) and in our data caregivers used this contour in sentences like *No, allà!* 'No, there!' to redirect their attention to the right place. The presence of the L+H* H% contour with an informative value is interesting because in our data it has a declarative value while in ADS it is generally found in interrogative sentences (Prieto, 2014). We hypothesize that caregivers use this contour when they want to transmit a combination of two meanings: the declarative expressive meaning with the pitch accent L+H* and the interrogative meaning with the high final boundary tone H%. Thus, in the sentence *Mira* 'Look' (bottom panel in Figure 7), caregivers might be trying to convey the idea 'Look' and also 'Can you see it?'.

All in all, specific intonation features are observed in CDS that would differ in ADS. As for intonation, (1) in an expressive situation caregivers use contours that in ADS are kept for vocative purposes (L+H* !H% and L+H* HL%); (2) contrary to what is observed in ADS, caregivers prefer the falling interrogative contour H+L* L% rather than the rising interrogative contour L+H* H% when requesting an object; (3) caregivers quite often use the contour L+H* H% with a declarative function, while in ADS this contour has an interrogative function. This is consistent with previous

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literature, showing that caregivers use certain intonation contours in CDS that serve CDS-specific intentions (Armstrong, 2012).

As for the pitch range differences across conditions, the widest pitch range was found in the expressive condition, the narrowest pitch range in the informative condition, and a somehow 'middle' pitch range in the imperative condition. However, statistical analyses revealed that the pitch range did not differ in the imperative and informative conditions (narrow pitch range) while it differed in the expressive condition (wide pitch range). We hypothesize that this is a consequence of the intonation contour that was mostly produced in each condition: the most frequent contour in both the imperative and informative conditions was the L* L% nuclear configuration, while in the expressive condition it was the L+H* L% nuclear configuration.

The gesture analysis revealed that caregivers used specific pointing shapes, gesture strokes duration, and lexical affiliates, to convey the different pragmatic meanings. As for pointing shapes, caregivers used index-finger deictic gestures in an expressive and an informative intention, but open hand deictic gestures (mostly palm up) when conveying an imperative intention. Liszkowski and Tomasello (2011) found that the relation between mothers' and infants' pointing is influenced by infants' pointing forms, and research in infants' pointing has shown that imperative gestures are associated with open-hand pointing and declarative gestures (expressive and informative acts) are associated with an extended index finger (Cochet & Vauclair, 2010).

As for the duration of the gesture stroke, the longest strokes were observed in the imperative situation while the shortest ones in the informative situation. The expressive strokes were closer to the informative than to the imperative ones. In adults, Levelt, Richardson, and La Heij (1985) found that the duration of the deictic gestures varied between 675 and 356 ms, this variation depending on the distance to the referent and hand laterality. The authors measured this duration in declarative deictic gestures, so our results for imperative strokes cannot be compared with Levelt et al's. However, if we compare our expressive and informative child-directed gestures with Levelt et al.'s (1985) results we observe that declarative child-directed gestures are much longer than adult-directed gestures.

The lexical affiliate of the pointing gesture, i.e. the word or words that correspond most closely in meaning (and are time aligned) with the gesture (McNeill, 2005; Schegloff, 1984), was also analyzed across conditions. The lexical affiliate has been proposed as a relevant measure to investigate the interrelation between speech and gesture production, especially when identifying the semantic meaning expressed in the gesture (Hadar & Pinchas-Zamir, 2004). Our results showed that caregivers spontaneously produced the most meaningful part of the pointing gesture (the gesture stroke) aligned with words that had different grammatical categories across conditions: the gesture stroke coincided with nouns in the expressive situation, the verbs coincided with the gesture stroke in the imperative situation, and in the informative

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situation there were mostly locative expressions coinciding with the gesture stroke. These findings suggest that caregivers spontaneously placed the gesture stroke within the utterance in a way that the lexical cues and the gesture stroke together conveyed the speakers' intended meaning in a specific situation.

Regarding the caregiver-infant interaction features, two main results were obtained. First, in all pragmatic conditions the proportion of pointing-speech combinations was higher than the proportion of speech-only or pointing-only acts. When looking at differences across conditions, it is interesting to note that caregivers used the highest proportion of pointing-speech combinations in the informative situation, while speech-only acts were more frequent in the expressive and imperative situations. The highest proportion of pointing-speech combinations in the informative game confirms previous findings in the literature showing that the use of deictic gestures is correlated with the presence of referring expressions (De Ruiter, Bangerter, & Dings, 2012; So, Kita, & Goldin-Meadow, 2009). De Ruiter et al. (2012), for instance, found that the pointing rate increased with the presence of locative expressions in speech. In our informative game caregivers had to inform infants about the hidden location of an object and that triggered many referring expressions, as results on the lexical affiliate reveal (namely, that in the informative condition the grammatical category accompanying the gestures were mainly locative expressions). Thus, our results parallel those in De Ruiter et al.'s (2012) in the sense that more locative expressions are highly correlated with the presence of more pointing gestures.

Second, infants understood the games and were engaged in them. Our aim when coding the child's reaction was to ensure that infants were engaged in the game and that they understood the caregiver's intention when directing their attention towards an object with a specific purpose. Results showed that infants were engaged in the game because they mostly reacted to the caregivers' attention-directing act, because they behaved as expected in most of the cases, and only scarcely did not show did not show any reaction. Taken together, results on the caregiver-infant interaction features demonstrate that the games were useful to elicit pointing-speech combinations in a way that were as naturalistic as possible and that infants understood the tasks and got engaged in them.

Taken together, our results have shown that prosodic and gesture cues also characterize the intentions of the communicative acts when caregivers direct the infants' attention towards an object. Contrary to previous theoretical views who considered that the meaning of a pointing gesture was obtained solely through common ground and socio-contextual information (Clark, 1996; Tomasello et al., 2007), we propose that it is a mixture of common ground and of the speech and gesture features accompanying the act what contributes to conveying the intention of a pointing gesture. Despite our findings, future research is needed to fully understand how infants learn to understand the meaning of pointing gestures and how they rely on speech and

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gestures for this purpose. In this study we analyzed prosodic and pointing cues, but other issues also need to be investigated to have a complete picture of the cues that infants might use to comprehend attention-directing acts, such as the syntactic structure of the sentences addressed to infants, how lexical cues are used by caregivers, or how referents are presented to the infant.

The pointing gesture is the first communicative gesture that infants learn to comprehend and the infants' ability to comprehend and produce this gesture is highly correlated with the infants' later language abilities (Colonnesi et al., 2010; Iverson & Goldin-Meadow, 2005). For these reasons, it is of crucial interest to investigate how and why infants learn to comprehend it, and also which cues are relevant to distinguish the pragmatic meanings behind a pointing gesture. We think that a better understanding of how infants comprehend pointing gestures will strongly contribute to our knowledge about language and cognitive development.

Acknowledgments

We thank Thomas Grünloh for his comments on the methodology. We thank Maria del Mar Vanrell, Rafèu Sichel-Bazin, Paolo Roseano, and Joan Borràs-Comes for their help with the transcription of intonation contours, and Alfonso Igualada and Santiago González for the inter-rater reliability tests. We are grateful to the children and their parents who voluntarily took part in this study. This research has been funded by a research grants FFI2012-31995 ("Gestures, prosody and linguistic structure"), 2009SGR-701 (GrEP - Grup de Recerca Emergent), by a travelling grant awarded by the Department of Translation and Language Sciences at the Pompeu Fabra University, and by the Recercaixa 2012–2015 grant awarded by 'La Caixa' Foundation.

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