THE DEVELOPMENT OF PROSODIC PATTERNS IN CATALAN-BABBLING INFANTS

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ABSTRACT

The aim of the present study is two-fold: first, to investigate whether Catalan-learning children display different prosodic patterns to distinguish communicative from non-communicative vocalizations at ages 0;7, 0;9, and 0;11; and second, to find out whether Catalan-babbling infants are able to use specific prosodic cues to express distinct pragmatic functions. In order to carry out this research, audio-video recordings of three Catalan-babbling infants born in monolingual families were made. From ages 0;6 to 1;0, these infants were recorded weekly for 30 minutes per session, at their homes and while playing normally with their parents. Vocalization analysis consisted of the independent marking of two prosodic features (pitch range and duration) and the codification of the communicative status of each vocalization. If they were judged to be communicative, vocalizations were further classified according to their specific pragmatic function. A total of 2,222 vocalizations were analyzed for this study, and we considered three points in the infants' development, namely ages 0;7, 0;9, and 0;11. Results show that the prosodic patterns that infants produce are different depending on the communicative status of the vocalization: vocalizations are shorter and with a higher pitch range when they are communicative than when they are not, irrespective of age and child. Further analyses show that infants display different prosodic patterns depending on the specific pragmatic functions they seem to be expressing: vocalizations expressing requests and protests have a wider pitch range and longer duration than vocalizations expressing response or statement. Thus, our results confirm the hypothesis that pre-linguistic infants are able to control their prosodic patterns in the second half of their first year to indicate not only communicativeness but also certain pragmatic functions.

RESUM

Aquest treball té dos objectius. En primer lloc, pretén investigar si els infants catalans entre 0;7 i 0;11 mesos empren de diferents patrons prosòdics per a distingir les vocalitzacions comunicatives de les no comunicatives. En segon lloc, pretén analitzar si els infants catalans utilitzen elements prosòdics específics per a expressar diverses funcions pragmàtiques. Per tal de dur a terme la recerca, tres infants catalans nascuts en famílies monolingües van ser enregistrats des dels 0;6 fins a l'any. Les sessions de gravació es van dur a terme setmanalment a casa dels infants mentre jugaven quotidianament amb els seus pares. . S'han analitzat les vocalitzacions produïdes a 0;7, 0;9 i 0;11, que en total han sigut 2222 vocalitzacions. S'ha dut a terme una anàlisi prosòdica amb la notació de la durada total i camp tonal i també, de forma independent, han estat classificades segons si eren comunicatives o no i, en cas de ser-ho, segons quina funció pragmàtica específica tenien. Els resultats mostren que els infants distingeixen les vocalitzacions comunicatives de les que no ho són a través dels trets de durada i de camp tonal: a totes les edats, les comunicatives són més curtes i amb més camp tonal que les no comunicatives. Una anàlisi més detallada de les vocalitzacions comunicatives ha mostrat que els infants empren determinats elements prosòdics per a indicar la funció pragmàtica de les seves vocalitzacions: les peticions i les protestes són més llargues i amb més rang tonal que les respostes o les declaratives. En conclusió, aquest estudi demostra que en l'etapa prelingüística, els infants ja controlen certs patrons prosòdics per a indicar que les vocalitzacions són comunicatives i per a expressar funcions pragmàtiques específiques.

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1. INTRODUCTION

Research on babbling has gained importance in the study of language acquisition. Even though traditionally the babbling period was thought to be non-relevant for linguistic analysis, an idea that was partly due to Jakobson's (1968) statement suggesting that the first linguistic stages were characterized by 'phonetic abundance' but 'phonemic poverty', many studies have since questioned Jakobson's statement with results showing some kind of continuity between babbling and early words (Boysson-Bardies & Vihman, 1991; Whalen, Levitt & Wang, 1991; Levitt & Utman, 1992; Hallé *et al.*, 1991; López Ornat *et al*., 2003; DePaolis, Vihman, & Kunnari, 2008). Even in newborns' cries, very recent research by Mampe, Friederici, Christophe, & Wermke (2009) has suggested that language-specific prosodic patterns are present. In their study, they compared 30 newborns born into French monolingual families and 30 newborns born into German monolingual families when the newborns were 3.45 days of age on average. The results showed that French newborns tended to produce rising melodies (L+H) in early cries whereas Germans tended to produce falling contours (H+L), similar to what they perceived pre-natally in their respective language environments.

Nevertheless, studies on the early and late babbling periods have found contradictory evidence for the presence or absence of language-specific influences. Those who have not found language-specific influences tend to support the breath group theory hypothesis (Lieberman, 1967). This theory defines a breath group as potentially multiword units marked at the right edge by distinctive pitch patterns. Tones would be organized in units that are physiologically defined by the breath cycle. Thus, rising contours would stabilize later than falling contours because they are acquired with language experience rather than being biologically determined. Kent & Murray (1982) represent a classic study of the intonation of English-learning infants. They found that the most usual contours at 0;3, 0;6, and 0;9 were flat, falling, and rising-falling patterns. They interpreted this finding as suggesting the preference for early falling intonation, which was due to a universal tendency for the decline in subglottal pressure as the vocalizations progress, as well as a reduction of vocal fold length and tension as the adducting and tensing muscles of the larynx relax at the end of a vocalization.

By contrast, Whalen, Levitt, & Wang (1991) studied 5 French-speaking children and 5 English-speaking children from 0;7 to 0;11. Their unit of analysis was two- and three-syllable reduplicative babbling. Results were analyzed both perceptually and acoustically, and they found that intonation patterns were different depending on the language environment: French children used more rising intonation and less falling intonation than English children. The authors suggested that these differences in contour direction could also be due to communicative purposes. Likewise, Levitt & Utman (1992) showed that even if prosodic patterns are biologically constrained, language experience can modify this natural tendency. They reported language-specific influences in one French-speaking child and one English-speaking child at 0;5, 0;8, 0;11, and 1;2. Data showed that the French child produced non-final syllables closer in duration to one another than did the American infant. This result is consistent with adult French, since French has greater isosyllabicity in non-final syllables. Similarly, DePaolis, Vihman, & Kunnari (2008) compared 10 English-, 10 French-, 5 Finnish- and 5 Welsh-speaking infants at the 4-word stage in their linguistic development. Data were analyzed in terms of *f*0, intensity and duration, and results showed that intensity and *f*0 varied widely in French, English and Welsh; Finnish-learning children seem to interpret intensity and *f*0 as separate cues because in Finnish adult speech there is a low variability of duration ratios and a fixed word stress. Duration, however, showed the clearest difference across infants learning different languages, since children exaggerate final syllable lengthening if the languages of their linguistic environments exhibit this phenomenon (as is the case of French). Finally, Hallé *et al.* (1991) compared 5 French-speaking children and 5 Japanese-speaking children and found that disyllables at the 25-wd point (at about 18 months age) were congruent with adult prosody in terms of *f*0 and duration, i.e. at the transition from babbling to early words: French children produced mostly rising contours whereas Japanese children produced falling or flat contours, in keeping with their respective ambient languages. By the same token, French children produced final lengthening on the last syllable of prosodic groups or words whereas Japanese children did not produce final lengthening, again in keeping with their ambient languages.

Snow (2006) also aimed to discover whether biological or language-specific influences guide the acquisition of prosody. He analyzed contour direction and accent pitch range in monosyllabic utterances from 60 English-learning infants between 0;6 and 1;11. In terms of accent range, results showed a U-shaped curve: at 0;6-0;8 the accent range is wide, but it becomes narrower again between 0;9-1;2. Then at 1;9-1;11 the accent range becomes wider again. He explains this difference as being due to respiratory constraints. In terms of contour direction, however, results showed no interaction between age and contour direction, suggesting a uniform developmental pattern of falls and rises. According to Snow, this fact indicates that respiratory constraints alone cannot explain the development of intonation and that other influences like emotional experience should be taken into account when studying pre-linguistic children. He concludes that the process of acquisition could be explained by a “regression-reorganization theory” which has the following developmental stages: at 0;6-0;8 pitch patterns reflect pre-intentional mechanisms that would support the breath group and emotional theories (linking physiological states and emotional experience); at 0;9-0;11 there is a regression phase suppressing intonational expressiveness; and finally at 1;6-1;8 pitch patterns are actively controlled.

The abovementioned studies have investigated the prosodic patterns irrespective of potential differences in the meaning of vocalizations. As we know, prosody is used by adults to express communicative intentions, attitudes and meaning, yet very few studies have focused on the development of prosodic patterns in children in relation to the communicative content they may convey. In our view, studying the development of intonation patterns is directly linked to the study of the emergence of communicative intention. In the following paragraphs we provide an overview of some of the work carried out in that area.

Many authors have studied the development of cognitive and social abilities as a necessary condition for language acquisition (Piaget, 1936, 1946; Vygotsky, 1962; Sinclair, 1973; Bruner, 1975; Bates, Camaioni, & Volterra, 1975; Trevarthen & Hubley, 1978; Tomasello, 1993), stating that the convergence of biological and socio-cultural factors enable human beings to use signs and therefore language. Trevarthen (1977, 1979, 1982) claims that two kinds of inter-subjectivity are present in children: children younger than 0;9 use their inborn primary inter-subjectivity, i.e. inborn motivation and sociability, while children older than 0;9 develop their secondary inter-subjectivity, i.e. social interaction directed at both people and objects. Piaget's approach to cognitive development locates the beginning of children's intentional communication between 0;8 and 1;0. According to Piaget, this is when children start using intentional behaviors: they perform actions to achieve a particular goal, they are aware of their actions' effects, and they are able to organize their actions. From then on, children develop intentional communicative behaviors by combining action schemes directed at objects with action schemes directed at people.

As Papaeliou, Mindakis, & Cavouras (2002) point out, "[t]he ability of infants, before the emergence of language, to communicate different kinds of messages through nonlinguistic aspects of voice can be investigated by examining whether vocalizations that have been classified in different message categories exhibit distinct acoustic features." The first author to study the emergence of communicative acts in that sense was Halliday (1975). He analyzed his son's early pitch contours from 0;9 to 2;6 and discovered that different vocal expressions seemed to convey distinct functions. Halliday found that his child produced mid falling tones when interacting with other people but low falling tones with narrower range when he was interested in the modification of an object. In a later study, Halliday (1982) claimed that the first communicative functions to emerge in the development of intentionality are the interactive function, the instrumental function, the regulator function, the informative function, the personal function, the heuristic function, and the imaginative function. López-Ornat & Karousou (2005) studied vocalizations from 0;8 to 2;6 in 95 Spanish-speaking infants. Parents were asked to answer a Child Development Inventory questionnaire about the linguistic behaviors of their children. Parents had to answer whether their children produced variegated babbling, canonical babbling, proto-words, imitation, proto-statements, proto-imperatives, proto-conversations, or non-communicative vocalizations. They could answer 'not yet', 'yes', or 'before but not now'. Their results revealed that children as young as 0;8 were able to produce vocalizations with pragmatic functions such as protoconversations (defined as the child producing turn-taking dialogues, with or without recognizable words) or protodeclaratives (defined as the child trying to attract someone's attention about something (s)he likes and accompanying it with gestures).

Some studies have faced the issue of how consistently children use intonation contours to convey pragmatic functions. Marcos (1987) analyzed perceptually the communicative functions of pitch range and pitch direction in infants, comparing the prosodic patterns of ten children when requesting, giving, showing, and labeling, from 1;2 to 1;10. In terms of pitch range, Marcos found the highest pitch range for repeated requests, a somewhat lower range for initial requests, a still lower range for giving and showing, and the lowest range for labeling. In terms of pitch direction, patterns were only clear with requests and labeling, since children used rising tones when requesting and falling tones when labeling.

Other studies have examined the prosodic patterns of infants' vocalizations in relation to their pragmatic functions when children are younger than 1 year of age. D'Odorico & Franco (1991) studied 5 Italian-learning children from 0;4 to 0;11 months of age, analyzing acoustically their vocalizations in terms of mean *f*0 values, maximum and minimum pitch, average number of pitch change and units of vocalizations in a prosodic unit, and mean duration. As for context types, vocalizations were classified as vocalizations during infant manipulation of a toy (VIM), vocalizations during shared experience (VSE, i.e. manipulating a toy but looking at the adult), vocalizations during adult manipulation of a toy (VAM), and vocalizations during exchanges with the adult (VEA, i.e. neither of them is manipulating the toy but they are both looking at each other). Results offered support for a 'selective production hypothesis' whereby different types of vocalizations were produced in different communication contexts until children were 0;9. Thus, children at 0;4-0;6 used different contour directions when producing a VIM and a VSE; at 0;6-0;8 children assimilated categories VSE and VAM; and at 0;8-1;0 VIM vocalizations could not be distinguished from the other vocalizations. The authors hypothesized that a child's ability to acoustically distinguish between categories tends to disappear as age increases. Therefore, children show a selective production hypothesis until 0;9 but not thereafter. Because their results revealed many individual differences among their infant subjects, the authors concluded that they had failed to capture communicative differences in contexts.

Papaeliou, Mindakis, & Cavouras (2002) examined the acoustic patterns of English infant vocalizations expressing emotions and communicative functions. They assumed, on the one hand, that younger infants are able to express their emotions vocally and, as their intentional communication develops, they become able to vocalize communicative functions (Bates, Camaioni, & Volterra, 1975; Hubley, Trevarthen, 1979; Marcos, 1987); on the other hand, they also assumed that the expression of emotions identifies the quality of communication whereas the expression of communicative functions identifies the direction and purpose of communication (Threvarten, 1990). Given these assumptions, their hypothesis was that infants' ability to vocally distinguish between emotions and communicative functions may serve as an index of their communicative capacity. They studied six English-speaking infants aged 0;7 to 0;11 and analyzed the following features in the vocalizations: duration; beginning, final, peak, lowest and mean *f*(0) values; range of *f*(0); standard deviation of *f*(0); and ratio of standard deviation of *f*(0) to duration of the vocalization. The meaning of the vocalizations was assigned by interviewing mothers about the meaning they would attribute to their infant's vocalizations, a system that, according to the authors, simulates the natural conditions of communication. They found that prosodic patterns were different when vocalizations conveyed communicative functions from when they expressed emotions: vocalizations carrying communicative functions were shorter, with lower *f*(0) values, and had greater intensity than vocalizations expressing emotions.

Similarly, Papaeliou & Trevarthen (2006) found evidence that pre-linguistic vocalizations can be a tool for both communicating and thinking. They observed four English-speaking infants from 0;7 to 0;11 and classified their vocalizations as 'communicative' or 'investigative' according to concurrent non-vocal behaviors. They considered a vocalization to be investigative if the infant was holding an object, inspecting an object or completing a task; they considered it communicative if the child was interacting with an adult, pointing, directing eye-gaze to the adult, and reaching or giving something. They observed that children displayed different prosodic patterns when vocalizations were classified as communicative, or when classified as investigative: compared to investigative vocalizations, communicative vocalizations had a higher mean and maximum *f*(0), higher standard deviation of *f*(0) , and shorter duration.

Taking into account all this literature, the goals of this project are two-fold. First, it seeks to determine whether Catalan-acquiring children also display different prosodic patterns that distinguish communicative from non-communicative vocalizations during the second half of their first year, specifically at 0;7, 0;9, and 0;11, since it is during this period that children learn intentional communication (Trevarthen, 1977, 1979, 1982; Piaget, 1936, 1946). Our hypothesis is that children's investigative[1] vocalizations are longer and with a narrower pitch range than when they are trying to communicate[2]. Second, it aims to discover whether Catalan-babbling infants are able to use prosodic cues selectively in order to express distinct pragmatic functions, since evidence in the literature suggests that Catalan children start producing adult-like intonation patterns during the late babbling period (Prieto *et al.* 2010).

The second aim of our study can be regarded as a continuation of the recent work done in on the acquisition of Catalan by Prieto *et al.* (2010). They studied the development of prosodic patterns in four Catalan children from the Serra-Solé database and demonstrated that children at 1;1 and 1;3 are able to produce a wide range of adult-like intonation contours. More precisely, they demonstrated that infants at the one-word stage are able to produce adult-like statements making virtually no errors when aligning the rising tonal accent. During the transition period from the one-word stage to the two-word stage, Prieto *et al*. (2010) found that Catalan infants are able to perfectly produce complex intonation contours like statements, vocatives and question intonation. At the two-word stage, infants produce intonation contours to express a request, discomfort or insistence. In the present study we also investigate the possible selection of different intonation

[1] We will also use Papaeliou & Trevarthen's term (2006) 'investigative' for non-communicative vocalizations, i.e. vocalizations produced when the child is not interacting with anybody but rather speaking or playing alone.

[2] 'Communicative vocalizations' are produced when the child is interacting or trying to interact with his/her parents. The distinction between 'communicative' and 'investigative' vocalizations relies on non-vocal cues (see 2.3.1.)

contours depending on the degree of intentionality, but in this case our subjects will be pre-linguistic children.

This dissertation is organized as follows. The following section explains the methodology used in this study. In particular, we present the children who participated in the study, the data collection method followed, and how the data was analyzed, both in terms of pragmatic functions and acoustic analysis, as well as the statistical analysis and graphing methods used. Next, the results of the analyses are presented and discussed. Finally, the conclusions that may be drawn from study are laid out.

2. METHOD

2.1. Participants

Three Catalan-learning infants participated in the study, two male (Biel and Martí) and one female (Àngela). They were recorded from 0;6 to 1;0[3]. In addition, another female participant (Ona) was recorded but data from this recording was not included in the present study because when recorded this child was one month younger than the others, i.e. when the other three were 1;0, Ona was still 0;11. The recordings of Ona will be set aside for further research since we ultimately intend to obtain a complete infant speech database for Catalan that includes data from early babbling until the two-word stage.

All parents of the three participants speak exclusively Catalan to their child and to each other. The children all come from small towns in the same region of Catalonia, Alt Penedès, located 50 km to the south of Barcelona. According to the information available from the official statistics website of Catalonia (www.idescat.cat), in two of these towns, Catalan is spoken regularly by about 90% of the population, whereas in the remaining town Catalan is spoken by 80% of the population[4]. Thus it may be safely assumed that there is very little Spanish influence in the children's linguistic environment. Parents were asked about their linguistic habits through a questionnaire (see Appendix 1). As for the three mothers, all have Catalan-speaking parents, have lived in Catalonia all their lives, and have Catalan as their first language (L1). They use Catalan in all dealings with their family, work colleagues, and friends. As for fathers, two of them have Catalan-speaking parents, and have always lived in Catalonia. Catalan is their L1 as well as the vehicular language for family, work, and friends. Àngela's father, by contrast, has Spanish-speaking parents and uses Spanish as the primary language for communicating with family and work colleagues. However, he both speaks and writes Catalan fluently, and uses it with his wife, daughter, and friends.

[3] This age range was chosen because it coincides with the fourth and fifth stages in the definition of babbling made by Oller (1980) and Stark (1980): (1st) 'Reflective vocalization' (0;0-0;2): Infants produce cries, fussing sounds, and resonant vocalizations; (2nd) 'Cooing stage' (0;2-0;4): Infants produce sounds heard as 'coos'; (3rd) 'Expansion' or 'vocal play' (0;4-0;6): Infants produce squeals, growls, nasal murmurs, and at the end of this period, approximations of consonants and vowels; (4th) 'Canonical' or 'reduplicated babbling' (0;6-0;10): Infants produce strings of identical consonant- and vowel-like elements.; (5th) 'Variegated' or 'non-reduplicative babbling' (0;10 – early words): Infants produce syllables with a variety of consonantal and vocalic types, and a greater variety of syllable types.
The second half of the first year is also when infants develop intentional communication. If we take as reference Piaget's four stages of cognitive development, our period of study would be included in the late 3rd and the 4th sub-stage of the sensorimotor stage. It is during these sub-stages that intentionality and logic emerge, starting with intentional grasping of a desired object and differentiating between means and goals, and ending up with the coordination of schemes and intentionality, and planning steps to achieve an objective.

[4] Linguistic census from 2001.

2.2. Data Collection

All children were video-recorded at their homes during weekly 30-minute sessions between ages 0;7 and 1;0 using a SONY camera, model DCR-DVD202E PAL. Recordings were made by the author of this study, who was previously acquainted with the families and children. Children were always recorded in the same room of their respective homes, typically their living-rooms, during free play sessions. All children were recorded as they interacted with their mothers except for one child, Àngela, who was recorded while interacting with both her father and her mother in most of the sessions. A tripod was used, placed as close to the child as possible and positioned so that the camera was pointing toward the child's face.

In order to monitor vocabulary acquisition, the same set of toys was given to the child in all sessions. The first toy offered, a pyramid of four colored plastic stackable disks with animal heads, was common to all three infant subjects and available to them only during the recording sessions. When subjects lost interest in this toy (which tended to happen after about ten minutes), their parents offered them one or another toy from the child¡¯s own collection, albeit consistently the same toys from one recording session to the next. Using the same set of toys for all sessions will enable us in future research to analyze lexical acquisition, since parents were inducing the child to perceive and produce the same vocabulary and there was thus some control over the possible target words.

From all the sessions recorded during this six-month period, we selected for analysis vocalizations produced at three specific points in time, i.e. when children were 0;7, 0;9, and 0;11. These ages were selected based on the hypothesis that these vocalizations would display the typical features of certain stages of development: before the onset of intentional communication, when intentionality starts, and when intentionality is already developed (Piaget, 1936, 1946; Trevarthen, 1977, 1979, 1982). Table 1 summarizes the data for all sessions included in this study (age of the child, duration of the session, and number of vocalizations per session). As the table shows, the children were recorded three to five times per month, except for Biel, who was only recorded twice at 0;9 due to illness.

Participant	Age	Duration	Nº of vocalizations
Àngela	0;7.10	0:30:09	81
	0;7.17	0:28:22	38
	0;7.29	0:34:03	44
	0;9.04	0:36:39	34
	0;9.11	0:19:03	26
	0;9.18	0:36:45	100
	0;9.25	0:37:30	42
	0;11.03	0:33:00	79
	0;11.08	0:36:34	95
	0;11.15	0:36:35	67
	0;11.22	0:33:20	54

Biel	0;7.02	0:31:07	57
	0;7.09	0:32:02	56
	0;7.16	0:30:33	87
	0;7.22	0:33:24	35
	0;9.23	0:30:36	95
	0;9.29	0:33:05	112
	0;11.05	0:34:41	72
	0;11.12	0:36:20	152
	0;11.18	0:34:21	96
	0;11.25	0:26:09	122
Martí	0;7.06	0:36:58	55
	0;7.13	0:27:19	60
	0;7.20	0:26:33	36
	0;9.04	0:19:03	53
	0;9.09	0:34:02	68
	0;9.17	0:37:15	70
	0;9.29	0:35:00	83
	0;11.00	0:32:29	110
	0;11.05	0:34:43	64
	0;11.12	0:39:44	109
	0;11.19	0:35:20	93
	0;11.25	0:33:23	122
TOTAL		17:52:07	2467

Table 1. Number and duration of recordings included in the study, classified by child and age.

2.3. Data Analysis

The approximately 18 hours of recordings were segmented into 2,467 vocalizations. From these, 245 were excluded from the analysis because the nature of the recording would rule out proper acoustic analysis (see Section 2.3.2). This yielded a corpus of 2,222 vocalizations, classified in table 2 according to child and age.

	0;7	**0;9**	**0;11**	**TOTAL**
Àngela	147	168	265	580
Biel	227	191	385	803
Martí	138	252	449	839
TOTAL	512	611	1,099	2,222

Table 2. Number of vocalizations included in the study, classified according to child and age.

Before analyzing the data, we established the unit of analysis of our study. Following Papaeliou & Trevarthen (2006), two utterances were considered distinct vocalizations if they were separated by 50 ms or more. We excluded from our analysis cries, laughs, vocalizations produced when infants had something in their mouths, and vocalizations accompanied by background noise.

2.3.1. Pragmatic Analysis

All vocalizations were first annotated in terms of the pragmatic function they conveyed using Phon software system (Rose *et al*., 2004). Different authors have treated dealt with this question in different ways. As noted above, D'Odorico & Franco (1991) used the terms 'vocalizations during infant manipulation of a toy', 'vocalizations during shared experience' (manipulating a toy but looking at the adult), 'vocalizations during adult manipulation of a toy', and 'vocalizations during exchanges with the adult' (neither of them is manipulating the toy but they are both looking each other). Blake & De Boysson-Bardies (1992), on the other hand, classified their subjects' vocalizations using the following labels: fine object manipulation, gross object manipulation, upright movement, confined movement, request, comment, book-reading, demonstrative, response to adult's utterance, give and take, rejection-protest, or physical interaction. Finally, Sarriá (1991) used these categories: request (object, help, or attention), rejection, protest, satisfaction, question (what, where, and how), statement, proto-conversation, narration, interactive game, imitation, non-social, or greeting (other studies such as Karousou (2003) have used this classification for the linguistic analysis of babbling). As we will see below, the classification of functions that we decided to use in the present study is partly based on Sarriá's.

Since the first aim of this project is to discover whether the vocalizations of Catalan-babbling children conveying communicative information are different from vocalizations not intended to communicate information, we first classified our data into one or the other, labeled respectively 'communicative' or 'investigative'. In order to do this, we relied exclusively on non-vocal or gestural cues visible in the video recordings, i.e. facial gestures, eye-glance direction, hand movements, and pointing. All vocalizations uttered either while or right after the child was looking at his/her parents were classified as 'communicative', as were those vocalizations uttered while the child was not looking directly at the parent but was clearly seeking the parent's feedback. In contrast, all vocalizations uttered when the child was clearly not paying attention to the other people around him or her, sometimes while playing with a toy, were labeled 'investigative'. Thus, even if perceptual prosodic features would suggest a vocalization to be communicative, they were considered investigative if non-vocal cues did not indicate it to be communicative.

An extra category was used to classify all those vocalizations that were difficult to label. Thus, 'not clear' was the label used when visual cues were not clear enough to decide whether a vocalization was communicative or not. For instance, when we heard that the child was vocalizing but her hand of face was not visible in the video (e.g. behind the sofa), it was included in the ‘not clear’ group. This third category enhances reliability, since no vocalization was forced to fit into one of the other two categories explained above. A total of 311 vocalizations were labeled as ‘not clear’ following this criterion.

Thus, of a total of 2,222 recorded vocalizations, our analysis yielded a total of 1,379 communicative vocalizations, 532 investigative vocalizations, and 311 vocalizations whose purpose was ‘not clear’.

The three panels in figure 1 show three still images from the recordings of one child, Àngela, when she was eleven months old. The left panel shows a moment when she was producing a communicative vocalization, the one in the middle while not communicating, and the panel on the right while producing a ‘not clear’ vocalization.

Figure 1. Image stills of Àngela producing a communicative vocalization (left panel), an investigative vocalization (middle panel), and a ‘not clear’vocalization (right panel).

In order to test the second hypothesis, i.e. whether children select certain prosodic cues to express distinct pragmatic functions, all communicative vocalizations were further classified into narrower categories depending on the specific pragmatic functions we judged the child to be performing based on facial and gestural cues apparent in the video recordings. The pragmatic functions we take into account are protest, request, response, satisfaction, statement, surprise, and vocative calling. Table 3 describes the meaning of the target pragmatic functions used in this study, together with the visual cues used to classify those functions.

Pragmatic function	***Meaning***	***Visual cues***
Protest	The child expresses disagreement or disapproval because of a situation s/he does not like.	Facial gestures showing opposition, or quick and sudden hand movements.
Request	The child would like to have an object but is unable to reach it.	The child’s eye glance is directed at a particular object or the child points at the object. If the child is

		not able to get it, s/he protests.
Response	Right after the parent says something to the child, the child answers.	The child looks at the parent while s/he is speaking or the child looks at him/her while answering.
Satisfaction	The child is happy because of something that happened to him/her or around him/her	Facial gestures like smiling or body gestures expressing pleasure and gratification like shaking hands.
Statement	The child is looking at an object and vocalizes while the parent is around. This function can be differentiated from the 'response' because in this case it is the child that initializes the communicative interaction.	The child is pointing at an object or looking at it while vocalizing, without any apparent interest in possessing the object.
Surprise	The child vocalizes something because a sudden unexpected event has occurred.	The child opens his/her mouth and eyes as s/he observes the unexpected event.
Vocative	The child is clearly calling somebody that has left the room or is attempting to catch the attention of his/her parent.	The child's eye glance is directed at the person that left the room or that the child is calling to.

Table 3. Infant pragmatic functions analyzed in this study. Meaning and visual cues used to classify them.

Some communicative vocalizations were impossible to classify in any of these pragmatic functions, since they were clearly communicative but too fuzzy to fit in any of these specific categories. These cases were labeled 'fuzzy intention' and represent 709 cases out of the total of 1,379 communicative vocalizations.

In sum, all vocalizations relevant for our study were first classified as 'communicative', 'investigative', or 'not clear' on the basis of audio and visual cues in the recordings. Next, the group of 'communicative' vocalizations was further subdivided into the following specific pragmatic functions: 'protest', 'request', 'response', 'satisfaction', 'statement', 'surprise', 'vocative', and 'fuzzy intention'. In order to screen out the potential influence of prosodic cues in the audio material, this specific classification was performed only when the recording of the vocalization in question displayed clear contextual and non-vocal information, so 'fuzzy intention' would include all those communicative vocalizations that were impossible to classify further. Importantly, the prosodic analysis was performed independently of the pragmatic classification (see the following section).

2.3.2. Acoustic Analysis

As noted, the main aim of this study is to find out whether different prosodic cues are at play when infants try to communicate or convey certain specific pragmatic functions. In order to do so, we manually extracted all the VLC media files (.wav) from our Phon corpus and analyzed them acoustically using the Praat software package (Boersma & Weenink, 1996). Vocalizations were excluded from this analysis under the following circumstances: (1) when child and parent overlapped when vocalizing, (2) when ambient noise was too loud, (3) when the child vocalized while having an object inside his/her mouth, and (4) when the sound did not show a visible trace on the spectrogram. As we have seen, the total number of excluded vocalizations was 245 out of the 2,467 that were segmented in the recorded sessions, leaving a corpus of 2,222 vocalizations.

Two prosodic features were then manually labeled on the spectrogram and the pitch contour: pitch maximum and minimum points, and starting and end points of vocalizations. The aim was to analyze global pitch range of the contour and total duration, which are the features that are most commonly used in studies of the prosody of infants' vocalizations (Scherer, 1986; Marcos, 1987; Papaeliou, Mindakis, & Cavouras, 2002; Papaeliou & Trevarthen, 2006). Even though we used pitch max and pitch min values in order to calculate the pitch range value, we decided not to include them in the analysis to avoid inter-subject variability and because pitch range is a more relative measure.

As for pitch range, an overview of the data indicated that the best way to obtain pitch range was selecting three pitch points from the fundamental frequency contour: the first pitch point (p1) representing the pitch value at the beginning of the vocalization, also referred to as the reference level of the speaker; the second pitch point (p2) selected at the maximum peak in the fundamental frequency contour; and finally, the third point (p3) representing the pitch value at the end of the vocalization. Figure 2 shows a prototypical selection of the index pitch points in our data. After selecting these three points, Praat calculated which of them had the maximum and minimum values. By subtracting the minimum value from the maximum, the pitch range was then calculated. In order to be able to compare different pitch ranges across the three children, the pitch values were extracted in semitones rather than in Hz.

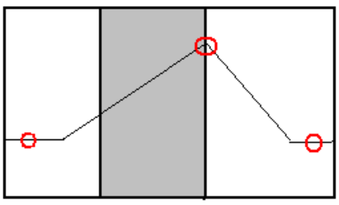


Figure 2. Schematic representation of the three target pitch points marked in the acoustic analysis

Additional considerations for determining the *f*0 index measurements were as follows:

- The peak point was usually selected at the highest pitch point; however, in those vocalizations with a U-shaped curve the lowest pitch point of the fundamental frequency line was selected.
- When the vocalization had more than one peak point at the same level, the last point was selected.
- If the vocalization displayed no clear peak, a random point in the middle was selected.

As for duration, the first point (t1) and last point (t2) in the fundamental frequency line were selected in order to obtain the total duration of the vocalization, measured in milliseconds. Following Papaeliou & Trevarthen's (2006) work, we considered two sounds to be distinct vocalizations if they were separated by at least 50 ms. The only exceptions that were made were when the pause was shorter but the sounds were clearly two distinct vocalizations, or vice versa, i.e. when the pause was a bit longer but the sounds are part of the same vocalization.

The two graphs in figure 3 illustrate how vocalizations were annotated in terms of pitch range and duration. Below the fundamental frequency contour, the first tier (shown at left) was used to annotate start and end time of the vocalization (t1, t2), and the second tier (shown at right) was used to annotate the three index pitch points (p1, p2, p3) to later calculate pitch range values. The two graphs in figure 4 are respective examples of a communicative vocalization (upper graph) and an investigative vocalization (lower graph) to see how different they look in a spectrogram.

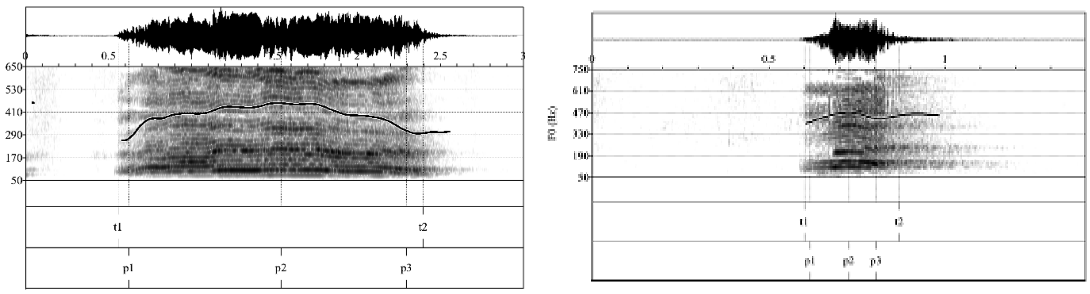


Figure 3. Waveform, spectrogram, and F0 contour of two annotated examples. The lower tier of the left-hand graph shows start time and end time and the lower tier of the left-hand graph the three index pitches.

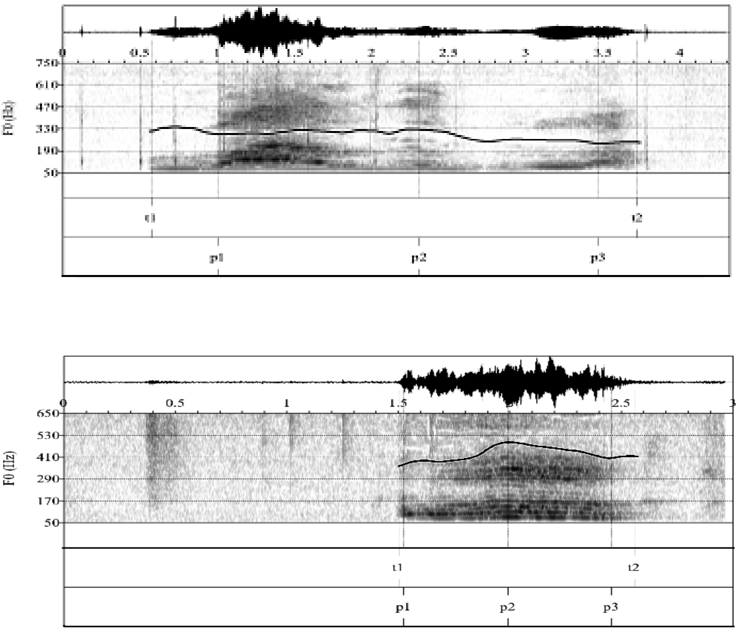


Figure 4. The upper graph is an example of an investigative vocalization performed by Martí at 0;9. The lower graph illustrates a communicative vocalization performed by the same child, Martí, at 0;11.

2.3.3. Statistical Analyses and Graphing Methods

The results for pitch range and duration were analyzed with an ANOVA parametric test using the SPSS software package. In particular, factorial ANOVAs were selected in order to enable us to evaluate the potential effects of two or more independent factors on the dependent variable together with the interactions between these factors.

Since our goal was to discover whether conveying communicative information determines the use of specific prosodic cues (in our study, pitch range and duration), the dependent variables used were pitch range (in semitones) and duration. In order to test our first question, i.e. whether the prosodic cues selected by children were prosodically different in communicative versus investigative vocalizations, a 2x3x3 experimental design with the following factors was performed: communicative status (2 levels: communicative and investigative), children's age (3 levels: seven months, nine months, and eleven months), and children (3 subjects). In order to test our second question, i.e. whether specific prosodic cues are selected to express specific pragmatic functions, a 8x3x3 experimental design with the following factors was performed: pragmatic functions (5 levels: protest, request, satisfaction, response, and statement), children's age (3 levels: seven months, nine months, and eleven months), and children (3 levels). In the two analyses, outliers were excluded, i.e. those cases where pitch range and duration were at a distance of at least 3 standard deviations from the overall mean.

Box plots were used as the graphing method because they show clearly the distribution of the data, its dispersion, its median, its average, and its maximum and minimum values. The boxes of these graphs include three lines: (1) the middle line inside the box represents the median value, i.e. the middle value of the distribution; (2) the lower line represents the maximum value of 25% of the data, i.e., the first quartile; and (3) the upper line represents the maximum value of 75% of the data, i.e. the third quartile. In sum, the vertical lines represent the distribution of 95% of the cases. Figure 5 shows a prototypical box plot.

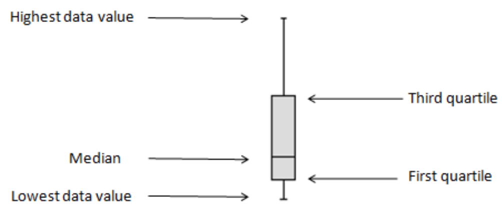


Figure 5. Schematic representation of a box plot.

3. RESULTS

This section includes two different parts. The first part presents the results of the analysis in terms of answering the first question, i.e. whether communicativeness determines the prosodic cues displayed by Catalan-speaking infants at 0;7, 0;9, and 0;11. The second part presents the results of the analysis that addresses the hypothesis that children as young as 0;7, 0;9, and 0;11 express specific pragmatic functions by means of various prosodic features.

3.1. Prosodic Cues and Communicativeness

Table 4 and figure 6 show a general view of all data included in the analysis. Table 4 displays the number of vocalizations produced by each child at each age, and their classification according to communicativeness. Figure 6 shows the number of 'communicative', 'investigative', or 'not clear' vocalizations across the different ages. The results in both table 4 and figure 6 show that all children produce more communicative vocalizations than investigative vocalizations at all ages and that such expressions increased longitudinally: at 0;7 and 0;9 communicative vocalizations are double the number of the non-communicative ones; however, at 0;11 the communicative vocalizations are four times more frequent than the non-communicative ones. They also show that 13.9% of the total number of vocalizations could not be identified as being either communicative or investigative. Crucially, the longitudinal analysis of the data reveals that between 0;9 and 0;11 there is an noticeable increase in the number of communicative vocalizations. These results would support the studies stating that children develop intentional communication after 0;8-0;9 (Piaget, 1936, 1946; Vygotsky, 1962; Bates, Camaioni, & Volterra, 1975; Tomasello, 1993).

	Àngela			**Biel**			**Martí**			**TOTAL**
	0;7	**0;9**	**0;11**	**0;7**	**0;9**	**0;11**	**0;7**	**0;9**	**0;11**	
‘communicative’ vocalizations	*80*	*78*	*205*	*128*	*71*	*254*	*86*	*182*	*295*	*1,379*
‘investigative’ vocalizations	*40*	*65*	*42*	*72*	*89*	*78*	*31*	*28*	*87*	*532*
‘not clear’ vocalizations	*27*	*25*	*18*	*27*	*31*	*53*	*21*	*42*	*67*	*311*
TOTAL	*147*	*168*	*265*	*227*	*191*	*385*	*138*	*252*	*449*	*2,222*

Table 4. Number of vocalizations classified in terms of type, child and age.

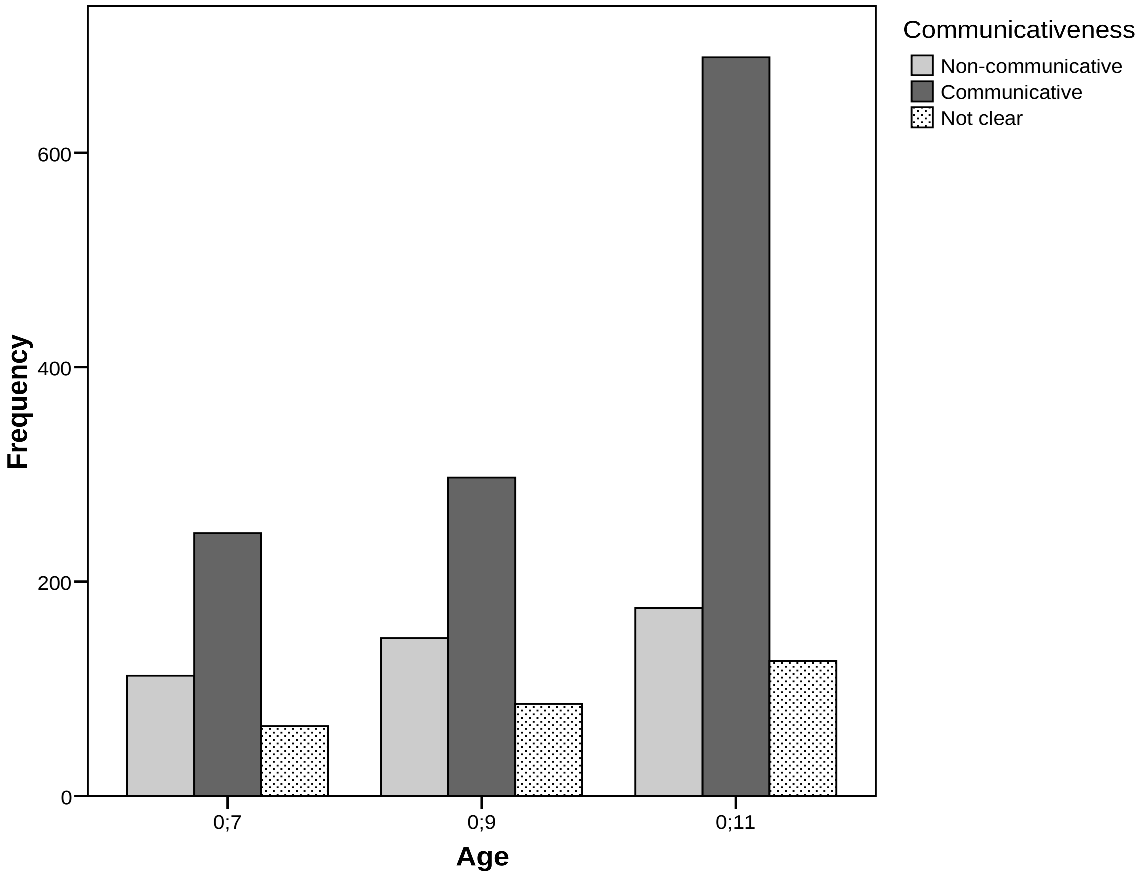


Figure 6. Evolution of investigative (non-communicative), communicative, and 'not clear' vocalizations over the ages under study.

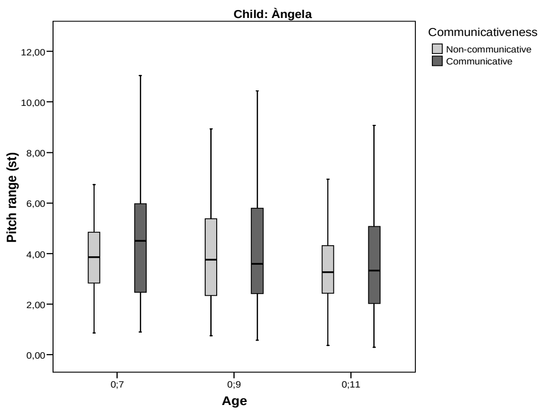
Since the prosodic cues we analyzed were utterance pitch range and total duration, they were set as dependent variables. First we will discuss the effect of communicativeness on pitch range and then we will move to the effects of communicativeness on duration. As noted, all statistical analyses were performed excluding outliers and vocalizations labeled as 'not clear'.

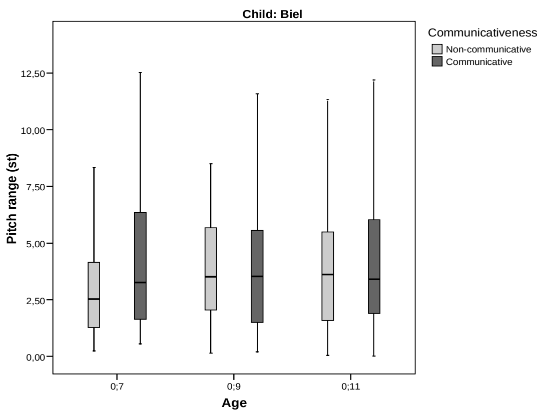
3.1.1. Pitch Range and the Communicative Status of Vocalizations

In our first factorial ANOVA analysis, the dependent variable was pitch range (in semitones) and the main factors were communicativeness (2 levels: communicative and investigative vocalizations), and age (3 levels: seven months, nine months, and eleven months). The subject factor was considered a random factor. The analysis revealed statistically significant effects of the communicative status of the vocalization on the pitch range of the vocalization (F(1, 2.225)=33.893, p<.05). This analysis also showed that there was a marginal interaction between age and child in pitch range (F(4, 4)=4.920, p=.076), and between communicative status and age (F(2, 4.757)=4.430, p=.082). No interaction was found between communicative status and child (F(2, 4.956)=0.994, p=.433).

The post-hoc analyses showed that communicative status significantly affected pitch range at 0;7 (F(1, 2.433)=23.496, p<.05), and that it was marginally significant at 0;9 (F(1, 3.792)=5.793, p=.077) and at 0;11 (F(1, 2.265)=4.394, p=.156). Post-hoc analyses also showed an effect of communicativeness on pitch range when comparing 0;7 to 0;11 in two children: for one of the children this effect was significant (Martí, p>.05) and for the other child this effect was marginal (Àngela, p=.060).

The three panels in figure 7 show box plots of the pitch range of vocalizations (in semitones) as a function of communicative status and children's age, and separated by child. These panels show that the pitch range that subjects displayed when communicating was generally wider than when they were not communicating. Even though this trend was observed in all our subjects at almost all ages, it is only significant for all the children at 0;7.





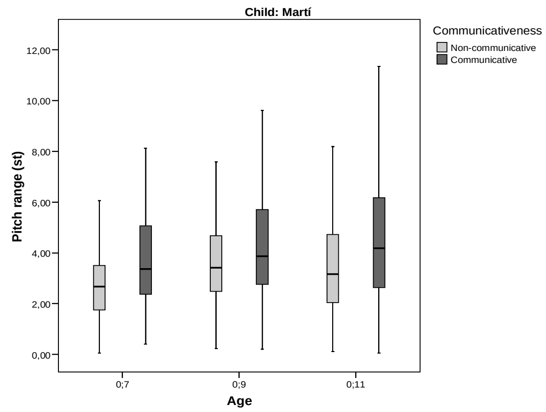


Figure 7. Box plots of the pitch range of vocalizations (in semitones) as a function of communicative status and children's age, and separated by child.

3.1.2. Duration and the Communicative Status of Vocalizations

In our second factorial ANOVA analysis, the dependent variable was total duration (in milliseconds) and the main factors were communicativeness (2 levels: communicative and investigative vocalizations) and age (3 levels: seven months, nine months, and eleven months). Again, the subject factor was considered a random factor. This analysis demonstrated a marginal but not significant effect of communicativeness on the duration of children's vocalizations ($F(1, 2.050)=10.194$, $p=.083$). No significant effect of child was observed ($F(2, 3.209)=1.274$, $p=0.392$). However, the ANOVA revealed a marginal interaction between age and child on total duration ($F(4, 4)=5.565$, $p=.063$). No interaction was revealed between age and communicativeness ($F(2, 4.081)=0.961$, $p=.455$) or between child and communicativeness ($F(2, 1.101)=0.539$, $p=.619$). The post-hoc comparisons revealed significant differences between 0;7 and 0;11 ($p<.01$), and between 0;9 and 0;11 ($p<.001$). However, no significant difference was observed when comparing 0;7 to 0;9 ($p=.096$).

Figure 8 displays the box plots of the total duration of vocalizations (in milliseconds) as a function of communicative status. The data is separated into the three different ages, for all infants. Results show that at all ages communicative vocalizations tend to be shorter than investigative vocalizations, although the difference is only significant at 0;9 and 0;11. As can be observed in Figure 8, this difference is more prominent for some ages than others. At 0;7, for instance, the average duration of a communicative vocalization is 802.434 ms compared to 873.560 ms for an investigative vocalization; at 0;9 the average duration of a communicative vocalization is 792.785 ms compared to 1,081.602 ms for an investigative vocalization; and at 0;11, a communicative vocalization lasts an average of 694.534 ms next to an investigative vocalization's 856.441 ms. After segmenting data by age, it was observed that duration is not significantly affected by communicativeness at

0;7 (F(1, 2.122)=0.040, p=.859). However, communicativeness is nearly significant at 0;9 (F(1, 2.058)=3.475, p=.200) and at 0;11 (F(1, 2.088)=6.316, p=.123).

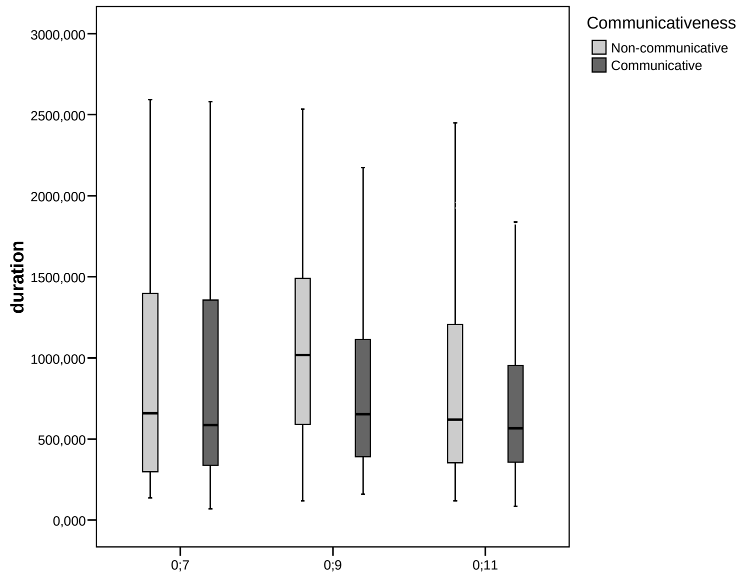
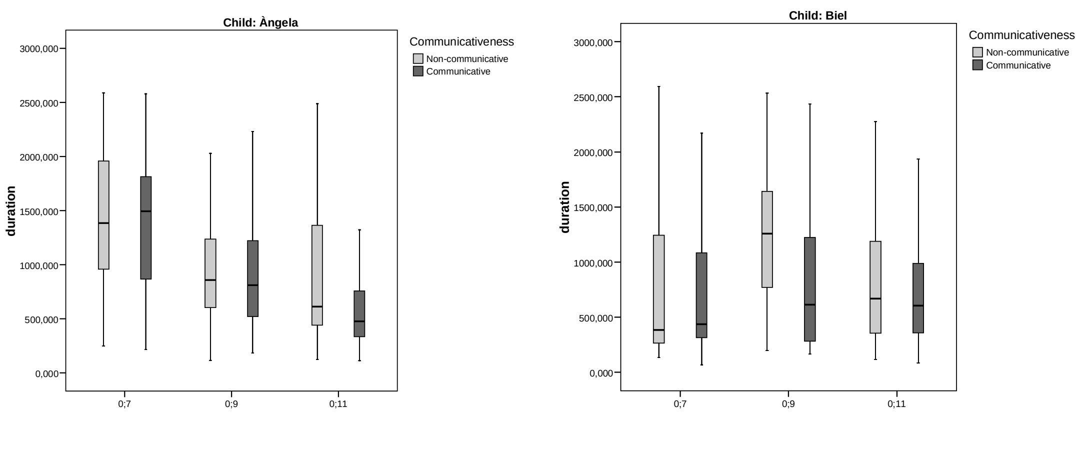


Figure 8. Box plots of the duration of vocalizations for all infants, separated by age and communicative status.

Some variability is found when children are analyzed separately. Age is a main effect in all three children, to a greater or a lesser extent (p>.001 for Àngela, p>.001 for Biel, p>.05 for Martí). Yet the communicative status of vocalizations is also a main effect in two of the children (p>.05 for Àngela and p>.001 for Biel) but not for the other child (p=.292 for Martí). The three panels in figure 9 represent the development of each child in terms of duration of their vocalizations, which are separated here according to communicative status. In these graphs it can be observed that all children at all ages tend to produce shorter vocalizations when attempting to communicate (except for Martí at 0;7).



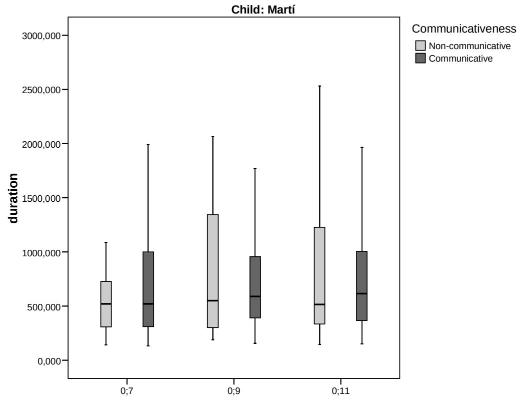


Figure 9. Box plots of the total duration of vocalizations (in ms) at the three different ages for each of the children as a function of the communicative status of the vocalizations. Top left: Àngela; top right: Biel; bottom: Martí.

In sum, statistical analysis of the data showed that pitch range is significantly affected by communicativeness but duration it is not. As for pitch range, vocalizations produced when children are 0;7 display wider pitch range when the children are communicating than when they are performing investigative babbling. This difference is not so clear when children are 0;9 and 0;11. Further research on communicative vocalizations is needed in order to understand this, since our results seem to contradict the notion that the ability to control linguistic cues increases with age. As for duration, our results show that it is not so consistently controlled by children. It is only when children are 0;11 that they start showing some control of duration in the sense that communicative vocalizations are shorter than investigative ones.

3.2. Prosodic Cues and Specific Pragmatic Functions

Results for duration in relation to the communicative status of the vocalizations seem to be more robust when children are 0;9 and 0;11 than when they are 0;7. However, results about how communicativeness affects the production of pitch range seem to indicate that children control their pitch range better at 0;7 (similar results were found in Snow, 2006). Because these results seem to be at odds with the normal pattern of acquisition of adult-like prosodic patterns, we went a step further into the data and looked in more detail at the behavior of prosodic cues within the communicative vocalization group. Hence, we investigated how prosodic cues, such as pitch range and duration, are influenced by the production of specific pragmatic functions that children display when communicating.

Table 5 shows the number of vocalizations analyzed classified in terms of child, age, and specific intentional purpose. As the table shows, specific intentions like 'surprise' and 'vocative' were seldom produced in comparison with other pragmatic functions like 'protest' or 'satisfaction'. Thus, we decided not to include 'surprise' and 'vocative' vocalizations in our subsequent analysis. Because of their low frequency, they cannot be safely compared with the relatively abundant other pragmatic functions. The table also shows that the group including most vocalizations is the group labeled as 'fuzzy intention'. This group includes all those communicative vocalizations that could not be unambiguously identified as any specific pragmatic function.

		Àngela			Biel			Martí			TOTAL
		0;7	0;9	0;11	0;7	0;9	0;11	0;7	0;9	0;11	
communicative vocalizations	protest	21	12	28	27	20	85	11	29	46	279
	request	2	-	2	-	1	12	5	10	23	55
	satisfaction	4	7	24	18	0	17	18	23	43	154
	response	-	-	12	2	7	25	-	6	11	63
	statement	-	-	59	-	-	7	-	6	18	90
	surprise	-	-	9	-	2	-	-	1	1	13
	vocative	-	-	7	-	-	-	-	-	2	9
	fuzzy intention	53	59	65	71	41	108	53	107	152	709
TOTAL		80	78	205	128	71	254	86	182	295	1,379

Table 5. Number of vocalizations classified in terms of conveyance of specific intentional purpose, and broken down by child and age.

In the following sections we discuss first the effects of pragmatic intention on pitch range and then the effects of pragmatic intention on duration. Again, outliers were excluded from the statistical analyses, as were vocalizations labeled as 'fuzzy intention', 'surprise', and 'vocative'.

3.2.1. Pitch Range and Pragmatic Intentions

In this third factorial ANOVA test, the dependent variable was pitch range (in semitones) and the main factors were intention (5 levels: protest, request, satisfaction, response, and statement) and age (3 levels: seven months, nine months, and eleven months). The subject factor was again considered a random factor. Results revealed a marginal but not significant effect of specific pragmatic intentions on pitch range ($F(8, 17.451)=2.388$, $p=.061$). No effect of child on pitch range was observed ($F(2, 10.780)=0.499$, $p=.621$), nor did age have any effect ($F(2,5.265)=2.355$, $p=.186$). As for interactions, the analyses showed no interaction between age and intention ($F(12, 27.820)=1.306$, $p=.270$), between age and child ($F(4, 31.728)=2.152$, $p=.097$), or between intention and child ($F(15, 29.641)=1.393$, $p=.214$).

The post-hoc analyses (Fisher's LSD) revealed no age effects on the selection of pitch range when expressing a certain pragmatic function. Crucially, the post-hoc analysis did reveal that some pragmatic functions behave in a significantly different way compared to others in terms of pitch range. The similarities and differences among pragmatic functions in terms of pitch range are the following:

- Protests behave like requests, but not like satisfactions, responses, and statements.
- Requests behave like protests and satisfactions, but not like responses and statements
- Satisfactions behave like protests, but not like requests, responses, and statements
- Responses behave like satisfactions and statements, but not like protests and requests
- Statements behave like satisfactions and responses, but not like protests and requests

Thus two groups can be observed from these behaviors, with protests and requests on one hand and statements and responses on the other. Only satisfactions seem to be less defined in terms of pitch range, since they are sometimes similar to protests and sometimes similar to statements.

Figure 10 shows the evolution of pitch range patterns according to the specific pragmatic intention, for all children. The differentiation between the two abovementioned groups can be observed in this graph: protests and requests tend to have higher pitch range values than responses and statements. Satisfactions behave differently depending on the age analyzed. Interesting results are obtained when comparing pitch range averages for the different specific intentions across age groups: at 0;7 protests have 5.88 st of pitch range on average, requests have 6.28 st, and satisfactions have 3.76 st.; at 0;9, protests have 4.79 st of pitch range on average, requests have 3.90 st, satisfactions have 4.35 st, responses have 3.09 st, and statements only 2.95 st; and at 0;11 protests have 4.77 st of pitch range on average, requests have 5.04 st, satisfactions have 4.36 st, and both responses and statement have 3.57 st. Importantly, special caution should be taken when interpreting the results for responses when the children are 0;7: though considerable variability seems to be present here, only two vocalizations were classified as responses at that age. Thus, results for responses at 0;7 are not consistent with the other pragmatic intentions analyzed.

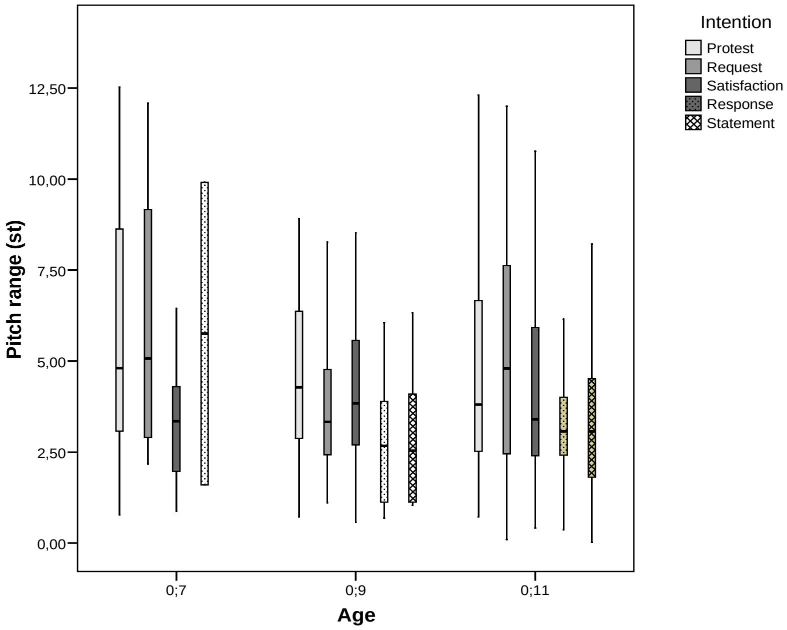


Figure 10. Box plots of the pitch range of the vocalizations (in semitones) as a function of the specific pragmatic function at the three different ages for all infants.

3.2.2. Duration and Pragmatic Intentions

For the fourth and last ANOVA analysis, the dependent variable was total duration (in milliseconds) and the main factors were intention (5 levels: protest, request, satisfaction, response, and statement) and age (3 levels: seven months, nine months, and eleven months). The subject factor was also considered a random factor. The statistical analysis showed a statistically significant effect of pragmatic intention on the duration of vocalization ($F(4, 6.819)=32.436$, $p>.001$). No effect of age ($F(2, 4.918)=1.308$, $p=.350$) nor child ($F(2, 1.376)=1.667$, $p=.429$) was observed. The ANOVA also showed no significant interaction between age and intention ($F(7, 7.283)=1.492$, $p=.301$), between age and child ($F(4, 6.424)=1.033$, $p=.428$), and between intention and child ($F(8, 5.670)=0.682$, $p=.700$). However, the analysis did show a triple interaction between age, intention, and child on duration ($F(6, 528)=2.259$, $p>.05$).

Post-hoc analyses (Fisher's LSD) were performed taking age and pragmatic intentions into account. The analyses revealed no significant differences between ages 0;7 and 0;9 ($p=.757$). However, at 0;11 the pragmatic function ~~has~~ an effect on duration while this is not the case at 0;7 and 0;9 [post-hoc revealed statistically significant differences between 0;7 and 0;11 ($p>.01$) and between 0;9 to 0;11 ($p>.05$), but not when comparing 0;7 to 0;9]. The post-hoc analyses also demonstrated that some pragmatic functions behave differently than others in terms of duration. Thus,

- Protests do no behave like any other pragmatic function

- Requests do not behave like any other pragmatic function
- Satisfactions behave like statements but not like protests, requests, and responses
- Responses behave like statements but not like protests, requests, and satisfactions
- Statements behave like responses and satisfactions but not like protests and requests

Interestingly, the same affinities observed for the pitch range patterns can again be observed in the behaviors related to duration. Statements, satisfactions, and responses seem display similar duration, whereas protests and requests behave independently. As figure 11 shows, even though protests and requests behave differently, they tend to display longer duration at all ages (especially at 0;7). As these children grow up, protests are always the pragmatic function that displays the longest duration. They are followed by requests, which are shorter than protests but longer than the other intentions. Satisfactions are shorter than protests and requests but longer than responses and statements (except when children are 0;7). And, finally, responses and statements are the pragmatic functions displaying the shortest durations at all ages. Again, it must be noted that the results for the duration of responses at 0;7 have to be treated carefully, since only two vocalizations were classified as responses at this age.

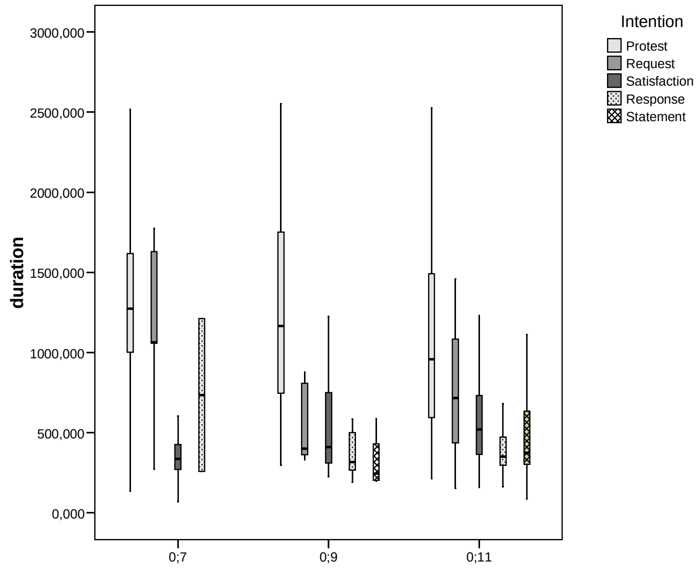


Figure 11. Box plots of the duration of vocalizations at three different ages for all infants, broken down by pragmatic function.

Hence, the analysis of prosodic cues like pitch range and duration in pre-linguistic children has shown that children control pitch range better than they do duration. On the one hand, in terms of pitch range, when vocalizations are classified as communicative or investigative, we observe that communicative vocalizations have a wider pitch range than investigative ones, and that this difference is more significant when children are 0;7.

Further analysis of communicative vocalizations has revealed that it is not the case that after 0;7 children lose control on pitch range, but rather that depending on the pragmatic intention expressed, pitch range is wider or narrower. For instance, protests and requests clearly have wider pitch ranges than responses and statements. On the other hand, the duration of vocalizations seem to be less strongly affected by their communicative status. It is only when children are 0;9 that they differentiate communicative from investigative vocalizations by duration. Our subsequent analysis of communicative vocalizations, whereby they were separated into specific pragmatic intentions, confirms this observation. Distinct groups of pragmatic functions have also been observed: responses and statements behave similarly, being shorter than the other pragmatic functions. Protests are the longest vocalizations, followed by requests, and in the middle there are satisfactions, which are shorter than protests and requests but longer than responses and statements. The three panels in figure 12 show examples of vocalizations expressing a specific pragmatic intention and displaying these prosodic cues.

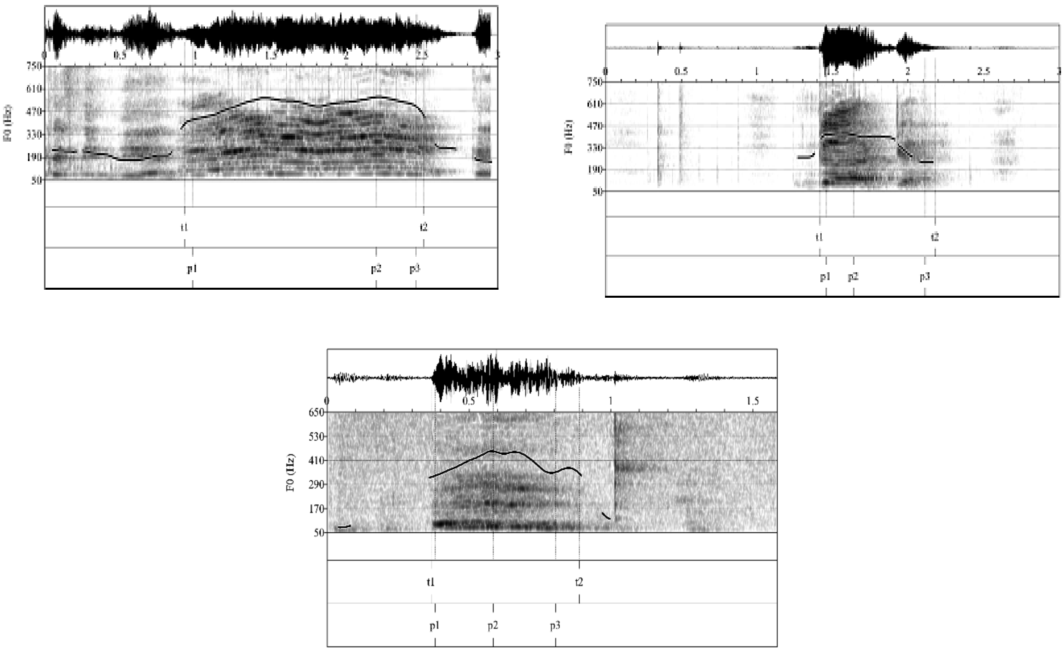


Figure 12. Top left, a protest performed by Àngela at 0;11. Top right, a statement by Biel at 0;11. Bottom, Marti's expression of satisfaction at 0;11.

4. DISCUSSION AND CONCLUSIONS

This study had two aims: first, to discover whether Catalan-babbling infants display specific prosodic cues when attempting to be communicative with their parents that are different from those used when they are not communicating; and second, to investigate whether babbling infants are able to express specific pragmatic intentions by means of specific prosodic cues.

A general overview of the data has shown that Catalan children increase their total number of vocalizations as they grow up. When recorded vocalizations are classified as either communicative or investigative (i.e. non-communicative) it can be seen that communicative expressions increase longitudinally: at 0;7 and 0;9 communicative vocalizations are double the number of non-communicative ones; however, at 0;11 communicative vocalizations are four times more frequent than non-communicative ones (see table 4).

In terms of duration, the communicative vocalizations seen in our data are distinguished from the non-communicative ones by the duration they display only when children are 0;9. The tendency is also observed when children are younger, but it is not statistically significant. In fact, from the analysis performed child by child, it can be observed that less duration is displayed by all children at all ages when communicating, except for Martí at 0;7. These results suggest that children at 0;7 still do not control the use of duration as a prosodic cue to convey communicativeness. It is not until they are 0;9 that this ability is acquired.

As for pitch range, our data show that children can control their vocalizations' pitch range already at 0;7. Children display wider pitch range when seeking to communicate and narrower pitch range when producing investigative vocalizations. This tendency is observed at all ages but it is strongest when children are 0;7. Because children develop intentional communication at about 0;9, the abovementioned results might be interacting with the specific pragmatic intention the child is expressing. Children as young as 0;7 are able to use pitch range in order to transmit communicativeness in their interactions, but this ability is not as strongly used when they are 0;9 and 0;11.

Thus, our results corroborate Papaeliou & Trevarthen's (2006) conclusions that communicative vocalizations tend to have higher pitch range and shorter duration than investigative vocalizations. Our data show that children as young as 0;7 can control their vocalizations' pitch range, displaying wider pitch range when they attempt to communicate and narrower pitch range when they do not. This tendency is also observed at 0;9 and 0;11 but the difference is not significant.

The data was further analyzed taking into account the beginnings of intentional communication: pitch range and duration were analyzed after classifying communicative vocalizations into eight specific pragmatic functions. This enabled us to test second hypothesis, namely to see whether Catalan-babbling infants are able to use prosodic cues selectively in order to express distinct pragmatic functions well before they produce their first words.

Interesting results were obtained after analyzing the prosodic cues that children display in every specific pragmatic function. The results showed that protests and requests have a wider pitch range and longer duration than responses and statements, which are shorter and have a narrower pitch range. The data analysis also revealed that satisfactions display less clear prosodic cues: they are shorter than requests but longer than responses and statements, and they have a narrower pitch range than protests and requests but a wider one than responses or statements. A detailed analysis of the communicative vocalizations also showed that some specific pragmatic intentions are developed earlier than others: children are able to express protest, satisfaction, and requests as early as 0;7, i.e. before the onset of intentionality as has been claimed in the literature. Other intentions like vocative calling, surprise, responses, or statements develop later and are not used by children until 0;11. And, from these, only statements and responses are used frequently by children at 0;11. In sum, before the first words are produced, children are able to select specific prosodic cues to express intentionality in their vocalizations. When children protest or request, they consistently use prosodic features like expanded pitch range and longer duration; when they express satisfaction, they use wide pitch range but short duration; and when they produce responses or statements, they use narrow pitch range and short duration.

In general, our study supports previous research on the prosodic features of pre-linguistic vocalizations (D'Odorico & Franco, 1991; Papaeliou, Mindakis, & Cavouras, 2002; Papaeliou & Trevathen, 2006) in the sense that infants are able to select some prosodic cues to express communicativeness. However, our study has gone a step further and crucially shown that important prosodic differences are obtained when pre-linguistic vocalizations are analyzed as being influenced by intentional communication. Therefore, we believe that prosodic patterns at the pre-linguistic stage have to be investigated in relation to the pragmatic meaning of the vocalization. Since other research on early linguistic stages has shown similar results (Marcos, 1987; Prieto, Estrella, Thorson & Vanrell, 2009), our suggestion is that this methodology could be applied in further studies analyzing the behavior or prosodic cues before children produce words.

In sum, like in other studies dealing with languages other than Catalan, our results answer our first experimental question. Thus, pre-linguistic infants produce longer vocalizations with a narrow pitch range when they are playing alone or with a toy and do not interact with their parents. In contrast, if they want to interact with their parents, their vocalizations are shorter and show a wider pitch range. These results are consistent with what Marcos (1987) and Papaeliou & Trevarthen's (2002) found in their studies. Moreover, our results would confirm the idea that even though children start developing intentional communication only after 0;7, they are already able to use linguistic cues like prosody for their communicative purposes. In addition, our results shed some light on our second experimental question, since they suggest that before children produce their first words, they systematically use prosodic cues to express their wishes, needs, and emotions. Thus, children at 0;11 are able to differentiate protests and requests from responses and statements by means of prosody. This suggests that any further research on prosodic patterns during the babbling period will have to take into account pragmatics, since the ability to communicate intentionally develops before the ability to produce the first words.

Our results can be understood as a further development of the findings suggesting the use of adult-like prosodic patterns for the expression of pragmatic intentions in the pre-linguistic stage. Our analysis has revealed a consistent use of target prosody by young infants: children use pitch range to clearly distinguish the communicative status of a vocalization and to differentiate among pragmatic functions; duration is also used, though results are not as consistent. Further research is needed to investigate what happens between 0;11 and the child's first use of words, and the relationship between babbling and early production of the lexicon. On the whole, we believe that prosodic cues need to be investigated as a function of pragmatics from the moment that infants begin to express their communicative intentions.

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7. APPENDIX I

QUESTIONNAIRE ABOUT LANGUAGE BEHAVIORS

Name and Surname...Telephone Number........................
E-mail...
Age..................... Place of birth..
Current place of residence..
If it is not where you were born, how long have you been living here?..............................
Father's place of birth...
Paternal grandparents' place of birth ....
Mother's place of birth..
Maternal grandparents' place of birth ....
How old were you when you started speaking Catalan?..
a) Language (Spanish, Catalan, others) you use to communicate with your:
father: mother: siblings: partner:

friends: work colleagues:

b) If you used to talk to your parents or siblings in a language other than what you use now, when did you change languages with your:
father: mother: siblings: partner:

c) Which other languages are you able to use (speak, read, write)?
....

Listening comprehension level in the following languages:

French	excellent	good	passable	poor
English	excellent	good	passable	poor
Catalan	excellent	good	passable	poor
Spanish	excellent	good	passable	poor

Reading comprehension level in the following languages:

French	excellent	good	passable	poor
English	excellent	good	passable	poor
Catalan	excellent	good	passable	poor
Spanish	excellent	good	passable	poor

Speaking fluency in the following languages:

French	excellent	good	passable	poor
English	excellent	good	passable	poor
Catalan	excellent	good	passable	poor
Spanish	excellent	good	passable	poor

Quality of pronunciation in the following languages:

French	excellent	good	passable	poor
English	excellent	good	passable	poor
Catalan	excellent	good	passable	poor
Spanish	excellent	good	passable	poor

Writing ability in the following languages:

French	excellent	good	passable	poor
English	excellent	good	passable	poor
Catalan	excellent	good	passable	poor
Spanish	excellent	good	passable	poor

In which language do you feel most comfortable?

Catalan Spanish Both the same Other

If you had a pet, which language would you use to speak to it?

Catalan Spanish Both the same Other

Roughly, what percentage of these languages did your everyday communication consist of when you were a child?

Catalan ....% Spanish ....%

And now?

Catalan ....% Spanish ....%