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LA CATÉGORISATION DES GENRES GRAMMATICAUX BASÉE SUR LES INDICES DISTRIBUTIONNELS DE LA PAROLE.

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RÉSUMÉ

Apprendre à assigner les mots à des catégories grammaticales constitue une étape importante de l'acquisition du langage. Cet apprentissage est à la base de l'acquisition de la syntaxe. Déterminer quelles informations présentes dans la parole sont pertinentes à la catégorisation a été l'objet de nombreuses recherches au cours des dernières années. Par exemple, il existe des indices sémantiques (v.g. un objet versus une action), phonologiques (v.g. la finale des mots), prosodiques (v.g. la durée et l'amplitude de l'ensemble ou d'une partie d'un mot) et distributionnels (v.g. position relative des mots dans une phrase). La syntaxe requière éventuellement aux enfants de catégoriser des mots sur une base purement distributionnelle, donc sans avoirs recours à des indices sémantiques, phonologiques ou prosodiques. L'objectif de la présente recherche est donc de déterminer à quel moment les enfants démontrent cette habileté.

Les genres grammaticaux de la langue française nous ont servi de cadre pour tester cette habileté chez des enfants francophones âgés de 14, 17, 20 et 30 mois. Dans un paradigme de préférence du regard, les enfants ont été familiarisés avec des pseudo-noms précédés de déterminants français, un masculin et un féminin (v.g. *un cagère*, *une ravol*). Les pseudo-noms étaient sélectionnés et manipulés de façon à ne comporter aucun autre indice (sémantiques, phonologique ou prosodique) que celui de la distribution des déterminants avec les pseudo-noms. Les enfants étaient ensuite testés avec les mêmes pseudo-noms, précédés de déterminants différents. La moitié des essais tests étaient grammaticaux, c'est-à-dire que l'appariement entre les déterminants et les pseudo-noms était consistant avec le genre de la familiarisation (v.g. *le cagère*, *la ravol*). L'autre moitié des essais tests étaient agrammaticaux, c'est-à-dire que l'appariement entre les déterminants et les pseudo-noms était inconsistant avec le genre de la familiarisation (v.g. *la cagère*, *le ravol*).

Les enfants âgés de 20 et 30 mois ont discriminé entre les essais grammaticaux et agrammaticaux, démontrant ainsi une capacité à catégoriser uniquement sur la base d'indices distributionnels. Les enfants plus jeunes n'ont pas montré de telles évidences. Ces résultats suggèrent que la catégorisation purement distributionnelle émerge autour de l'âge de 20 mois ou légèrement plus tôt.

INTRODUCTION

Une tâche importante à laquelle les enfants sont confrontés lorsqu'ils acquièrent leur langue maternelle est d'apprendre à assigner les mots à des catégories grammaticales. Pour ce faire, les enfants doivent découvrir l'appartenance aux catégories directement à partir de la parole, contrairement à l'apprentissage d'une langue seconde, où de façon générale, on enseigne explicitement les étiquettes des catégories (v.g. noms, verbes). L'acquisition des catégories grammaticales est essentielle à l'aspect productif du langage. En effet, les phrases ne sont pas définies par des mots spécifiques, tels que *maison* ou *marcher*, mais bien par des catégories grammaticales, comme des noms et des verbes. Cette particularité des langues humaines permet de générer un nombre presque infini de phrases et de comprendre des phrases que l'on entend pour la première fois. Le but de la présente recherche est de mieux comprendre quels indices dans la parole les enfants utilisent pour catégoriser de nouveaux mots. Plus précisément, cette recherche vise à déterminer si les enfants peuvent éventuellement catégoriser de nouveaux mots en se basant uniquement sur des indices distributionnels (v.g. patrons de cooccurrence, position relative des mots dans une phrase), c'est-à-dire en l'absence d'indices sémantiques, phonologiques ou prosodiques.

De nombreuses études ont mis en évidences l'habilité des enfants à catégoriser les mots dès un très jeune âge. Cependant, aucune étude n'a démontré clairement la capacité des enfants à catégoriser de nouveaux mots lorsque les stimuli sont dépourvus d'informations autres que distributionnelles. Pourtant, au niveau syntaxique, les catégories grammaticales sont définies en termes de relations structurelles, qui elles sont de nature distributionnelle. Par exemple, les catégories fonctionnelles, comme les déterminants et les pronoms, sont définis en terme de relations distributionnelles avec les catégories de contenu, comme les noms et les verbes. Les relations structurelles existent avec ou sans corrélats sémantiques, phonologiques ou prosodiques. Les enfants doivent éventuellement apprendre à catégoriser distributionnellement des mots, nouveaux et connus, sans nécessiter d'indices sémantiques, phonologiques ou prosodiques.

Les genres grammaticaux en français peuvent servir de cadre pour cette question de recherche. En français, les noms sont divisés en masculins et féminins et les déterminants s'accordent en genre avec les ceux-ci. Un nom féminin est précédé par un déterminant féminin (v.g. *une maison, la maison*) et un nom masculin est précédé par un déterminant masculin (v.g. *un ballon, le ballon*). Dans la présente recherche, on vise à déterminer si les enfants francophones peuvent catégoriser de nouveaux noms en tant que masculins ou féminins en se basant exclusivement sur des indices distributionnels contextuels. Plus précisément, on évalue si les enfants sont capables de catégoriser de nouveaux noms selon le déterminant (masculin ou féminin) qui précède, et s'ils peuvent généraliser à d'autres déterminants du même genre.

La méthodologie utilisée dans la présente recherche est le paradigme de préférence du regard. Selon cette procédure, les enfants entendent des stimuli auditifs lorsqu'ils orientent leur regard vers un écran de télévision sur lequel un support visuel est présenté. Les enfants sont d'abord familiarisés à un ensemble de stimuli auditifs et sont ensuite testés par rapport à ces derniers. Les différences de temps de regards entre différents types de présentation nous renseignent sur la compréhension des enfants par rapport aux stimuli présentés.

Ce mémoire présente l'article scientifique rédigé dans le cadre du présent projet de maîtrise. La première partie de l'article présente une recension des écrits dans le domaine de la catégorisation des mots dans le processus d'acquisition du langage, ainsi que les buts et hypothèses précis de la présente recherche. Les différentes expériences de l'étude sont ensuite décrites, de même que les résultats obtenus. Enfin, la dernière partie de l'article discute des résultats rapportés dans cette étude, en relation avec des études précédentes dans le domaine de la catégorisation syntaxique.

DISTRIBUTIONALLY BASED CATEGORIZATION IN INFANTS

1.1 Abstract

The present study examined whether infants can perform gender categorization of nouns based solely on distributional information. In a visual preference procedure, French-learning 14-, 17-, 20- and 30-month-old infants were familiarized with pseudo-nouns preceded by French determiners, one masculine and one feminine. The pseudo-nouns were carefully controlled for any possible phonological or prosodic cues so that the distribution of the determiners with the pseudo-nouns was the only available cue for gender categorization of the pseudo-nouns. Infants were tested on the same pseudo-nouns preceded by different determiners. In grammatical trials, the gender pairings were consistent with those of familiarization, whereas in the ungrammatical trials, they were not. Infants aged 20 and 30 months discriminated between grammatical versus ungrammatical trials, showing evidence of gender categorization based solely on distributional information, whereas younger infants failed. These results contrast with previous findings of categorization using combined distributional and phonological cues in younger infants. We suggest that distributionally based categorization is a more advanced level of knowledge than that requiring the association of distributional cues with phonological and prosodic.

1.2 Introduction

When learning a language, children face many challenges. For example, they have to segment words form from continuous speech, to map sounds and meaning to word forms and to learn the syntax of the language. In order to learn the syntax, children must learn that sentences are not only composed of specific words, but are rather composed of abstract grammatical categories that can generate an infinite number of words. The question of how do children achieve such a task has not been fully understood yet.

Different mechanisms have been proposed by various theoretical models. One of these is known as the semantic bootstrapping model (e.g., Pinker, 1984). According to

this view, children perceive certain semantic referents (e.g., objects, actions and properties), which correlate with syntactic categories such as nouns, verbs and adjectives. They learn these grammatical categories by mapping words to these semantic referents. Once the semantic referents have been linked to the syntactic categories, children can then further analyze which distributional information is relevant for syntactic categorization of novel words. Alternate models have been proposed by the tenants of the Distributionally based theories (e.g., Braine, 1992; Maratsos & Chalkley, 1980). According to these theories, syntactic categories can be derived based on distributional regularities among words. Examples of distributional regularities are co-occurrence patterns, and the relative position of the words in a sentence. Finally, another theoretical approach suggests that there is phonological and prosodic information that correlates with some syntactic categories, and that children can use this information present in the input to learn grammatical categories and break into syntax (e.g., Christophe, Guasti, Nespor, Dupoux & Ooyen, 1997; Morgan, 1986; Shi, Morgan & Allopenna, 1998; Shi, 2005).

These theories diverge on how children discover the syntax and the grammatical categories, and there is no consensus about whether semantics comes before syntax, or vice versa, in the process of category formation. However, we know that at birth, infants already show evidence of categorization by attending to prosodic and phonological cues in the speech (Shi, Werker & Morgan, 1999). Indeed, Shi et al. (1999) found that 1-3-day-old newborns can use prosodic and phonological information to categorically discriminate content words versus function words. This is consistent with previous findings showing that, across languages, function words and content words have distinct phonological regularities: in comparison with content words, function words tend to have shorter vowel duration, weaker amplitudes and simplified syllable structure (Shi, Morgan & Allopenna, 1998).

There is also evidence that during the second year of age, children have some knowledge about more specific categories, such as nouns. For example, Höhle, Weissenborn, Kiefer, Schulz and Schmitz (2004) showed evidence of noun

categorization by the age of 14-16 months, in German-learning infants. In German (like in many languages) determiners and pronouns co-occur with nouns and verbs respectively. Therefore, these function words can potentially be used as a cue to categorize the following word. In a Headturn preference procedure, infants were familiarized with pseudo-words preceded either by a determiner (noun condition) or a pronoun (verb condition) in German. In the test phase, 14- to 16-month-old infants showed a different listening time when the same pseudo-words were presented in noun phrases versus in verb phrases, but only if they were familiarized in the noun condition and not in the verb condition. According to the authors, these results suggest that by 14 months of age, infants possess the abstract representation of the co-occurrence restrictions between determiner and nouns, but not between pronouns and verbs. It is unclear, however, if the success shown by the noun group means that of the categorization was entirely based on distributional patterns. It is possible that the stimuli used in that experiment had some subtle supporting cues for noun categorization, other than the distribution of the determiners with the pseudo-nouns. For example, prosodic cues could have biased the stimuli toward noun categorization when the pseudo-words were produced as nouns versus as verbs). Phonological characteristic of the pseudo-nouns could have made the pseudo-nouns more noun-sounding than verb-sounding like.

While Höhle et al. (2004) failed to show evidence of verb categorization in 14-16 month-olds, Mintz (2006) showed it in 12-month-old English-learning infants. In that study, a slightly different methodology than that of Höhle et al. (2004) was used to test whether infants' categorization of novel words is based on the immediately preceding and following contextual words (i.e., frequent frames). Mintz (2003) had previously showed the existence of frequent frames in the input and that such distributional contexts are reliable for the distinction of grammatical categories such as nouns and verbs. In the familiarization of Mintz (2006)'s study, infants were presented with sentences, each containing a pseudo-word. The pseudo-words occurred either in a noun frequent frame (e.g., *the_in*) or in verb frequent frame (e.g., *to_it*). In the test phase, the same pseudo-words appeared again in sentences, in frames that were presented during familiarization.

However, the pseudo-words and frames parings were novel: a particular pseudo-word never appeared in a frame in which it occurred during familiarization. For example, infants could hear *Can you deeg the room?* and *I lonk you now!* during familiarization, and hear *Can you lonk the room?* and *I deeg you now!* during the test. Half of these sentences were grammatical (i.e., the pseudo-words occurred in a frequent frame supporting the same grammatical category as that of familiarization) and the other half, ungrammatical (i.e., the pseudo-words occurred in a frequent frame supporting a different grammatical category as that of familiarization). The infants showed verb categorization by exhibiting differential listening times to ungrammatical trials versus grammatical trials for the pseudo-words that had been familiarized in verb-frame sentences, but showed no difference in listening times for the noun-frame sentences. One possible interpretation of these results is that other supporting information in the stimuli than the frames *per se* might have helped the infants to categorize verbs (e.g., phonological or prosodic cue shared by the pseudo-verbs).Therefore, like in Höhle, et al. (2004)'s study, it remains unclear whether infants categorized novel words based on distributional information alone, or whether infants could have used some other cues present in the stimuli.

Evidence of noun categorization was also shown with 14-month-old French-learning infants in a study by Shi and Melançon (2010). In that study, one group of infants was familiarized with pseudo-words preceded by determiners (noun condition), while another group of infants was familiarized by pronouns (verb condition). Both groups of infants were then tested on the same pseudo-words presented in noun versus verb phrases (with determiners and pronouns different from familiarization). Infants in the noun condition showed evidence of categorization, whereas infants in the verb condition failed. The stimuli used in that study were carefully chosen so that the pseudo-words contained no prosodic differences (in pitch, amplitude and duration) when presented in noun versus verb phrases. However, despite their prosodic control, other acoustic cues could have remained and accounted for the successful categorization of the pseudo-words in the noun condition.

There are other studies on category formation in which the phonological and distributional cues of the stimuli were specifically manipulated (Gerken, Wilson & Lewis, 2005; Gomez & Lakusta, 2004). Gomez and Lakusta (2004) conducted an experiment with artificial language, using an *aX bY* paradigm, in which *a* and *b* words were comparable to function words, and *X* and *Y* words were comparable to content words: like in natural languages, there are fewer members of the functor-like elements (*a* and *b* words) than the content-like elements (*X* and *Y* words). Infants aged 12 months were tested on whether they could form categories by associating the distributional information of *a* and *b* words with the phonological information (i.e., monosyllabic versus disyllabic) in *X* and *Y* words. They found that not only infants could form the categories, but they were also able to generalize them to novel words.

Another study by Gerken et al., (2005) tested whether 17-month-old English-learning infants could form categories in a Russian grammatical gender paradigm after a brief period of training. They found that infants were able to form gender categories only when two cues were present in the input: distributional information provided by the functional morpheme (i.e., gender suffix) and phonological information at the end of the noun stem. Infants showed no evidence of grammatical gender categorization when only the distributional information of the functional morpheme was present in the stimuli. These results showed that infants of this age may need a correlation of cues (e.g., distributional and phonological) in order to form the categories. In other words, it suggests distributional information alone might be insufficient for initial category formation.

Nevertheless, the syntax of a language is defined by the rule-governed distributional relations between grammatical categories. As an example, in many languages, determiners precede nouns and pronouns precede verbs. These syntactic categorical relations are independent of semantic, phonological and prosodic information. A mature native speaker knows such rules and can easily apply them to novel words. Children must eventually be able to learn to rely exclusively on distributional rules to categorize words.

The ability to categorize words may be divided into two levels of learning. As described by Braine (1987), at Level 1 learning, a correlation of cues (e.g., distributional and phonological) would be needed to acquire the relations between words, such as the associations shown in Gomez and Lakusta (2004) and Gerken et al. (2005). At Level 2 learning, correlating cues would be no longer necessary, and distributional information alone would be sufficient for categorization. In this vein, the goal of the present study was to determine when this ability of distributionally based categorization (i.e., Level 2 learning) emerges in infancy.

French grammatical gender was used in the present study to test distributionally based categorization. In French, unlike other languages like English, the distribution of determiners with nouns is almost always obligatory (e.g. *J'adore la garderie* 'I love daycare', but not **J'adore garderie*). Thus, the structure of the language makes the possibility to allow bare nouns very restricted. Moreover, French is a gender-marking language: nouns are divided into masculine and feminine and the determiners agree in gender with nouns. More precisely, a feminine noun is preceded by a feminine determiner (e.g., *une maison*, *la maison*), and a masculine noun is preceded by a masculine determiner (e.g., *un ballon*, *le ballon*). It was found that, for many nouns, gender attribution can be predicted based on phonological properties such as noun endings (Lyster, 2006; Tucker, Lambert, and Rigault, 1977). An analyses of the noun corpus of a French dictionary revealed that more than 60% of the nouns carry an ending that associates in a systematic way with gender (Tucker, et al., 1977), such as *–ette* ending (e.g., *pousette*) that co-occurs with feminine, and *–in* ending (e.g., *bain*) that co-occurs with masculine gender. However, such associations are not perfect and exceptions exist for every one of these associations. To illustrate, *squelette* is a masculine noun in French that carries an ending that is highly frequent in feminine nouns, whereas *main* is a feminine noun that carries an ending that is highly frequent in masculine nouns. Furthermore, many nouns carry a neutral ending that do not co-occur in a systematic manner with a specific gender (e.g., *–ale, –ère*) (Lyster, 2006). Therefore, because phonological information is often unreliable, infants must ultimately

learn to categorize nouns based on their distributional information with determiners, which is more reliable.

The present study strictly controlled all possible acoustical and phonological cues to gender categorization. This allowed us to unambiguously examine whether French-learning infants can categorize novel nouns as masculine or feminine on the sole basis of distributional information, i.e., on the distribution of a determiner with nouns. More precisely, we examined whether infants can categorize novel nouns based purely on the preceding determiner as a cue to gender, and generalize to other determiners of the same gender. Given the categorization abilities shown in previous studies, we decided to begin our investigation with infants aged 14 and 17 months.

1.3 Experiment 1

1.3.1 Methods

Participants

Participants were sixteen 14-month-old (8 males and 8 females; Mean age = 446.88 days; SD = 7.97; range: 432-459) and sixteen 17-month-old (6 males and 10 females; Mean age = 537.25 days; SD = 6.49; range: 526-548) monolingual Quebec-French-learning infants. An additional 12 infants were tested but were not included in the analyses because of fussiness (5), parental interference (3), experimental error (1), equipment failure (1) and ceiling effect (2).

Stimuli

The stimuli consisted of French determiners and pseudo-nouns. Several reasons motivated the use of pseudo-nouns in this study. The main reason was that pseudo-nouns allowed us to examine infants' capacity to assign novel words to gender categories. It also allowed us to control the word form in order to eliminate potential phonological bias for gender. Finally, pseudo-nouns allow controlling for infant's prior exposure to the stimuli such that all stimuli in our experiment were equally unfamiliar to all infants.

Four pseudo-nouns were used in the stimuli set: *mouveil, ravol, cagère* and *gombal*. These pseudo-nouns were chosen from a pre-study with French-speaking adults. We designed the pre-study to determine pseudo-nouns that were equally probable in both masculine and feminine genders. The goal was therefore to neutralize any phonological cues to gender in the pseudo-nouns selected for the present study with infants. In that pre-study, ten participants were verbally presented with a list of 26 pseudo-words which we had constructed. For each pseudo-word, each participant was asked to verbally produce a sentence using the pseudo-word as a noun. Then, he or she had to decide whether the pseudo-word was noun-like in French, and whether it was a typical-sounding noun. Since, determiners are generally required in noun phrases by the French grammar, the participants spontaneously produced a determiner before the pseudo-word in every sentence. Therefore, we were able to implicitly induce gender production from the adults for each pseudo-word. The rational is that if a pseudo-word is phonologically biased toward one of the two genders, it should be produced more often with a determiner of that gender, whereas if a pseudo-word is not phonologically biased toward one gender, it should be produced equally with determiners of both genders. The four pseudo-words listed above were produced comparably with determiners of both genders across participants and were judged as typical-sounding noun in French (see Table 1.1).

The final stimuli set consisted of noun phrases. The following phrases were used as stimuli for the familiarization phase: *un mouveil, une mouveil, un ravol, une ravol, un gombal, une gombale, un cagère, une cagère*. The final stimuli set for the test phase consisted of the following phrases: *le mouveil, la mouveil, le ravol, la ravol, le gombal, la gombale, le cagère, la cagère*.

The auditory materials were recorded in a sound attenuated booth by a native Quebec-French female speaker in an infant directed speech style. The stimuli were recorded using a digital audio recorder Sound Device 702T (44 kHz sampling frequency, 24bits bit rate), and then then transferred digital-to-digital to a computer. The four pseudo-nouns were each produced several times in isolation and several times in noun

Table 1.1 Adults' judgment of typicality and gender for the 26 pseudo-nouns. Typicality was coded as 0 for "not typical-sounding noun in French" and 1 for "typical-sounding noun in French. Gender was coded 0 when the pseudo-noun was used with a masculine determiner, and 1 when used with a feminine determiner. A pseudo-noun with an ambiguous gender use will have a mean around 0.50 on the Gender dimension.

Pseudo-word	Typicality		Gender	
	M	SE	M	SE
Saucame	0,50	0,17	0,30	0,15
Nouca	0,80	0,13	0,20	0,13
Goli	0,80	0,13	0,10	0,10
Sertère	0,45	0,16	0,30	0,15
Selexe	0,50	0,17	0,25	0,13
Chérelle	0,65	0,15	0,25	0,13
Fidu	0,55	0,16	0,00	0,00
Tarchoire	0,75	0,13	0,00	0,00
Noicame	0,35	0,15	0,35	0,15
Ravol	0,75	0,13	0,50	0,17
Cagère	0,75	0,13	0,50	0,15
Gombal	1,00	0,00	0,40	0,16
Zonade	0,75	0,11	0,85	0,11
Charôme	0,85	0,08	0,20	0,13
Noupole	0,60	0,16	0,25	0,13
Vêcare	0,75	0,13	0,15	0,11
Guilèque	0,80	0,13	0,00	0,00
Nousé	0,60	0,16	0,55	0,16
Mersel	0,80	0,13	0,40	0,16
Rochère	0,75	0,13	0,50	0,17
Docaste	0,15	0,11	0,25	0,13
Tiétare	0,60	0,15	0,25	0,13
Chimeille	1,00	0,00	0,85	0,11
Rêti	0,65	0,15	0,25	0,13
Tonpia	0,65	0,15	0,15	0,11
Mouveil	0,95	0,05	0,60	0,16

phrases, with each of the four determiners (i.e., *un*, *une*, *le* and *la*). The pseudo-nouns were produced with three different intonations (i.e., flat, rising and falling). In total, three tokens of every noun phrase (one token per intonation) were selected. In order to avoid possible acoustic/prosodic cues in the pseudo-nouns associated with the production in masculine versus feminine phrases, the final stimuli were created within Praat software (version 4.5.26) (Boersma & Weenink, 2007), via a cross-splicing technique: each pseudo-noun produced in isolation (that is, in a gender neutral context) with one of the three intonations was spliced and conjoined with the determiners of both gender. The latter were spliced from noun phrases with the corresponding pseudo-nouns

produced in the same intonation as the citation form. More precisely, both the isolated pseudo-noun and the corresponding noun phrase sound files were cut at a matching point following the beginning of the pseudo-noun. For the pseudo-nouns *gombal* and *cagère*, the cutting point was just before the release of the initial consonant. For the pseudo-nouns *mouveil* and *ravol*, the cutting point was in the middle of the initial consonant. This was done to avoid an artificial sounding of the spliced phrases.

The visual display for all trials consisted of a cartoon-like puppet standing in the center of the screen. The mouth movement of the puppet approximately matched the auditory stimuli so that the puppet "spoke" the stimuli. While doing so, the puppet was also moving her hands, head and body. The visual stimuli were created using Adobe® Flash® CS3 Professional software and exported in a QuickTime format with a 30 fps frame rate and a resolution of 1360 x 768 pixels. The purpose of this animation was to make the task interesting for the infants.

Design

The experiment consisted of a familiarization and a test phases. During familiarization, infants were presented with noun phrases in which the four pseudo-nouns described above were paired with indefinite determiners (i.e., *un* – masculine, *une* – feminine). Among the four pseudo-nouns, two were preceded by the masculine indefinite determiner *un* (e.g., *un mouveil*, *un ravole*) and two were preceded by the feminine indefinite determiner *une* (e.g., *une gombale*, *une cagère*). The grammatical gender of the determiner that was paired with the pseudo-nouns was counterbalanced across infants, forming two different familiarization conditions. For each familiarization condition, the stimuli were organized in three different sound files of 15.1 seconds with an inter-stimulus interval of 700 milliseconds. In each sound file, the stimuli were presented quasi-randomly, such that the each noun phrase would occur twice within the file. Furthermore, to ensure variability in the stimuli, the noun phrases with each of the three intonations were presented an equal number of times (twice each) across the three sound files. In total, each sound file contained two different intonations of each of the

four noun phrases (see Table 1.2). One sound file was used for one familiarization trial, and all three sound files were used across different trials. The familiarization trials were presented until the infant accumulated 90 seconds of looking time. Then, the test phase was initiated.

Table 1.2 Randomization of NPs exemplars within each sound file during familiarization and test phases of Experiments 1 to 3. Across sound files within the same phase, the same NP exemplars appeared quasi-randomly with the restriction that the same NP and the same intonation never repeated immediately in any familiarization file and never occurred more than twice in adjacent order in a test file. The inter-stimulus interval (between any two phrases) was 700 milliseconds.

Table 1.2a Randomization of NPs exemplars within each sound file during familiarization phase.

FAMILIARIZATION SOUND FILES		
Sound file 1	**Sound file 2**	**Sound file 3**
50 ms silence	50 ms silence	50 ms silence
un mouveil falling	*un ravol* rising	*une cagère* flat
700 ms silence	700 ms silence	700 ms silence
une cagère rising	*une cagère* falling	*une gombal* rising
700 ms silence	700 ms silence	700 ms silence
un ravol flat	*une gombal* flat	*un mouveil* flat
700 ms silence	700 ms silence	700 ms silence
une gombal falling	*un mouveil* rising	*un ravol* falling
700 ms silence	700 ms silence	700 ms silence
une cagère flat	*un mouveil* falling	*un ravol* rising
700 ms silence	700 ms silence	700 ms silence
une gombal rising	*une cagère* rising	*une cagère* falling
700 ms silence	700 ms silence	700 ms silence
un mouveil flat	*un ravol* flat	*une gombal* flat
700 ms silence	700 ms silence	700 ms silence
un ravol falling	*une gombal* falling	*un mouveil* rising

Table 1.2b Randomization of NPs exemplars within each sound file during test phase.

TEST SOUND FILES					
Sound file 1 (grammatical)	**Sound file 2 (ungrammatical)**	**Sound file 3 (grammatical)**	**Sound file 4 (ungrammatical)**	**Sound file 5 (grammatical)**	**Sound file 6 (ungrammatical)**
50 ms silence	50 ms silence	50 ms silence	50 ms silence	50 ms silence	50 ms silence
le mouveil flat	*le cagère* flat	*la gombal* flat	*la ravol* flat	*la gombal* falling	*la ravol* falling
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la gombal rising	*la ravol* rising	*le mouveil* rising	*le cagère* rising	*le mouveil* falling	*le cagère* falling
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la gombal flat	*la ravol* flat	*le mouveil* flat	*le cagère* flat	*le mouveil* flat	*le cagère* flat
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le mouveil rising	*le cagère* rising	*la gombal* rising	*la ravol* rising	*la gombal* rising	*la ravol* rising
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la gombal falling	*la ravol* falling	*la gombal* falling	*la ravol* falling	*la gombal* flat	*la ravol* flat
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le mouveil falling	*le cagère* falling	*le mouveil* falling	*le cagère* falling	*le mouveil* rising	*le cagère* rising
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le mouveil flat	*le cagère* flat	*le mouveil* flat	*le cagère* flat	*le mouveil* flat	*le cagère* flat
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la gombal rising	*la ravol* rising	*la gombal* rising	*la ravol* rising	*la gombal* rising	*la ravol* rising

In the test phase, the same four pseudo-nouns were again presented in noun phrases, this time paired with definite determiners (*le* – masculine, *la* – feminine). The test phase consisted of two trial types: grammatical and ungrammatical trials. In the grammatical trials, two pseudo-nouns from familiarization (one that had been paired with a masculine indefinite determiner, and one with a feminine indefinite determiner) were now paired with a definite determiner consistent in gender with the familiarization (e.g., *le mouveil*, *la gombale*). In the ungrammatical trials, the remaining two pseudo-nouns were paired with a definite determiner inconsistent in gender with the familiarization (e.g., *le cagère*, *la ravole*). Six sound files (three grammatical and three ungrammatical) of 15.2 second duration were thus created for the test phase. Each file consisted of two noun phrases, each presented four times within the file, with an inter-stimulus interval of 700 milliseconds. The two noun phrases were presented in a quasi-random way, with the restriction that the same noun phrase would not occur more than twice consecutively. For a given grammatical sound file, the intonation and gender of noun phrases (e.g. starting *le mouveil* – masculine and flat intonation) were ordered in the same way as those in the corresponding ungrammatical sound file (starting with *le cagère* – masculine and flat intonation) (see Table 1.2). In total, the test phase consisted of 10 trials (four sound files out of the six were presented twice), with a maximal length of 15.2 seconds for each trial. Grammatical and ungrammatical trials were presented in alternation. The type of the first trial (grammatical versus ungrammatical) was counterbalanced across participants. The grammaticality of the noun phrases was also counterbalanced across participants (as shown in Table 1.3).

Procedure

The participants were tested individually in a preferential looking paradigm. Upon arrival, the caregiver(s) were informed of the procedure and were asked not to interfere during the experiment (e.g. by talking to the child or by pointing at the screen). Then, the caregiver and the infant were led to a sound-attenuated booth, where the infant sat on the caregiver's laps, approximately two meters in front of a 42-inch LG 1360 x

Table 1.3 Familiarization conditions and Test conditions across different groups of infants for Experiments 1 to 3. Table 1.3a and Table 1.3b represent different familiarization stimuli presented to two different groups of infants. Table 1.3a and Table 1.3b show the same test stimuli. The difference is that grammaticality of test material is reversed (i.e., the grammatical trials in Table 1.3a are ungrammatical in Table 1.3b, and the ungrammatical trials in Table 1.3a are grammatical in Table 1.3b), because of the familiarization difference. There were eight sub-groups of infants for the eight different test conditions, representing the counterbalancing of the first test trial (grammatical first versus ungrammatical first), and the counterbalancing of the permutations of the pseudo-nouns as grammatical versus ungrammatical stimuli, in addition to the grammaticality counterbalancing.

Table 1.3a

Familiarization	*un mouveil, une gombal, un cagère, une ravol*			
Test	**Sub-group 1**	**Sub-group 2**	**Sub-group 3**	**Sub-group 4**
Trial :	*le mouveil, la gombal*	*le ravol, la cagère*	*le cagère, la ravol*	*le gombal, la mouveil*
Trial :	*le ravol, la cagère*	*le mouveil, la gombal*	*le gombal, la mouveil*	*le cagère, la ravol*

Table 1.3b

Familiarization	*une mouveil, un gombal, une cagère, un ravol*			
Test	**Sub-group 1**	**Sub-group 2**	**Sub-group 3**	**Sub-group 4**
Trial :	*le mouveil, la gombal*	*le ravol, la cagère*	*le cagère, la ravol*	*le gombal, la mouveil*
Trial :	*le ravol, la cagère*	*le mouveil, la gombal*	*le gombal, la mouveil*	*le cagère, la ravol*

768 TV monitor. The caregiver was listening to masking music through noise cancellation headphones. The experimenter, who was blind to the audio-visual stimuli, observed the infant's eye behavior through a closed-circuit TV and pressed down a computer key whenever the infant looked at the TV monitor. The HABIT2002 software (Cohen, Atkinson & Chaput, 2000) was used to present the stimuli in the test room. The experiment was infant-controlled: each trial was initiated when the infant was looking toward the TV monitor and stopped when the infant failed to look at the TV for more than two seconds or until the maximum trial length was reached. Between trials, an attention getter was playing to attract the infant's attention. The attention getter consisted of a bird zooming in and out, synchronized with a whistle sound.

1.3.2 Results and Discussion

Infants' averaged looking times while listening to the grammatical trials and ungrammatical trials of the test phase were calculated. Our interest in this experiment was also to examine if there was any development in gender categorization from 14 to 17 months of age. Preliminary analyses were first carried out in order to examine the effects of test trial order and sexe and age. To do so, we conducted a 2 X 2 X 2 X 2 mixed-design ANOVA, with Grammaticality of the test trials as a within-subject factor and First test trials order (grammatical versus ungrammatical), Sexe (male versus female) and Age (14 versus 17 months) as between-subject factors. A significant interaction was revealed between Grammaticality and First test trial order, $F(1, 24) = 4.335$, $p = .048$, $\eta^2 = .153$. Following simple effect analyses showed that the effect of Grammaticality was not significant neither when the first test trial was grammatical, $F(1, 14) = 1.744$, $p = .211$, $\eta^2 = .127$, or when it was ungrammatical, $F(1, 14) = 2.881$, $p = .115$, $\eta^2 = .194$. No interaction was found between Grammaticality and Sexe, $F(1, 24) = 0.340$, $p = .565$, $\eta^2 = .014$, between Grammaticality, First test trial order and Sexe, $F(1, 24) = 0.352$, $p = .558$, $\eta^2 = .014$, between Grammaticality, First test trial order and Age, $F(1, 24) = 1.032$, $p = .320$, $\eta^2 = .041$, between Grammaticality, Sexe and Age, $F(1, 24) = 0.575$, $p = .456$, $\eta^2 = .023$, nor between Grammaticality, First test trial order, Sexe and Age, $F(1, 24) = 1.014$, $p = .324$, $\eta^2 = .041$. Since no effect of test trial order and of sexe was found, those factors were not included in subsequent analyses.

A 2 X 2 mixed design ANOVA was then computed, with Grammaticality of the test trials as a within-subject factor and Age (14 versus 17 months) as between-subject factor. No main effect of Grammaticality was observed, $F(1, 30) = 0.015$, $p = .904$, $\eta^2 < .0005$, indicating that the infants' listening time to grammatical ($M = 7.99$ sec; $SE = 0.61$ sec) and to ungrammatical ($M = 8.04$ sec; $SE = 0.54$ sec) trials was not significantly different. No interaction was found between Grammaticality and Age, $F(1, 30) = 0.356$, $p = .555$, $\eta^2 = .012$, suggesting that neither the 14-month-olds nor the 17-month-olds showed different looking patterns toward grammatical versus ungrammatical trials (Figure 1.1).

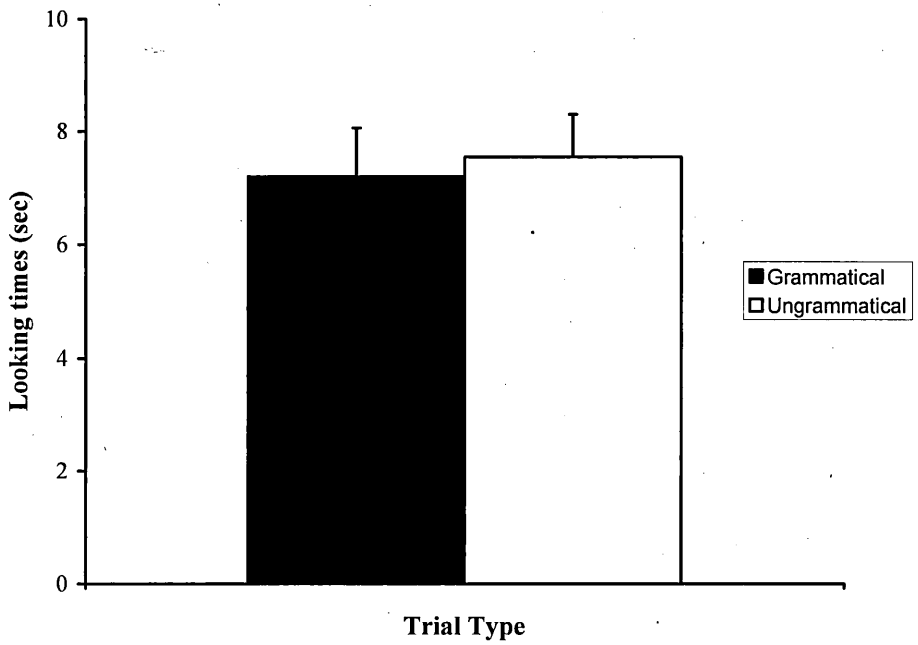

Figure 1.1a 14-month-old infants' looking (listening) times (means and standard errors) to the two test trial types, grammatical (the determiner gender pairing consistent with the familiarization) versus ungrammatical (the determiner gender pairing inconsistent with the familiarization).

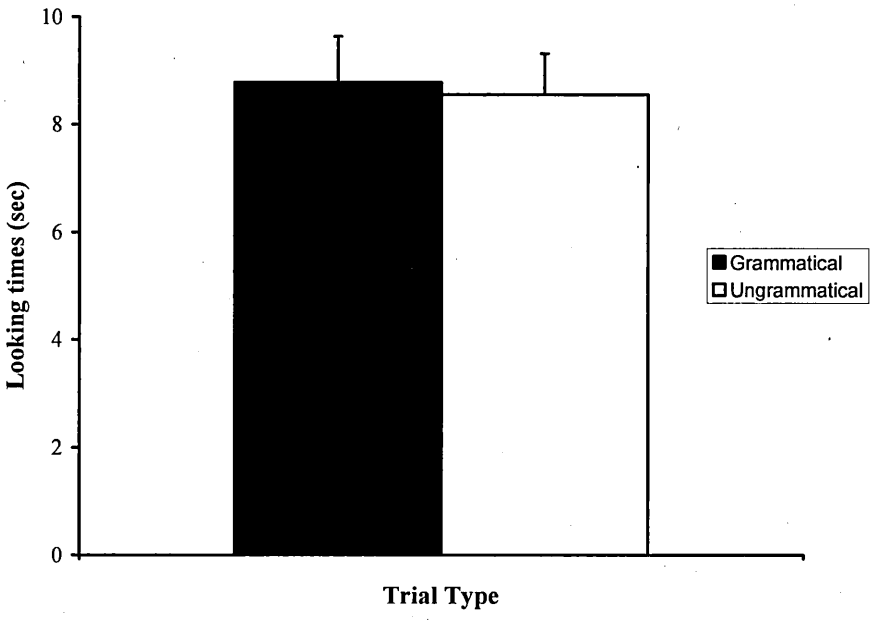

Figure 1.1b 17-month-old infants' looking (listening) times (means and standard errors) to the two test trial types, grammatical versus ungrammatical.

The same analyses were performed with the first test trial of each type removed, since the first or first two trials have been suggested to be unstable sometimes (e.g., Cooper, & Aslin, 1994; Marquis & Shi, 2008; Shi & Werker, 2001, Vouloumanos & Werker, 2004). The results thus obtained were comparable to those of the previous analyses. No interaction was found between Grammaticality, First test trial order, $F(1, 24) = 2.813$, $p = .107$, $\eta^2 = .105$, between Grammaticality and Sexe, $F(1, 24) = 0.784$, $p = .385$, $\eta^2 = .032$, between Grammaticality, First test trial order and Sexe, $F(1, 24) = 0.152$, $p = .700$, $\eta^2 = .006$, between Grammaticality, First test trial order and Age, $F(1, 24) = 0.196$, $p = .662$, $\eta^2 = .008$, between Grammaticality, Sexe and Age, $F(1, 24) = 0.130$, $p = .722$, $\eta^2 = .005$, nor between Grammaticality, First test trial order, Sexe and Age, $F(1, 24) = 0.118$, $p = .735$, $\eta^2 = .005$, indicating that there was no effect of test trial order, sexe or a combination of these factors. Therefore, those factors were not included in the subsequent analyse. The latter revealed no main effect of Grammaticality, $F(1, 30) = 0.016$, $p = .900$, $\eta^2 = .001$, indicating no significant difference between the infants' listening time to grammatical ($M = 4.48$ sec; $SE = 0.61$ sec) versus ungrammatical ($M = 7.42$ sec; $SE = 0.57$ sec) trials, and no interaction between Grammaticality and Age, $F(1, 30) = 0.039$, $p = .844$, $\eta^2 = .001$.

These results showed that both the 14-month-olds and the 17-month-olds failed to show evidence of gender categorization based purely on distributional grounds. These results contrast with those of recent studies (Höhle, et al., 2004; Mintz, 2006; Gomez & Lakusta, 2004; Gerken, et al. (2005); Shi and Melançon, 2010), which showed evidence of categorization in infants of the same age and even younger. One possible explanation is that infants of this age have not yet attained the Level 2 learning discussed in Braine (1987) and still require the correlation of phonological/prosodic cues, as shown in Gomez and Lakusta (2004) and Gerken, et al. (2005), in order to form the categories. Another possibility is that distributional cues to gender categories in French may carry some ambiguity because of the determiners plural forms, which is the same for both masculine and feminine nouns (e.g., *les maisons* - feminine, *les ballons* - masculine). It is thus possible that this ambiguity delay the acquisition of gender categorization in

French, compared to noun and verb categorization. Therefore, in Experiment 2, we asked whether slightly older children (i.e., 20-month-olds) would show evidence of distributionally based categorization of gender.

1.4. Experiment 2

1.4.1 Method

Participants, stimuli, design and procedure

Participants were sixteen 20-month-old (11 males and 5 females; Mean age = 633.25 days; SD = 12.44; range: 610-651) monolingual Quebec-French-learning infants. Additional 4 infants were tested but were not included in the analyses because of fussiness (3), experimental error (1) and ceiling effect (1). The stimuli, design and procedure were identical to those of Experiment 1.

1.4.2 Results and Discussion

First of all, preliminary analyses were performed to examine the effects of test trial order and sexe. To do so, a 2 X 2 X 2 mixed-design ANOVA was conducted on infants averaged looking times, with Grammaticality of the test trials as a within-subject factor and First test trials order (grammatical versus ungrammatical) and Sexe (male versus female) as between-subject factors. No interaction was found between Grammaticality and First test trial order, $F(1, 12) = 2.783, p = .121, \eta^2 = .188$, between Grammaticality and Sexe, $F(1, 12) = 1.678, p = .220, \eta^2 = .123$, nor between Grammaticality, First test trial order and Sexe, $F(1, 12) = 0.001, p = .980, \eta^2 < .0005$. Thus, no effect of trial order nor sexe was revealed. Since no effect of trial order nor of sexe was found, those factors were not included in subsequent analyses. A paired t-test was conducted on infants' averaged looking times to grammatical versus ungrammatical trials. Infants' looking time to the grammatical trials ($M = 9.09$ sec; $SE = 0.88$ sec) was similar to their looking time to the ungrammatical trials ($M = 8.91$ sec; $SE = 0.82$ sec), $t(15) = 0.224, p = .826$, 2-tailed (see Figure 1.2).

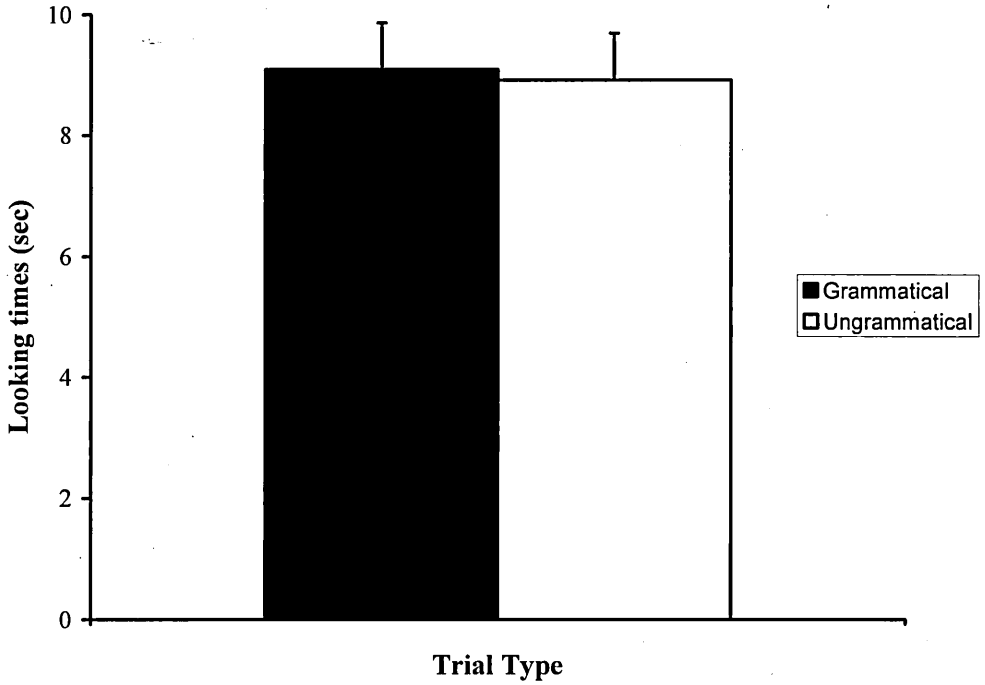

Figure 1.2 20-month-old infants' looking (listening) times (means and standard errors) to the two test trial types, grammatical versus ungrammatical.

Furthermore, as in Experiment 1, the same analyses were conducted with the first test trial of each type removed. The results were consistent with those of the previous analyses: There was no effect of test trial order, $F(1, 12) = 1.217$, $p = .292$, $\eta^2 =$ 092, and no effect of sexe, $F(1, 12) = 0.707$, $p = .417$, $\eta^2 = .056$. A following paired t-test excluding those factors revealed that there was no difference in looking times to the grammatical trials ($M = 8.89$ sec; $SE = 0.93$ sec) and the ungrammatical trials ($M = 8.66$ sec; $SE = 0.85$ sec), $t(15) = 0.330$, $p = .746$, $\eta^2 = .007$, 2-tailed.

Surprisingly, like the 14- and 17-month-olds from Experiment 1, the 20-month-olds showed no evidence of gender categorization. It is possible that even at this age infants failed our task because they still do not have Level 2 categorization ability, i.e., using only distributional cues. Nevertheless, we know from production studies in French that children's production of grammatical words, including pronouns and determiners, increases significantly between 20 and 30 months of age (Bassano, 1998; Bassano,

Maillochon & Eme, 1998), suggesting that they may also have some knowledge of the structural relations between grammatical genders of determiners and nouns.

There is in fact evidence from online comprehension studies that 25-month-old French-learning infants can use gender information of determiners to process familiar nouns (Van Heugten and Shi, 2009), as do 28-month-old Dutch-learning toddlers (Johnson, 2005). Similar results were shown in a study with Spanish-learning children aged between 34 to 42 months (Lew-Williams and Fernald, 2007), although this ability is most likely to have emerged earlier, consistently with Van Heugten et al. (2009)'s and Johnson (2005)'s studies.

Considering the above production and comprehension studies, we expected that children between two and three years of age should have the ability to categorize novel nouns into gender classes based solely on the distribution of the determiners and the nouns. Testing a much older age group would allow us to ascertain the validity of our task. Indeed, in the present study, the method, especially the visual stimuli, slightly differed from what is commonly used with preferential looking procedures. Usually, lights (in HPP) or static pictures such as a checkerboard are used as visual stimuli. In Experiments 1 and 2 of the present study, the null results could possibly be explained by the fact that children were so attracted by the talking puppet that they looked at the screen regardless of the auditory stimuli that were presented. Positive results with older children, who should have categorization ability, would therefore mean that the present method of stimuli presentation using a talking puppet as visual support is valid, and that the results in Experiments 1 and 2 are interpretable.

1.5 Experiment 3

1.5.1 Method

Participants, stimuli, design and procedure

Participants were sixteen 30-month-old (6 males and 10 females; Mean age = 935.00 days; SD = 11.19; range: 917-959) monolingual Quebec-French-learning infants.

Additional 2 infants were tested but were not included in the analyses because of fussiness (1) and experimental error (1). The stimuli, design and procedure were identical to those of Experiment 1 and 2.

1.5.2 Results and Discussion

The same analyses as Experiment 1 and 2 were conducted on infants' looking data. Preliminary analyses were done to examine the effects of test trial order and sexe. A 2 X 2 X 2 mixed design ANOVA was carried out with Grammaticality of the test trials as a within-subject factor and First test trials order (grammatical versus ungrammatical) and Sexe (male versus female) as between-subject factors. No interaction was found between Grammaticality and First test trial order, $F(1, 12) = 1.104, p = .314, \eta^2 = .084$, between Grammaticality and Sexe, $F(1, 12) = 1.127, p = .309, \eta^2 = .086$, nor between Grammaticality, First test trial order and Sexe, $F(1, 12) = 0.381, p = .548, \eta^2 = .031$. Thus, no effect of trial order nor sexe was revealed. Therefore, those factors were not included in the subsequent analyse. As predicted, a paired t-test indicated that infants' looking time to the grammatical trials ($M = 8.16$ sec; $SE = 0.57$ sec) was significantly different from to their looking time to the ungrammatical trials ($M = 10.20$ sec; $SE = 0.58$ sec), $t(15) = 4.521, p < .001, \eta^2 < .577$, 2-tailed (see Figure 1.3).

As in Experiment 1 and 2, we conducted the same analyses with the first test trial of each type removed. A 2 X 2 X 2 mixed design ANOVA, with Grammaticality of the test trials as a within-subject factor and First test trials order (grammatical versus ungrammatical) and Sexe (male versus female) as between-subject factors, revealed marginally significant effects of test trial order, $F(1, 12) = 4.205, p = 063, \eta^2 = .259$, and of sexe, $F(1, 12) = 4.228, p = .062, \eta^2 = .261$. No Grammaticality X First test trial order X Sexe interaction was found, $F(1, 12) = 0.136, p = .719, \eta^2 = .011$. A paired t-test without those factors showed that the preference for the ungrammatical trials ($M = 7.65$ sec; $SE = 2.50$ sec) over the grammatical trials ($M = 10.03$ sec; $SE = 2.50$ sec), $t(15) = 4.830, p < .0005, \eta^2 = .609$, 2-tailed, was as robust as in the previous analyses including all test trials.

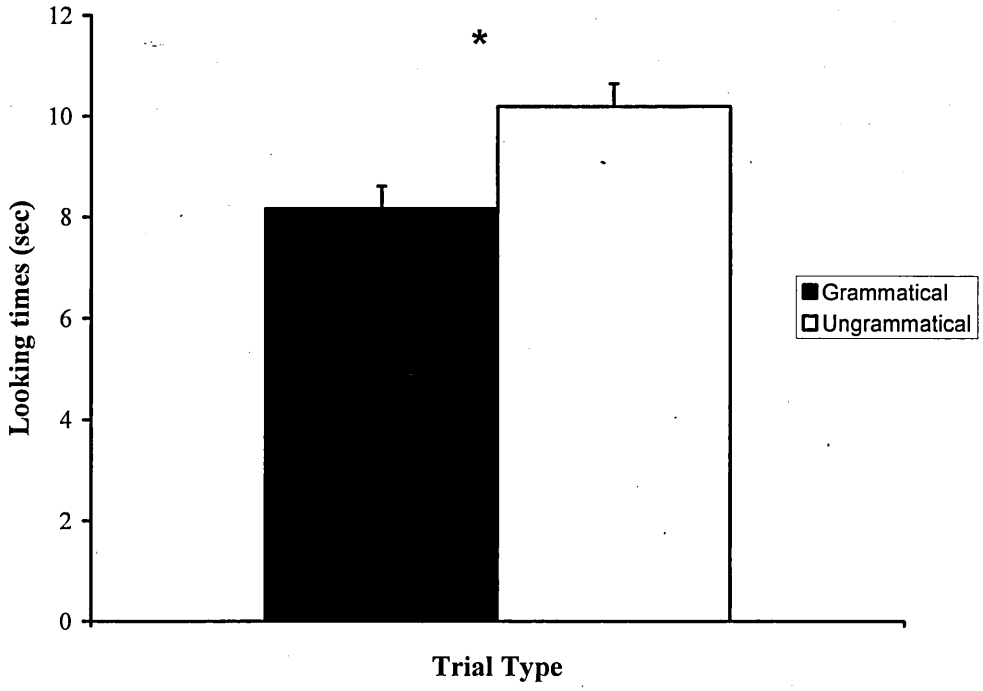

Figure 1.3 30-month-old infants' looking (listening) times (means and standard errors) to the two test trial types, grammatical versus ungrammatical.

These results suggest that infants aged 30 months can categorize novel nouns into gender classes based purely on distributional grounds. Moreover, the robust preference for ungrammatical over grammatical trials shown by these infants contrasts with the results of the 20-month-olds from Experiment 2, who failed to show a preference for any trial type.

The positive results of Experiment 3 also confirmed that the current method using an animated puppet as visual support was reliable. Therefore, the questionable validity of the current method has been ruled out as a possible interpretation of the null results obtained in Experiments 1 and 2. Together, the results of Experiment 1 to 3 may suggest that the ability to categorize gender based solely on distributional cues is present in 30-month-old French-learning infants, consistent with the literature on children's production (Bassano et al., 1998) and comprehension (Shi & Van Heugten, 2009).

It remains possible, however, that this ability emerges earlier in development, but that our task does not allow children to show this ability until an older age. Indeed, previous studies have shown evidence of categorization in much younger children (Gerken et al., 2005; Gomez & Lakusta, 2004; Höhle, et al., 2004; Mintz, 2006; Shi & Melançon, 2010). It is possible that the learning task that our infants faced was too complex. The present design required infants to associate two pseudo-nouns with a masculine indefinite determiner and two other pseudo-nouns with a feminine indefinite determiner. Then, infants were tested with the same four pseudo-nouns preceded by different determiners. Grammatical trials involved different pseudo-nouns as did ungrammatical trials. In order to succeed in the present task, infants needed to categorize all four nouns and different determiners in the appropriate gender classes. Hence, the learning task in the present study may be too complex for infants aged 20 months and younger to show their distributionally based categorization. We therefore simplified our design, by using fewer pseudo-nouns, which required the learning of fewer number of determiner-noun pairings, and by increasing the familiarization time. We hypothesized that 20-month-old infants should show an emerging knowledge of distributionally based gender categorization. This is the goal of Experiment 4.

1.6 Experiment 4

1.6.1 Method

Participants

Participants were sixteen 20-month-old (9 males and 7 females; Mean age = 638.44 days; SD = 9.99; range: 626-659) monolingual Quebec-French-learning infants. Additional 6 infants were tested but were not included in the analyses because of fussiness (4) and ceiling effect (2).

Stimuli, design and procedure

The stimuli consisted of two pseudo-nouns used in the Experiments 1 to 3: *cagère* and *ravol*, paired with the determiners *un*, *une*, *le* and *la*. The same tokens of these noun

phrases than in the final stimuli set (i.e., after cross-splicing) of the previous experiments were used: three tokens of *un cagère*, *une cagère*, *un ravol*, *une ravol*, for the familiarization phase, and three tokens of *le ravol*, *la ravol*, *le cagère*, *la cagère* for the test phase.

As in the previous experiments, the design consisted of a familiarization and a test phases. Familiarization trials presented the two pseudo-nouns *cagère* and *ravol* each preceded by one of the indefinite determiners, *un* – masculine, or *une* – feminine, e.g., *un ravol*, *une cagère*. The pairings of the grammatical gender of the determiner with the pseudo-nouns were counterbalanced across infants, forming two different familiarization conditions, as shown in Table 1.5.

For each familiarization condition, the stimuli were concatenated into three different sound files of 15.2 seconds, with an inter-stimulus interval of 700 milliseconds (see Table 1.4). In each sound file, the two noun phrases were presented four times in a quasi-random fashion, with the restriction that the same noun phrase would not occur more than twice consecutively. The noun phrases with each intonation were presented an equal number of times (four times each) across the three sound files. Each sound file contained two different intonations of each of the two noun phrases. One sound file was used for one familiarization trial, and all three sound files were used across different trials. The familiarization trials were presented until the infant accumulated 120 seconds of looking time. Then, the test phase was initiated.

In the test phase, the same two pseudo-nouns were again presented, this time preceded by definite determiners (*le* – masculine, *la* – feminine). As in Experiments 1 to 3, the test phase consisted of grammatical and ungrammatical trials. In the grammatical trials, the two pseudo-nouns of the familiarization were paired with a definite determiner consistent in gender with the familiarization (e.g., *le ravol*, *la cagère*). In the ungrammatical trials, the same two pseudo-nouns were paired with a definite determiner inconsistent in gender with the familiarization (e.g., *le cagère*, *la ravol*). Unlike Experiments 1 to 3, in which the nouns for the grammatical trials were different from

those for the ungrammatical trials, in the present experiment, both test trial types consisted of the same two nouns.

Table 1.4 Randomization of NPs exemplars within each sound file during familiarization and test phases of Experiments 4 and 5. Across sound files within the same phase, the same NP exemplars appeared quasi-randomly with the restriction that the same NP never occurred more than twice in adjacent order. The inter-stimulus interval (between any two phrases) was 700 milliseconds.

Table 1.4a Randomization of NPs exemplars within each sound file during familiarization phase.

FAMILIARIZATION SOUND FILES		
Sound file 1	**Sound file 2**	**Sound file 3**
50 ms silence	50 ms silence	50 ms silence
un ravol falling	*une cagère* flat	*un ravol* rising
700 ms silence	700 ms silence	700 ms silence
une cagère rising	*un ravol* flat	*une cagère* falling
700 ms silence	700 ms silence	700 ms silence
une cagère rising	*un ravol* flat	*un ravol* rising
700 ms silence	700 ms silence	700 ms silence
un ravol falling	*une cagère* flat	*une cagère* falling
700 ms silence	700 ms silence	700 ms silence
un ravol rising	*un ravol* falling	*une cagère* flat
700 ms silence	700 ms silence	700 ms silence
une cagère falling	*une cagère* rising	*un ravol* flat
700 ms silence	700 ms silence	700 ms silence
un ravol rising	*une cagère* rising	*un ravol* flat
700 ms silence	700 ms silence	700 ms silence
une cagère falling	*un ravol* falling	*une cagère* flat

Table 1.4b Randomization of NPs exemplars within each sound file during test phase.

TEST SOUND FILES					
Sound file 1 (grammatical)	**Sound file 2 (ungrammatical)**	**Sound file 3 (grammatical)**	**Sound file 4 (ungrammatical)**	**Sound file 5 (grammatical)**	**Sound file 6 (ungrammatical)**
50 ms silence	50 ms silence	50 ms silence	50 ms silence	50 ms silence	50 ms silence
la cagère rising	*le cagère* rising	*le ravol* rising	*la ravol* rising	*la cagère* falling	*le cagère* falling
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le ravol falling	*la ravol* falling	*la cagère* flat	*le cagère* flat	*le ravol* flat	*la ravol* flat
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le ravol rising	*la ravol* rising	*la cagère* rising	*le cagère* rising	*la cagère* rising	*le cagère* rising
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la cagère flat	*le cagère* flat	*le ravol* falling	*la ravol* falling	*le ravol* falling	*la ravol* falling
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la cagère falling	*le cagère* falling	*la cagère* falling	*le cagère* falling	*le ravol* rising	*la ravol* rising
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le ravol flat	*la ravol* flat	*le ravol* flat	*la ravol* flat	*la cagère* flat	*le cagère* flat
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
la cagère rising	*le cagère* rising	*la cagère* rising	*le cagère* rising	*la cagère* rising	*le cagère* rising
700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence	700 ms silence
le ravol falling	*la ravol* falling	*le ravol* falling	*la ravol* falling	*le ravol* falling	*la ravol* falling

As for Experiments 1 to 3, six sound files (three grammatical and three ungrammatical) of 15.2 secs duration were created for the test stimuli (see Table 1.4). Each file consisted of two noun phrases, each presented four times within the file, with an inter-stimulus interval of 700 milliseconds. The two noun phrases were presented in a quasi-random way, with the restriction that the same noun phrase would not occur more inconsistent in gender with the familiarization (e.g., le cagère, la ravol). Unlike Experiments 1 to 3, in which the nouns for the grammatical trials were different from those for the ungrammatical trials, in the present experiment, both test trial types consisted of the same two nouns.

As for Experiments 1 to 3, six sound files (three grammatical and three ungrammatical) of 15.2 secs duration were created for the test stimuli (see Table 1.4). Each file consisted of two noun phrases, each presented four times within the file, with an inter-stimulus interval of 700 milliseconds. The two noun phrases were presented in a quasi-random way, with the restriction that the same noun phrase would not occur more than twice consecutively. The pseudo-nouns and intonation of the noun phrases (e.g. *le cagère* – flat intonation) in the grammatical trials were ordered in the same way as those in the corresponding ungrammatical sound file (*la cagère* – flat intonation). In total, the test phase consisted of 10 trials (four sound files out of the six were presented twice), with a maximal length of 15.2 seconds for each trial. Grammatical and ungrammatical trials were presented in alternation. The type of the first trial (grammatical versus ungrammatical) was counterbalanced across participants. The grammaticality of the noun phrases was also counterbalanced across participants (see Table 1.5).

The procedure was identical to that of Experiments 1 to 3.

Table 1.5 Familiarization conditions and Test conditions across different groups of infants for Experiments 4 and 5. Table 1.5a and Table 1.5b represent different familiarization stimuli presented to two different groups of infants. Table 1.5a and Table 1.5b show the same test stimuli. The difference is that grammaticality of test material is reversed (i.e., the grammatical trials in Table 1.5a are ungrammatical in Table 1.5b, and the ungrammatical trials in Table 1.5a are grammatical in Table 1.5b), because of the familiarization difference. There were four sub-groups of infants for the four different test conditions, representing the counterbalancing of the first trial order (grammatical versus ungrammatical), in addition to the grammaticality counterbalancing.

Table 1.5a

Familiarization	*un ravol, une cagère*	
Test	**Sub-group 1**	**Sub-group 2**
Trial :	*le ravol, la cagère*	*la ravol, le cagère*
Trial :	*la ravol, le cagère*	*le ravol, la cagère*

Table 1.5b

Familiarization	*une ravol, un cagère*	
Test	**Sub-group 1**	**Sub-group 2**
Trial :	*le ravol, la cagère*	*la ravol, le cagère*
Trial :	*la ravol, le cagère*	*le ravol, la cagère*

1.6.2 Results and Discussion

We conducted the same analyses than in the previous experiments. Preliminary analyses were first performed to examine the effects of test trial order and sexe. We conducted a 2 X 2 X 2 mixed design ANOVA, with Grammaticality of the test trials as a within-subject factor and First test trials order (grammatical versus ungrammatical) and Sexe (male versus female) as between-subject factors. No interaction was found between Grammaticality and First test trial order, $F(1, 12) = 3.721$, $p = .078$, $\eta^2 = .237$, between Grammaticality and Sexe, $F(1, 12) = 0.364$, $p = .557$, $\eta^2 = .029$, nor between Grammaticality, First test trial order and Sexe, $F(1, 12) = 1.658$, $p = .222$, $\eta^2 = .121$. Since no effect of trial order and sexe was revealed, those factors were not included in

the subsequent analyse. A paired t-test revealed a significant difference between infants' looking time to the grammatical trials ($M = 8.28$ sec; $SE = 0.93$ sec) versus to the ungrammatical trials ($M = 7.30$ sec; $SE = 0.84$sec), $t(15) = 2.287$, $p = .037$, $\eta^2 = .259$, 2-tailed (see Figure 1.4).

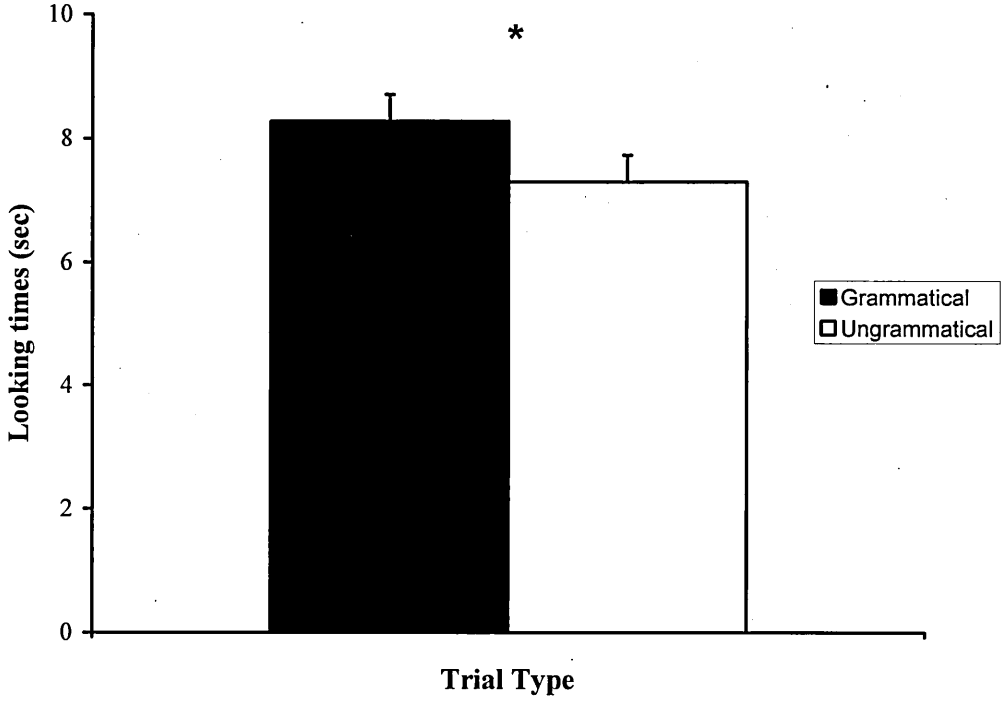

Figure 1.4 20-month-old infants' looking (listening) times (means and standard errors) to the two test trial types, grammatical versus ungrammatical, in the simpler learning task.

Again, the same analyses were conducted with the first test trial of each type removed. There was no effect of the first test trial order, $F(1, 12) = 0.984$, $p = .341$, $\eta^2 = .076$, of sexe, $F(1, 12) = 1.220$, $p = .291$, $\eta^2 = .092$, or of a combination of both factors, $F(1, 12) = 2.769$, $p = .122$, $\eta^2 = .187$. A paired t-test without those factors revealed that the difference in looking time between the grammatical and ungrammatical trials was significant (Grammatical: $M = 33.16$ sec; $SE = 4.06$ sec; Ungrammatical: $M = 26.54$ sec; $SE = 3.50$ sec), $t(15) = 2.913$, $p = .011$, $\eta^2 = .361$, 2-tailed.

Unlike the 20-month-olds tested in the Experiment 2, the 20-month-olds tested with this simplified design showed emerging knowledge of distributionally based gender categorization. The simplification made to the task in Experiment 4 allowed us to reveal younger infants' ability to categorize grammatical gender. The goal of the next Experiment is to examine whether this ability emerges in younger infant. Specifically, we asked whether 14-month-olds would reveal evidence of distributionally based categorization as the 20-month-olds in Experiment 4.

1.7 Experiment 5

1.7.1 Method

Participants, stimuli, design and procedure

Participants were sixteen 14-month-old (8 males and 8 females; Mean age = 439.25 days; SD = 8.64; range: 427-456) monolingual Quebec-French-learning infants. Additional 5 infants were tested but were not included in the analyses because of fussiness (2), experimental error (1) and ceiling effect (2). The stimuli, design and procedure were identical to those of Experiment 4.

1.7.2 Results and Discussion

As for the previous experiments, preliminary analyses were done to examine the effects of test trial order and sexe. A 2 X 2 X 2 mixed design ANOVA was conducted, with Grammaticality of the test trials as a within-subject factor and First test trials order (grammatical versus ungrammatical) and Sexe (male versus female) as between-subject factors. There was no interaction between Grammaticality and First test trial order, $F(1, 12) = 2.094$, $p = .173$, $\eta^2 = .149$, between Grammaticality and Sexe, $F(1, 12) = 0.014$, $p = .909$, $\eta^2 = .001$, nor between Grammaticality, First test trial order and Sexe, $F(1, 12) = 2.926$, $p = .113$, $\eta^2 = .196$, indicating that there was no effect of test trial order, sexe or a combination of those factors. Further analyses were therefore conducted excluding those factors. A paired t-test was then conducted of infant's looking times. With all test trials included in the analysis, no significant difference in looking time between grammatical

(M = 7.22 sec; SE = 0.77 sec) and ungrammatical (M = 7.81 sec; SE = 0.77 sec), $t(15)$ = 1.197, p = .250, η^2 = .087, 2-tailed (see Figure 1.5), was observed.

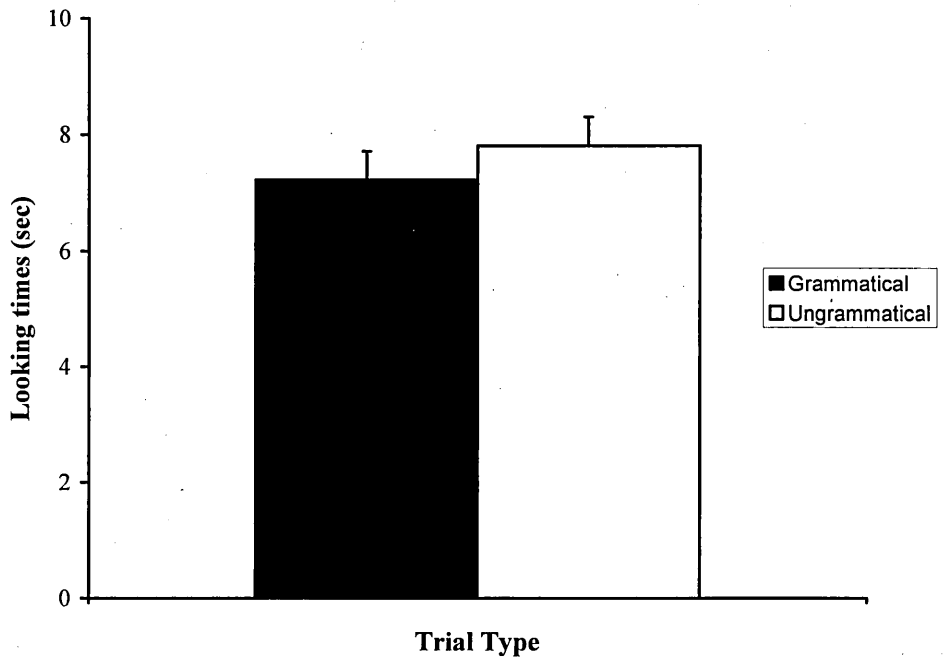

Figure 1.5 14-month-old infants' looking (listening) times (means and standard errors) to the two test trial types, grammatical versus ungrammatical, in the simpler learning task.

Similarly, the analysis with the first test trial of each type removed showed no significant effect of test trial order, $F(1, 12) = 0.380$, p = .549, η^2 = .031, of sexe, $F(1, 12) = 0.010$, p = .920, η^2 = .001, or of a combination of those factors, $F(1, 12) = 1.212$, p = .293, η^2 = .092. A paired t-test revealed no significant difference between infant's looking time to grammatical (M = 6.61 sec; SE = 3.58 sec) versus ungrammatical (M = 7.39 sec; SE = 3.20 sec), $t(15)$ = 1.586, p = .177, η^2 = .118, 2-tailed.

Unlike the 20-month-olds in Experiment 4, these 14-month-olds infants failed to show evidence of categorization despite the simplified learning task and the longer familiarization. These results suggest that the ability to categorize gender based solely on distributional grounds emerges around 20 months of age or slightly before.

1.8 General discussion

The goal of the present study was to determine when children begin to perform gender categorization based solely on the distribution of the determiners with the nouns. Previous studies have shown verb categorization in 12-month-olds (Mintz, 2006), noun categorization in 14- to 16-month-olds (Höhle, et al., 2004; Shi & Melançon, 2010), gender categorization in 17-month-olds (Gerken et al., 2005), and form-classes in an artificial language in 12-month-olds (Gomez & Lakusta, 2004). In these studies, the stimuli were manipulated in a way that no semantic cues were available for categorization. The remaining information was distributional, and phonological or acoustical. In that sense, the results in these studies may reflect the Level 1 learning in Braine's term (1987), as discussed earlier.

In the present study, the stimuli were carefully manipulated in order to remove all possible semantic, phonological and prosodic cues, so that the only remaining cues for categorization were distributional. The possible semantic cues were controlled by using pseudo-words instead of real words. The possible phonologic information was also controlled by selecting gender neutral pseudo-nouns from a list used in our pre-study with adults. Finally, any prosodic cues were removed by using cross-spliced gender neutral productions of the pseudo-nouns. Therefore, the only information for gender categorization in the stimuli was the distribution of the determiners with the pseudo-nouns. In that sense, children who succeeded in the present task must rely exclusively on distributional information.

The results of Experiments 1 to 3 showed that 14-month-olds, 17-month-olds failed to show evidence of gender categorization. On the other hand, 20-month-olds showed evidence of using distributional cues alone to successfully categorized novel nouns into genders, at least when the learning task was relatively simple. Infants aged 30 months showed robust categorization ability even in the complex learning task. However, 14-month-old infants in Experiment 5 still failed to show any evidence of gender categorization, neither in the complex nor in the simplified learning task. These

results suggest that the ability to use distributional information alone to categorize novel nouns into genders emerges close to 20 months of age. That is, younger infants may require the correlation of multiple cues (Level 1 learning) to categorize nouns into gender classes. It remains possible that children's ability to use distributional cues alone for categorizing gender is underestimated in our experiments, even in the simpler learning task. Hence, a further simpler type of training (e.g., one category to learn during the training phase, as in Höhle et al, 2004 and Shi & Melançon, 2010), may show that such ability emerges earlier in infancy.

It is noteworthy that the 30-month-olds in Experiment 3 showed a robust novelty preference (i.e., preference for the ungrammatical over the grammatical trials), while the 20-month-olds from Experiment 4 showed a familiarity preference (i.e., preference for the grammatical over the ungrammatical trials). In the literature, novelty preference has often been associated with a longer exposure time to the stimuli and with older infants, and conversely, familiarity preference has been associated with younger infants and relatively complex stimuli (e.g., Hunter & Ames, 1988; Thiessen & Saffran, 2003). One interpretation is that novelty preference indicates better encoding or better knowledge of the material presented than familiarity preference (Hunter & Ames, 1988). In line with this interpretation, the difference of preference between the two groups of infants is even more striking given the fact that the 20-months-olds were presented with simpler stimuli (two pseudo-nouns instead of four) and a longer familiarization. Even with this simpler design, the 20-month-olds showed a familiarity preference, and thus seem to be more challenged by the gender categorization task than the 30-month-olds. Hence, the familiarity preference shown by the 20-month-olds suggests an emerging knowledge of distributionally based categorization, while the novelty preference shown by the 30-month-olds indicates a more robust knowledge.

Our results are compatible with the literature on online processing of nouns involving gender cues. As mentioned earlier, for several languages, there is evidence that children begin to use gender information in noun comprehension starting from about two years of age (Johnson, 2005; Van Heugten and Shi, 2009). However, in those

studies, the possibility remained that the children simply learned to associate specific determiners with specific familiar nouns, without having generalized the abstract knowledge of noun gender classes. For example, a child may learn to use *le* and *un* (masculine determiners) with *ballon* (a masculine familiar noun) because they heard their specific co-occurrences, without knowing that *le* and *un* belong to the same category (masculine determiners) and apply to all masculine nouns. The positive results obtained in the present study suggest that the infants possess abstract representation of grammatical gender classes for nouns and determiners at an early age. Indeed, the 30-month-olds of Experiment 3 and the 20-month-olds of Experiment 4 were able to generalize this appropriate usage of determiners to novel nouns.

The stimuli used in the present study were carefully controlled so that only distributional cues were available for gender categorization. Therefore, our task required a more abstract level of knowledge, i.e., Level 2 knowledge in Braine's term. Other studies, such as Gerken et al. (2005)'s and Gomez and Lakusta (2004)'s studies, specifically manipulated the stimuli so that a correlation of two cues were available for categorization. Those studies reflected an earlier ability (i.e., Level 1 knowledge). The findings of our study and the recent categorization studies suggest that category formation appears to first require the association of phonological/acoustical cues with distributional cues, and that at a later stage, children could rely solely on distributional information. Although our present study did not examine whether younger infants could successfully categorize novel nouns into gender categories using phonological and/or acoustical support, we suggest that this possibility is plausible.

For example, phonological and prosodic cues have been found to correlate with grammatical categories. Cues of this nature can be use to distinguish between lexical (e.g. nouns, verbs and adjectives) and functional (e.g. determiners and pronouns) items (e.g. Cutler, 1993; Shi et al., 1998), and there is evidence that newborn infants can discriminate between these two broad categories using phonological and acoustical cues (Shi et al., 1999). Phonological and prosodic cues also support distinctions between more refined categories, such as nouns and verbs (e.g. Cassidy & Kelly, 1991; Kelly,

1992; Shi & Moisan, 2008; Soreno and Jongman, 1990). Monaghan, Christiansen and Chater (2007) analysed corpus of four languages (English, French, Dutch and Japanese) and found that both distributional and phonological cues could be used in a complementary way to distinguish between lexical and functional items, as well as between nouns and verbs. Moreover, Shi et al. (1998) conducted simulations using natural language, and demonstrated that both phonological and prosodic cues could be use efficiently to derive lexical and functional categories. Shi and Moisan (2008) showed that infant-directed speech in French contains prosodic cues that distinguish noun and verb productions. In light of these studies, future experiments should test whether infants much younger than 20 months can categorize novel nouns into gender when the familiarization input contain phonological or acoustic cues associated with distributional patterns.

In conclusion, using a careful control of all possible phonological and prosodic cues in the stimuli, we examined infants' ability to categorize nouns into gender classes on the sole basis of the distribution of determiners with the nouns. We showed that by 20 months of age, infants begin to show such ability and that by 30 months of age, this ability is robust. This study is first to demonstrate this abstract grammatical knowledge.

Acknowledgment

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CONCLUSION

La présente recherche avait pour objectif d'évaluer à quel moment émerge la capacité à catégoriser de nouveaux mots avec comme seul indice la distribution des déterminants avec les noms. Des études précédentes ont montré des évidences de catégorisation de verbes chez des enfants de 12 mois (Mintz, 2006), de noms chez des enfants de 14 à 16 mois (Höhle, et al., 2004; Shi & Melançon, 2010), de genre chez les 17 mois (Gerken et al., 2005) et de formation de catégories en langage artificiel chez les 12 mois (Gomez & Lakusta, 2004). Dans ces études, les stimuli étaient manipulés de façon à ce qu'aucun indice sémantique n'ait été accessible pour la catégorisation. Le reste des informations disponibles pour la catégorisation étaient distributionnels et phonologiques ou prosodiques. La présente recherche est la première à étudier la catégorisation basée uniquement sur des indices distributionnels.

Pour ce faire, nous avons méticuleusement manipulé les stimuli afin d'exclure tout indice possible d'ordre sémantique, phonologique ou prosodique, de sorte que seuls les indices distributionnels soient disponibles pour la catégorisation. Les indices sémantiques on été contrôlés par l'utilisation de pseudo-mots au lieu de vrais mots. Les indices phonologiques potentiels ont aussi été contrôlés en sélectionnant des pseudo-noms neutres en genre. Finalement, les indices prosodiques possibles ont été éliminés en utilisant une technique d'épissage croisé (*cross-splicing*).

Dans la présente recherche, nous avons utilisé un paradigme de préférence du regard, dans lequel les enfants étaient familiarisés avec des déterminants indéfinis (masculins et féminins) et des pseudo-noms, et étaient ensuite testés sur les mêmes pseudo-noms, cette fois précédés de déterminants définis (masculins et féminins). Les résultats ainsi obtenus suggèrent que les enfants âgés de 20 mois commencent à montrer une habileté émergente à catégoriser de nouveaux noms purement sur la base d'indices distributionnels. De plus, à 30 mois, cette habileté semble très robuste. Ces résultats sont compatibles avec la littérature sur le traitement en temps réel de noms impliquant des indices de genre (Johnson, 2005; Van Heugten and Shi, 2009).

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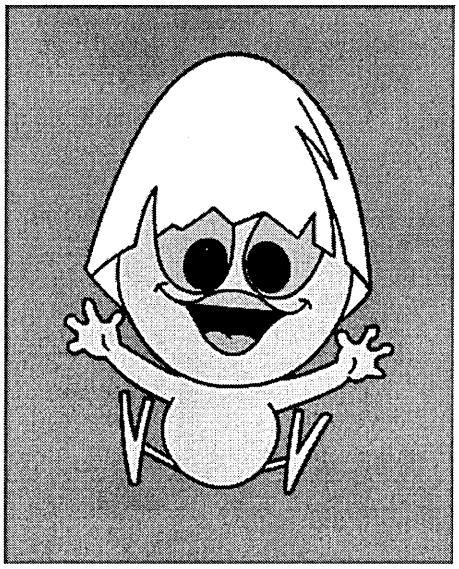
APPENDICE A : SUPPORTS VISUELS UTILISÉS DANS LES EXPÉRIENCES

Marionnette parlante:

Capteur d'attention:



APPENDICE B : VALEURS ACOUTIQUES DES STIMULI UTILISÉS

Appendice B.1. Valeurs acoustiques des déterminants pairés avec *Mouveil*

Determinants	Durée du mot (sec)	Hauteur moyenne (Hz)	Hauteur min (Hz)	Hauteur max (Hz)	Amplitude moyenne (dB)	Amlitude min (dB)	Amplitude max (dB)
Un 1	0.191	206.261	195.492	217.234	60.375	57.584	61.675
Un 2	0.168	368.304	286.437	404.240	73.380	68.254	75.563
Un 3	0.268	380.127	304.258	418.689	68.563	63.949	71.577
Une 1	0.244	213.369	202.111	226.321	62.755	59.182	64.714
Une 2	0.204	355.511	284.061	391.794	72.046	65.000	74.935
Une 3	0.273	375.479	279.800	419.035	70.413	63.111	74.054
Le 1	0.238	197.766	179.234	227.991	58.882	49.887	62.197
Le 2	0.199	342.852	249.070	406.986	73.413	57.519	75.923
Le 3	0.331	328.018	225.566	402.108	70.108	59.667	72.358
La 1	0.206	198.829	177.941	221.905	58.137	53.324	60.237
La 2	0.203	331.527	247.993	381.886	73.585	60.436	76.791
La 3	0.305	326.686	226.697	403.374	70.383	61.027	72.877

Appendice B.2. Valeurs acoustiques des déterminants pairés avec *Gombal*

Determinants	Durée du mot (sec)	Hauteur moyenne (Hz)	Hauteur min (Hz)	Hauteur max (Hz)	Amplitude moyenne (dB)	Amlitude min (dB)	Amplitude max (dB)
Un 1	0.158	196.370	184.632	210.103	65.288	61.598	67.744
Un 2	0.171	348.182	230.247	407.716	69.432	64.112	72.249
Un 3	0.221	370.577	315.142	399.479	69.941	62.70	72.174
Une 1	0.232	220.335	202.093	242.445	71.806	67.520	74.656
Une 2	0.286	343.944	216.209	409.114	68.665	60.340	71.796
Une 3	0.233	424.617	310.902	465.019	70.220	62.341	73.553
Le 1	0.278	207.046	174.485	235.884	69.582	58.325	73.186
Le 2	0.238	302.148	219.922	371.003	71.773	62.168	75.111
Le 3	0.240	362.991	259.114	443.886	72.526	64.848	74.146
La 1	0.295	202.763	172.317	235.880	65.235	56.375	68.187
La 2	0.231	315.439	235.547	390.591	71.975	64.883	75.380
La 3	0.263	351.813	255.507	467.487	68.442	57.349	71.057

Appendice B.3. Valeurs acoustiques des déterminants pairés avec *Cagère*

Determinants	Durée du mot (sec)	Hauteur moyenne (Hz)	Hauteur min (Hz)	Hauteur max (Hz)	Amplitude moyenne (dB)	Amlitude min (dB)	Amplitude max (dB)
Un 1	0.174	200.135	181.776	215.812	66.930	57.885	69.285
Un 2	0.188	423.115	296.459	523.691	71.065	63.148	74.281
Un 3	0.194	385.545	265.432	477.986	70.974	57.254	73.769
Une 1	0.208	222.491	206.839	238.788	72.869	66.604	75.020
Une 2	0.200	435.446	344.465	489.099	74.408	52.985	78.462
Une 3	0.232	392.974	293.427	442.500	70.360	50.990	74.222
Le 1	0.197	201.148	184.091	221.701	66.241	55.363	68.120
Le 2	0.162	319.606	233.642	408.646	74.438	65.008	77.256
Le 3	0.237	309.439	215.784	444.115	72.339	62.631	75.278
La 1	0.267	204.671	178.843	235.046	65.423	52.130	69.292
La 2	0.178	339.583	339.583	449.945	72.623	63.547	75.078
La 3	0.234	335.159	220.712	474.620	71.707	58.325	75.609

Appendice B.4. Valeurs acoustiques des déterminants pairés avec *Ravol*

Determinants	Durée du mot (sec)	Hauteur moyenne (Hz)	Hauteur min (Hz)	Hauteur max (Hz)	Amplitude moyenne (dB)	Amlitude min (dB)	Amplitude max (dB)
Un 1	0.191	201.438	192.436	216.020	68.315	63.235	70.261
Un 2	0.244	361.048	244.315	438.568	71.908	65.191	74.952
Un 3	0.260	364.208	277.747	405.182	71.573	67.859	72.984
Une 1	0.215	220.852	209.382	239.734	71.155	66.570	73.231
Une 2	0.206	424.196	304.439	497.540	72.263	68.233	74.260
Une 3	0.262	375.769	312.077	413.412	75.347	63.493	78.719
Le 1	0.279	205.901	201.504	226.747	71.533	65.766	73.428
Le 2	0.220	338.296	236.144	422.381	74.944	64.658	77.611
Le 3	0.295	329.761	227.694	404.782	74.626	67.145	76.459
La 1	0.331	206.997	199.517	221.518	68.318	59.391	71.364
La 2	0.307	340.757	225.553	435.727	71.674	60.629	74.948
La 3	0.295	329.955	227.082	405.968	70.930	61.175	73.581

Appendice B.4. Valeurs acoustiques des pseudo-noms

Pseudo-nom	Durée du mot (sec)	Durée Syllabe1 (sec)	Durée Syllabe2 (sec)	Hauteur moyenne voyelle1 (Hz)	Hauteur min voyelle1 (Hz)	Hauteur max voyelle1 (Hz)	Amplitude moyenne voyelle1 (dB)	Hauteur moyenne voyelle2 (Hz)	Hauteur min voyelle2 (Hz)	Hauteur max voyelle2 (Hz)	Amplitude moyenne voyelle2 (dB)
Mouveil 1	0.755	0.139	0.616	417.931	351.508	464.485	72.879	194.208	163.091	270.113	66.368
Mouveil 2	0.934	0.921	0.814	234.829	217.693	241.244	69.974	314.704	220.089	403.277	69.648
Mouveil 3	0.770	0.208	0.793	394.261	356.855	410.181	64.974	313.613	307.968	324.706	69.305
Mouveil 4	0.758	0.150	0.608	455.533	385.056	502.403	64.263	187.091	169.805	273.778	65.779
Mouveil 5	0.959	0.191	0.768	231.358	208.933	239.449	68.622	315.611	216.312	425.037	70.050
Mouveil 6	0.814	0.272	0.542	407.880	314.791	439.356	67.809	321.393	315.686	338.500	70.433
Gombal 1	0.847	0.316	0.530	453.452	395.334	503.081	68.819	205.195	180.814	333.476	64.797
Gombal 2	1.001	0.309	0.693	220.909	197.925	232.395	71.333	257.508	193.330	379.540	68.910
Gombal 3	0.814	0.325	0.489	398.275	353.046	427.763	67.679	307.856	290.065	323.125	68.594
Gombal 4	0.834	0.304	0.530	455.507	371.006	516.168	69.482	200.872	185.388	275.001	66.461
Gombal 5	0.974	0.282	0.692	202.189	185.069	212.386	66.781	296.187	203.130	391.177	67.994
Gombal 6	0.831	0.325	0.507	386.792	322.311	422.336	67.830	316.879	306.965	321.654	68.257
Cagère 1	0.842	0.197	0.645	475.867	444.074	494.703	70.704	217.703	180.408	382.304	65.549
Cagère 2	1.056	0.196	0.859	225.332	197.639	271.049	64.814	300.584	184.256	444.034	66.711
Cagère 3	0.951	0.218	0.733	407.970	382.277	413.300	70.341	320.642	314.981	328.519	71.099
Cagère 4	0.839	0.187	0.653	470.552	433.570	504.458	71.253	221.115	178.371	375.199	64.953
Cagère 5	1.122	0.221	0.901	230.808	195.776	278.158	65.539	311.874	187.683	442.888	67.118
Cagère 6	0.959	0.204	0.756	408.923	396.750	413.468	71.091	233.975	140.152	344.125	69.048
Ravol 1	0.822	0.239	0.584	446.594	358.446	498.813	69.142	205.848	187.778	247.199	66.248
Ravol 2	0.940	0.184	0.756	229.146	194.187	258.568	65.908	346.132	217.246	445.244	68.724
Ravol 3	0.994	0.252	0.741	399.268	382.077	407.496	70.434	321.432	296.408	335.621	69.593
Ravol 4	0.806	0.231	0.575	446.906	391.470	487.735	70.908	208.012	192.618	238.728	66.755
Ravol 5	0.950	0.160	0.790	218.361	183.441	242.890	65.264	368.133	215.866	461.269	70.686
Ravol 6	0.860	0.250	0.610	371.048	338.373	387.998	72.108	319.377	313.553	323.206	73.941

Appendice B.5. Valeurs acoustiques moyennes des déterminants

Determinants	Durée du mot (sec)	Hauteur moyenne (Hz)	Hauteur min (Hz)	Hauteur max (Hz)	Amplitude moyenne (dB)	Amlitude min (dB)	Amplitude max (dB)
Un	0,202	317,109	247,864	361,227	68,979	62,731	71,376
Une	0,233	333,749	263,817	372,900	71,026	62,197	73,969
Le	0,243	287,081	217,188	351,353	70,867	61,082	73,423
La	0,260	290,348	225,608	360,329	69,036	59,049	72,033

Appendice B.6. Valeurs acoustiques moyennes des pseudo-noms

Pseudo-word	Durée du mot (sec)	Durée syllabe1 (sec)	Durée syllabe2 (sec)	Hauteur moyenne voyelle1 (Hz)	Hauteur min voyelle1 (Hz)	Hauteur max voyelle1 (Hz)	Amplitude moyenne voyelle1 (dB)	Hauteur moyenne voyelle2 (Hz)	Hauteur min voyelle2 (Hz)	Hauteur max voyelle2 (Hz)	Amplitude moyenne voyelle2 (dB)
Mouveil	0,832	0,314	0,690	356,965	305,806	382,853	68,087	274,437	232,158	339,235	68,597
Gombal	0,884	0,310	0,573	352,854	304,115	385,688	68,654	264,083	226,615	337,329	67,502
Cagère	0,962	0,204	0,758	369,909	341,681	395,856	68,957	267,649	197,642	386,178	67,413
Ravol	0,895	0,219	0,676	351,887	307,999	380,583	68,961	294,822	237,245	341,878	69,325