BUCLD 37 Proceedings
To be published in 2013 by Cascadilla Press
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Grammatical Knowledge and its Immediate Processing during Online Comprehension by Infants

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1. Introduction

There is increasing evidence that infants begin to acquire syntax from an early age. They start to recognize function words in their language, which are important for the grammar, during the first year of life (Hallé, Durand, & de Boysson-Bardies, 2008; Höhle & Weissenborn, 2003; Shafer, Shucard, Shucard, & Gerken, 1998; Shi & Lepage, 2008; Shi, Werker, & Cutler, 2006; Shi, Cutler, Werker, & Cruickshank, 2006). Shortly after their first birthday they classify function words into categories (Cyr & Shi, in press; Shi & Melançon, 2010) and use them to categorize content words (Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Mintz, 2006; Shi & Melançon). They are also able to perform grammatical categorization after brief training with artificial or unknown languages, using the distributional relation between function-word-like elements and content-word-like elements (Gerken, Wilson, & Lewis, 2005; Gomez & LaKusta, 2004). Moreover, infants perceive non-adjacent grammatical dependencies of function words (Höhle, Schmitz, Santelmann, & Weissenborn, 2006; Santelmann & Jusczyk, 1998; van Heugten & Shi, 2010).

Grammatical knowledge in infants has also been investigated in comprehension tasks involving the identification of reference. In a well-known study Gerken and McIntosh (1993) asked two-year-olds to identify target images by pointing. They created four types of sentences by manipulating the context preceding the noun (e.g., Correct function word (FW) – *Find the ball*, Incorrect FW – **Find was ball*, No FW – *Find _ ball*, Nonsense FW – *Find gub ball*). Infants performed significantly better in the Correct FW condition, suggesting that they understood the grammatical relations between function words and content words, and that they used this knowledge during word identification. Kedar and colleagues (2006) tested this knowledge using the Intermodal Preferential Looking Paradigm procedure. They presented pairs of objects along with an auditory instruction naming one of them. As in Gerken and McIntosh, auditory stimuli included Correct FW, Incorrect FW, No FW and Nonsense FW.

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The Incorrect FW was the conjunction 'and' (e.g., **Can you see and ball?*). They showed that 18-month-old age infants identified the named objects better and faster when hearing a function word in the Correct FW condition. These studies measured infants' offline responses, that is, after auditory stimuli were presented. One interesting question is whether infants process grammatical representations online while speech is unfolding.

Several studies examined infants' use of grammatical information during online comprehension. Zangl and Fernald (2007) presented comparable stimuli as in Gerken and McIntosh (1993) (i.e., Correct FW, No FW, Nonsense FW – *Look at loo shoe*) while displaying pairs of images on a monitor. They assessed infants' efficiency in recognizing the named target by measuring their looking time to the target object during the 367–1800 ms window from the onset of the target noun. They showed that 18- and 24-month-olds' online comprehension was disrupted in Nonsense FW trials. Infants looked more at the target object in the Correct FW condition. Using a similar task, Van Heugten and Johnson (2011) tested 19-24-month-old Dutch-learning toddlers. Dutch, unlike English, has multiple forms of determiners, reducing the co-occurrence frequency between each determiner and nouns. Looking responses during a time window of 2000 ms from the target noun onset were analyzed. Their results showed online processing of function words, in line with those of Zangl and Fernald. A recent study using ERP also showed online processing of the grammatical relationship between a function word and the following content word (Bernal, Dehaene-Lambertz, Millotte, & Christophe, 2010). French-learning 24-month-olds were presented with utterances such as *elle veut manger la fraise* – 'she wants to eat the raspberry' versus *elle la regarde* – 'she looks at it'. The word *la* was a determiner in the former sentence and preceded a following noun, whereas the homophonous *la* in the latter was an object pronoun followed by the main verb. Infants displayed distinct brain responses around 400 ms after the onset of the content word following *la*, indicating that syntactic structures were computed online while words are being heard.

More refined grammatical representations have also been examined in online comprehension studies. Grammatical genders, which are present in many natural languages, involve structural agreement across multiple categories. Grammatical categories (e.g., determiners, nouns and adjectives) may be subdivided into masculine and feminine classes. Within a certain linguistic scope all elements agree in gender (e.g., in French la_{FEM} $belle_{\mathrm{FEM}}$ $maison_{\mathrm{FEM}}$ – the nice house), and violations of such agreement are ungrammatical (e.g., *le_{MASC} $beau_{\mathrm{MASC}}$ $maison_{\mathrm{FEM}}$). A few studies tested this knowledge in online tasks. Lew-Williams and Fernald (2007) presented Spanish-learning 34-42-month-olds pairs of objects of either the same gender or different genders while one of them was named. In the same-gender condition, the determiner was compatible in gender with both objects, whereas in the different-gender condition, the determiner agreed in gender with only one of the two objects. Children's looking behaviour was analyzed for a time window starting 300 ms

from the determiner onset. Children were faster in looking at the target object in the different-gender condition than in the same-gender condition.

Dutch is a language that marks common gender (CG) and neutral gender (NG). Johnson (2005) presented 28-month-old Dutch-learning toddlers trials displaying objects of the same gender (e.g., *bal*$_{CG}$ – ball / *boom*$_{CG}$ – tree) or different genders (e.g., *bal*$_{CG}$ – ball / *boek*$_{NG}$ – book) with an utterance naming one of the objects (i.e, *kijk eens naar de*$_{CG}$ *bal*$_{CG}$ – 'look at the ball'). A third condition presented objects of different genders, but the auditory instruction was gender-incorrect (e.g., **kijk eens naar het*$_{NG}$ *bal*$_{CG}$). Mean response latencies were analyzed within a 240 – 2000 ms window after the determiner onset. Toddlers were faster to shift from distractor to target during the different-gender condition for trials involving common gender nouns. They tended to shift away from target to distractor during the incorrect-gender condition for trials of common gender nouns. Thus, infants showed some level of sensitivity to the gender agreement between determiners and nouns.

Online processing of gender agreement was shown in younger children by Van Heugten and Shi (2009), who presented French-learning 25-month-olds pairs of objects of the same gender (e.g., *banane*$_{FEM}$ – banana / *balançoire*$_{FEM}$ – swing) or different genders (e.g., *banane*$_{FEM}$–banana / *bateau*$_{MASC}$ – boat) while one in a pair was named. For the different-gender object pairs, the determiner was either in gender-correct (i.e., *regarde la*$_{FEM}$ *banane*$_{FEM}$ – 'look at the banana') or gender-incorrect (i.e., **regarde le*$_{MASC}$ *banane*$_{FEM}$) agreement with the noun. Online target recognition was better for different-gender trials with correct agreement. Recognition in same-gender trials, in which the determiner agreed with both objects, was delayed. Different-gender trials with incorrect agreement between the determiner and the noun showed the worst performance. This effect of determiner gender was replicated in another online comprehension study with French-learning infants (Melançon & Shi, 2011).

The existing studies indicate that infants begin to process grammatical structures early in acquisition, and that they access grammatical representations rapidly during online comprehension of utterance meanings. They integrate the grammatical relations between function words and content words while speech is ongoing. It remains unclear, however, if upon hearing a determiner alone infants use its grammatical information to pre-select the upcoming noun that has not yet being heard. Indeed, in all the online studies to date, the window of analysis was large, covering the processing of both the determiner and the noun. Therefore, one might ask whether hearing the phonological form of a noun is mandatory for activating its grammatical representation. Mani and Plunkett (2010) showed that the phonological form for an object is automatically activated by its picture alone in 18-month-olds. In their picture recognition task, a prime picture of an object was first presented in silence (e.g., a bee), followed by a pair of objects (e.g., a ball and a truck). One of them, the target, was named. Their results showed that when the prime object was phonologically related to the target (e.g., *bee – ball*), recognition of the target was better than when the prime image was phonologically unrelated (e.g., *comb - ball*). Because the prime

object was never named during that experiment, these results suggest that seeing an object implicitly activated its phonological form in the lexicon, an ability also found in adults (Meyer & Damian, 2007). It is unknown whether an object picture alone also activates the grammatical features of the word.

The present study thus addresses two acquisition questions: 1) Are the grammatical features of a familiar object activated as soon as its image is seen? 2) Is the grammatical agreement between categories within a DP immediately processed and used to predict the upcoming noun referent before the noun is heard? We addressed these questions by testing infants' online comprehension involving gender-marked DPs, using precise windows of analysis.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Participants were 30-month-old Quebec-French-learning infants (mean age: 948 days, range: 915-968 days).

2.1.2. Auditory and visual stimuli

Speech stimuli for key trials included three nouns, all very familiar to two-year-old infants. Two of them were of the feminine gender: *girafe* – girafe, *grenouille* – frog. The other one was of masculine gender: *soulier* – shoe. Two gender-marked determiners (*la*$_{FEM}$ /*le*$_{MASC}$ – the) and a gender-marked adjective (*mignonne*$_{FEM}$/*mignon*$_{MASC}$ – lovely) were also used. These words were combined into three determiner phrases (DPs) for the key trials, i.e., Det+Adj+Noun, and the three categories were in grammatical gender agreement (i.e., *la*$_{FEM}$ mignonne$_{FEM}$ *girafe*$_{FEM}$, *la*$_{FEM}$ mignonne$_{FEM}$ *grenouille*$_{FEM}$, *le*$_{MASC}$ *mignon*$_{MASC}$ *soulier*$_{MASC}$). In addition, other nouns (e.g., *bébé* – baby) and determiners (definite and indefinite) as well as nonsense nouns served as the stimuli for more trials, which were designed for a larger study that is ongoing and was not analyzed for this article.

A native Quebec-French female speaker produced multiple tokens of the stimuli in a sound proof booth (sampling frequency 48 kHz, bit rate 24 bits). One carrier phrase was recorded (*Oh regarde!* – 'Oh look!').

To depict the nouns, we chose colourful pictures representing the words. The images were comparable in size and brightness. We also used pictures of other familiar objects as distractors in the key trials, and the nouns of these objects were either masculine or feminine (*chapeau*$_{MASC}$ – hat, *singe*$_{MASC}$ – monkey, *poule*$_{FEM}$ – hen).

An animation of a rising rainbow with a bird song was used as the attention getter between all trials. Another animation showing colourful balls along with a cheerful interjection (i.e., 'Wow!') was used as pre- and post-test trials. The pre-test trial served to familiarize the infant with the procedure. The post-test trial marked the end of the experiment.

2.1.3. Design

Each trials presented pictures of two different objects simultaneously at the far left and far right side of the screen, along with the DP naming one of the objects (i.e., the target). The other non-named object served as the distractor. At the beginning of the trial both images appeared on the screen in silence, allowing the child to view the objects for 2000 ms before any sound. The carrier phrase *Oh regarde*! – 'Oh look!' then started, followed by the DP. The pictures stayed until the end of the trial. The carrier *Oh regarde!* was the same token across all trials. The determiner onset occurred at exactly 3500 ms and the noun approximately at 4720 ms. Average duration was 404 ms for the tokens of determiners, 865 ms for the adjective tokens, and 1308 ms for the nouns. Figure 1 shows the timeline of a trial.

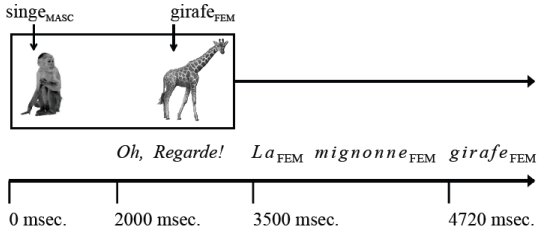

Fig. 1. Timeline of an Informative trial.

By varying the gender of the object pictures, we created two trial types for the key trials. In the Informative trial, the target object was feminine (i.e., *girafe*$_{FEM}$ – girafe) and the distractor object was masculine (i.e., *singe*$_{MASC}$ – monkey). Therefore, the determiner *la*$_{FEM}$ and the adjective *mignonne*$_{FEM}$ in the DP were informative of the upcoming target object. Uninformative trials presented two objects of the same gender. One trial showed a feminine target object (i.e., *grenouille*$_{FEM}$ – frog) paired with a feminine distractor object (i.e., *poule*$_{FEM}$ – hen), the other a masculine target object (i.e., *soulier*$_{MASC}$ – shoe) paired with a masculine distractor object (i.e., *chapeau*$_{MASC}$ – hat). The determiner and adjective agreed in gender with both the target and the distractor, therefore not informative of the target. The appendix presents the stimuli of the key trials.

2.1.4. Procedure and apparatus

Infants were individually tested in an acoustical chamber. The child sat on his or her parent's lap, facing a 42-inches television screen. Loudspeakers were positioned adjacent to each side of the screen, and auditory stimuli were presented from both loudspeakers simultaneously. A video camera recorded the infant. The parent listened to masking music from headphones. During the

experiment the camera sent simultaneous video signals of the infant to a monitor in the neighbouring room, where the experimenter, who was blind to all stimuli, observed the looking behaviour of the child. As soon as the child was settled and looked at the screen, the experimenter started the experiment. Every trial was initiated when the infant looked at the screen.

2.1.5. Coding eye movements

All infants were offline coded frame by frame at a rate of 30 frames/sec by a blind researcher. Each frame was coded as left look, right look or away (i.e., looking elsewhere).

2.1.6. Analyses and predictions

We analyzed the time window from the onset of the DP prior to the noun. If seeing the objects without hearing their forms activated their gender features, and if the determiner gender was immediately activated and computed against the gender(s) of the objects, infants then should pre-select the gender-agreeing object in the Informative trial, but not in the Uninformative trials. If, however, seeing the objects did not activate the gender of the corresponding nouns, there should be no target recognition before the target was named. Likewise, if hearing the determiner did not activate its gender immediately, there should also be no target recognition prior to the noun onset. We also analyzed subsequent time windows to reveal infants' incremental processing of gender agreement and its influence on the recognition of the noun referent.

2.2 Results and discussion

The first window of analysis, the Pre-Noun window, lasted one second, starting 300 ms from the determiner onset to the time point before the noun. The proportion of looking to target (PLT) was calculated as the total looking time to the target divided by the sum of the looking time to the target and that to the distractor. We compared the PLTs to chance level 0.50. Above-chance performance would indicate target recognition. For the Pre-Noun window, infants looked at the target picture significantly more than chance during the Informative trial (M = .66, SE = .06, $t(31)$ = 2.274, p = .030), but not in Uninformative trials (M = .49, SE = .07, $t(28)$ = -.112, p = .912), although the comparison between the two trial types did not reach significance (paired $t(28)$ = 1.463, p = .155). To examine what happened when infants heard the noun, we analyzed a one-second time window, the Noun Window, starting 300 ms after the noun onset. The comparison of PLTs with chance showed that during this time window target recognition was further strengthened in the Informative trial (M = .82, SE = .04, $t(31)$ = 7.705, p = .000). For Uninformative trials, the PLT was still not different from chance (M = .58, SE = .07, $t(29)$ = 1.095, p = .283). The two trial types were now significantly different from each other (paired

$t(29) = 3.145$, $p = .004$). Thus, target recognition was facilitated in the Informative trial but impeded in Uninformative trials. We expected that infants should eventually recognize the target in Uninformative trials late in processing. We thus examined a later time window, starting 600 ms after the noun onset, covering the final part of the noun and a post-noun period. During this Late window, PLTs for Informative versus Uninformative trials were still different (paired $t(28) = 2.766$, $p = .010$), suggesting a continuous advantage when the determiner gender was informative. For Uninformative trials, infants were now looking to the target significantly above chance ($M = .67$, $SE = .06$, $t(28) = 2.824$, $p = .009$). The preference towards the target in the Informative trial was maintained during the Late window, with the PLT still significantly above chance ($M = .84$, $SE = .04$, $t(31) = 7.582$, $p = .000$). All statistics were two-tailed.

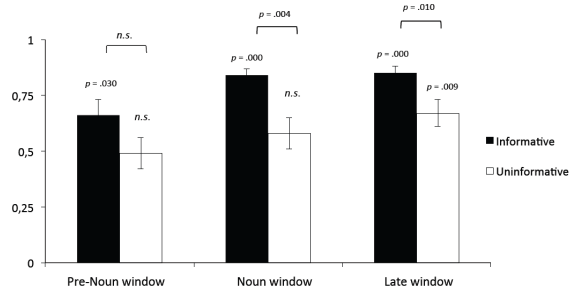

Fig. 2. Proportion of looking to target (and standard errors) in Informative and Uninformative trials in Experiment 1 for the three time windows.

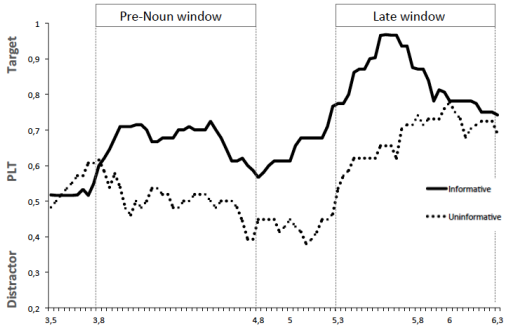

Fig. 3. Timecourse of trials in Experiment 1.

These results showed that infants process grammatical gender information online, consistent with previous studies. Moreover, they process gender agreement as soon as gender features are available. In particular, seeing an object activates its grammatical gender feature. Infants also activate the gender of a determiner while hearing its word form and immediately compute the gender agreement between the determiner and the nouns of the viewed objects. Thus, when gender agreement was informative in our experiment, infants

showed pre-noun recognition, and when gender agreement was uninformative (i.e., determiner agreeing with both objects), recognition was only achieved when much of the target noun form was heard.

As Experiment 1 showed that infants use grammatical information incrementally, we then asked what would happen if the determiner and the noun in a DP do not agree in gender. Since gender agreement violations are ungrammatical in gender-marked languages, we thus artificially prepared ungrammatical stimuli from grammatical recordings.

3. Experiment 2

3.1. Methods

3.1.1. Participants

Participants were another group of 30-month-old Quebec-French-learning infants (mean age: 942 days, range: 913-966 days).

3.1.2. Auditory and visual stimuli

The stimuli for the key trials included two nouns that are familiar to two-year-old infants, one feminine (*maison* – house), and the other masculine (*camion* – truck). The masculine determiner *le* ('the') was selected to be paired with the nouns. We used only the masculine form of the adjective (*mignon* – pretty) in Experiment 2. These words were combined to form two DPs, i.e., Det+Adj+Noun, one in grammatical agreement (le_{MASC} $mignon_{\text{MASC}}$ $camion_{\text{MASC}}$), another violating the agreement (*le_{MASC} $mignon_{\text{MASC}}$ $maison_{\text{FEM}}$). In addition, other nouns (e.g., *bébé* – baby) and determiners (definite and indefinite) as well as nonsense nouns served as the stimuli for more trials, which were designed for a larger study that is ongoing and was not analyzed for this article.

The same native Quebec-French female speaker produced multiple tokens of the stimuli. Recording equipment and procedure were the same as in Experiment 1. The same carrier phrase (*Oh regarde!* – 'Oh look!') from Experiment 1 was used. To avoid any disfluency in producing ungrammatical utterances, all stimuli, grammatical and ungrammatical, were prepared from grammatical DPs via a cross-splicing technique. For example, the noun *maison* was selected from the grammatical DP la_{FEM} $mignonne_{\text{FEM}}$ $maison_{\text{FEM}}$. The noun was spliced just after the release of the [m] and cross-spliced together with Det+Adj *le mignon* [m] recorded from the grammatical utterance le_{MASC} $mignon_{\text{MASC}}$ $mouton_{\text{MASC}}$. We note that in order to keep the stimuli conditions across experiments consistent, all the stimuli in Experiment 1 were also cross-spliced, even though there was no need for creating any ungrammatical utterances in that particular experiment.

Colourful pictures similar to the ones used in Experiment 1 were also used to depict the nouns in Experiment 2. The stimuli for the attention getter, the pre-test trial and the post-test trial were taken from Experiment 1.

3.1.3. Design

The trials were built in the same way as in Experiment 1. Each trial presented pictures of two objects side by side on the screen, along with a DP naming one of them. At the beginning of a trial, both images appeared on the screen in silence, and the carrier *Oh regarde*! started 2000 ms after the trial onset. Determiner onset occurred at 3500 ms, and the noun approximately at 4583 ms. Average duration was 340 ms for the determiner tokens, 733 ms for the adjective tokens, and 1232 ms for the nouns.

There were two types of trials for the key trials. The Informative type presented two objects of different genders. To counterbalance the gender of the target in Experiment 1, which was feminine, the target object in Experiment 2 was of masculine gender (i.e., *camion* – truck), and the distractor object was of feminine gender (i.e., *maison* – house). Therefore, as in Experiment 1, the determiner and the adjective in the DP were informative of the target object (i.e., *Oh regarde,* $\underline{le}_{\text{MASC}}$ $\underline{mignon}_{\text{MASC}}$ $camion_{\text{MASC}}$). The Misleading trial presented the same two objects. However, the target object was feminine (i.e., *maison* – house), and the distractor masculine (i.e,, *camion* – truck). The DP naming the target was misleading, that is, the Det+Adj part was of masculine gender (i.e., $\underline{le}_{\text{MASC}}$ $\underline{mignon}_{\text{MASC}}$), while the Noun was of feminine gender (i.e., $maison_{\text{FEM}}$). This manipulation resulted in the ungrammatical utterance **Oh regarde! le*$_{\text{MASC}}$ $mignon_{\text{MASC}}$ $maison_{\text{FEM}}$.

3.1.4. Procedure, apparatus and predictions

The procedure and apparatus were as in Experiment 1.

Experiment 1 showed that the gender of the determiner was processed online, before the noun was heard. In Experiment 2 we predicted that the gender-marked determiner in the Misleading trial should lead infants to pre-select the gender-matching distractor object. We also predicted that this effect of misleading gender would persist till late in processing of the DP.

3.2. Results

The PLT was calculated in the same manner as in Experiment 1. We first analyzed the Pre-Noun window, starting 300 ms after the determiner onset, covering the Det+Adj portion. We found that the Informative and Misleading trials differed significantly from each other in this Pre-Noun window (paired $t(31) = 4.660$, $p = .000$). As expected, the PLTs were significantly different from chance for both trial types, but the looking preference was not towards the same objects. In the Informative trial infants looked more to the target object, i.e., above chance ($M = .78$, $SE = .05$, $t(31) = 5.214$, $p = .000$), while in the Misleading trial infants looked more to the distractor object, i.e., below chance ($M = .32$, $SE = .06$, $t(33) = -2.477$, $p = .019$). During the Noun window the two trial types were again significantly different from each other (paired $t(30) =$

3.914, p = .000). Comparisons with the 0.50 chance level revealed that the looking preference towards the target was maintained during the Informative trial (M = .89, SE = .04, t(30) = 9.407, p = .000), and that looks during the Misleading trial did not differ from chance (M = .58, SE = .06, t(33) = 1.336, p = .191). The timecourse graph shows that in the Misleading trial infants started to shift away from the preference for the distractor observed in the earlier window, moving towards the direction of the target. During the Late window infants eventually recognized the target in the Misleading trial, with the PLT significantly above chance (M = .74, SE = .05, t(33) = 4.890, p = .000). In the Informative trial target recognition was maintained in the Late window, significantly above chance (M = .89, SE = .03, t(31) = 11.157, p = .000). Furthermore, the significant difference between the Informative and Misleading trials was sustained during the Late window (paired t(31) = 2.322, p = .027), suggesting that it cost infants processing time to recover from the effect of misleading gender of the determiner. All statistics were two-tailed.

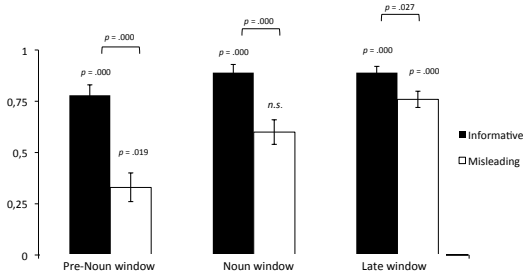

Fig. 4. Proportion of looking to target (and standard errors) in Informative and Misleading trials in Experiment 2 for the three time windows.

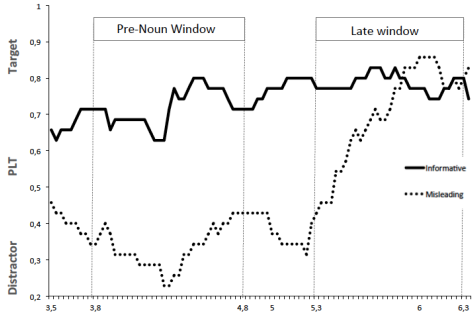

Fig. 5. Timecourse of trials in Experiment 2.

4. General discussion

The present study tested the immediate processing of grammatical gender in infants. We showed that 30-month-old Quebec-French-learning infants represent

gender agreement and use the information online during comprehension. Crucially, we found that infants immediately use activated grammatical information to predict the next word before the word is heard. Infants in our study activated the gender feature of a determiner while hearing its word form. They also activated the genders of nouns while only seeing their object images. Moreover, they rapidly computed the gender agreement between these words and used the output to predict the noun referent. When the determiner matched in gender with the target noun but not with the distractor (Informative trials), target recognition was achieved before the noun was heard. When the determiner matched in gender with the distractor but not with the target (Misleading trial), infants first looked at the distractor (before hearing the noun) and began shifting towards the target picture after a part of the noun was heard. When the determiner matched with both objects in gender (Uninformative trials), target recognition was also delayed, as infants waited to hear the noun form in order to select the target.

The grammar-based pre-selection shown in our study is striking. This effect has not been demonstrated in other online studies with infants (as discussed in the Introduction) and adults. In an eye-tracking study by Dahan, et al. (2000) adults did not pre-select the noun target based on the informative gender feature of a preceding determiner. The gender of the determiner only had a constraining effect (for selecting among phonological competitors) after the initial part of the noun was heard. This, however, could have been due to the higher demand of their task, since multiple distractors were presented with the target. It is possible that adults will show an earlier grammatical effect in simpler task conditions.

Our experiments used a gender-marked adjective. Because the gender of the adjective always agreed with that of the determiner, one may wonder if infants used the gender marking in the determiner or adjective or both for processing. We are certain that the gender of the determiner must have played a role, given the evidence from previous online comprehension studies (e.g., Johnson, 2005; Lew-Williams & Fernald, 2007; Melançon & Shi, 2011; Van Heugten & Shi, 2009). Notably, in another infant study that we conducted recently (Melançon & Shi, 2012) we used similar DPs as in the present experiments except a gender-unmarked adjective (i.e., *jolie*$_{\text{FEM}}$/*joli*$_{\text{MASC}}$–pretty, both /ʒɔli/) following a determiner, and we found that a gender-informative determiner alone led to pre-selection. With respect to adjectives, the comparison of our present results with those of that study suggests that infants processed the gender marking of the adjective in the present study. Specifically, target recognition in uninformative trials started slightly earlier (Noun window) in Melançon and Shi (2012) than in the present study (Late window), suggesting that infants in the latter case were delayed because they were processing the gender features of the adjective.

In conclusion, our study offers the following novel findings: 1) Seeing an object automatically activates the grammatical information of the corresponding word; 2) Grammatical agreement between categories within a DP is immediately computed and used for predicting noun meaning, even before the noun is heard.

Such immediate, automatic processing demonstrates that grammatical knowledge is available and robust during early acquisition.

Appendix

Stimuli for key trials in Experiments 1 and 2, targets are in bold

Trial Type	Auditory Stimuli	Visual Stimuli	
		Left Side	Right Side
Informative	*la*$_{FEM}$ *mignonne*$_{FEM}$ *girafe*$_{FEM}$	singe$_{MASC}$	**girafe**$_{FEM}$
	le$_{MASC}$ *mignon*$_{MASC}$ *camion*$_{MASC}$	**camion**$_{MASC}$	maison$_{FEM}$
Uninformative	*le*$_{MASC}$ *mignon*$_{MASC}$ *soulier*$_{MASC}$	**soulier**$_{MASC}$	chapeau$_{MASC}$
	la$_{FEM}$ *mignonne*$_{FEM}$ *grenouille*$_{FEM}$	poule$_{FEM}$	**grenouille**$_{FEM}$
Misleading	**le*$_{MASC}$ *mignon*$_{MASC}$ *maison*$_{FEM}$	**maison**$_{FEM}$	camion$_{MASC}$

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