Linguistic Anticipation in Children's Correction Sentences

Abstract

The present research explored the development of prediction systems in 24- and 30-month-old toddlers in a visual-world-paradigm. Participants heard a sentence that included a correction ("no") or a conjunction ("and") while seeing an array of pictures with an associatively related noun ("cat") and the erroneous noun ("dog"). The young group showed signs of early prediction of the associative picture on both types of sentences while the older group showed signs of an early prediction of the coordination condition, but a later prediction in the correction sentences. Our results suggest that older toddlers deployed different predictive systems, while the younger group used the same system.

Keywords: linguistic anticipation, correction disfluency, language acquisition.

Introduction

Linguistic prediction has been postulated as an important factor underlying language acquisition and development (Chang et al., 2006; Dell & Chang, 2014; Ramscar et al., 2014; Reuter et al., 2019).

Theoretical prediction models postulate two predictive systems (Huettig, 2015; Pickering & Gambi, 2018). System 1 is an associative, fast, resourceless and automatic system based on diffusion of activation between related concepts and dependent on Hebbian learning. For example, in a sentence like "The dog barks at the…", the word "dog" preactivates "cat", but also other related but incongruent words like "bone" or "leash".

Instead, system 2 is inferential because it generates predictions from linguistic and nonlinguistic context, and the speakers' intentions; it is flexible, so these predictions are more accurate and consistent with expected input. Using the example above, system 2 would generate preactivation of lexical candidates congruent with the context of the sentence. For instance, in the sentence "David arrested the…", some plausible words for the context would be activated, such as "thief" or "robber", but not other related and implausible such as "policeman".

Despite evidence available so far, it is unknown how these predictive systems develop considering that young children have a low linguistic experience compared to adults since they are in the process of acquiring vocabulary, syntactic and morphological rules (Pearl, 2021), as well as linguistic context (Kidd et al., 2011). So, it might be possible to map at which evolutionary moments, substantial changes in predictive abilities and their two systems occur.

Previous studies indicate that two-year-olds have a robust association system (Angulo-Chavira & Arias-Trejo, 2018). At the same age, they can predict semantic information based on verbs. For example, listening to "eat" anticipates edible objects such as "cake", as opposed to "see" that does not present a clear restriction (Gambi et al., 2018; Mani & Huettig, 2012). Based on this evidence, around 24 months, toddlers may be making predictions based on system 1 mechanism.

In fact, according to the study made by Gambi et al. (2016), system 2 mechanism emerges around 4 to 5 years of age since they can predict information related to structure and grammatical roles (e.g., agent and patient).

Thus, the evidence suggests that the mechanisms of systems 1 and 2 change with age and the linguistic skills acquired throughout development. The present study reviews how the two prediction mechanisms develop and change throughout development from two grammatical constructions: copulative coordination and correction disfluency.

Disfluencies are errors, pauses, or silences during speech and occur in 6% of every 100 words spoken (Fox-Tree, 1995). In this sense, Kidd et al. (2011) evaluated the predictive abilities through a disfluency cue in toddlers from 18 to 30 months of age. The results showed that from 30 months, toddlers could anticipate new information when a disfluency occurs.

For their part, in the case of adults, the work of Lowder & Ferreira (2016) shows that when faced with a corrective disfluency sentence ("The chef reached for some salt, uh, I mean some ketchup"), adults can anticipate the related information (they anticipate pepper because of its relationship to salt) before the last noun is mentioned. However, this anticipation process does not occur when they are presented with a copulative coordinated sentence in which only information is added ("The chef reached for some salt and also some ketchup").

Finally, in our previous work (Angulo-Chavira et al. (in preparation), we evaluate young adults, school-age children and 30-month-old toddlers in a replica of Lowder & Ferreira (2016). The results showed that toddlers carry out an anticipation process in a sentence with copulative coordination ("In the yard I saw a dog and a rabbit") but not in the correction disfluency condition ("I saw a dog in the yard, no, a rabbit"). This result was inverted through development, so children eventually predict semantically related information in the disfluency condition but not in the coordination one. Furthermore, children's predictions were slower than adults' ones. Therefore, it is possible that toddlers' processing is slower, requiring more time to predict, but early ages also use system 1 to make predictions in both conditions.

For these reasons, an experiment was designed using the visual tracking paradigm in which it was checked whether 24- and 30-month-old toddlers could anticipate semantically related linguistic information when a corrective disfluency is presented, as opposed to when they are presented with a corrective disfluency.

Our main hypothesis is that 24-month-old toddlers would carry out a priming process in both conditions; that is, they would look at the semantically related image when there is a corrective disfluency and copulative conjunction, since, as demonstrated by Kidd et al., (2011), prediction using disfluencies develops at 30 months of age. Thus, 30-month-old toddlers would have differential prediction processes before correction disfluencies and coordination sentences.

Method

Participants

A total of 29 toddlers of 24 months of age (M_{age}= 2.06, 18 boys) and 30 toddlers of 30 months of age (M_{age}= 2.52, 16 boys) were evaluated in a visual world paradigm. All were native speakers of Mexican Spanish. All participants had a normal or corrected-to-normal vision and reported no neurological or language problems.

Stimuli

The stimuli consisted of 16 sentences: eight copulative coordinate sentences and eight with a correction disfluency. For each sentence, four words were selected from the same semantic category. The first noun (e.g., *dog*) was the first noun presented in the sentence context (“In the yard I saw a...”); the second noun had a low degree of association with first noun but was plausible in the context (e.g., *rabbit*). There was also an associative distractor noun that was highly associated with the first noun and highly plausible in the context (e.g., *cat*). Finally, there was an unrelated distractor without any associative relationship with the first noun, which was unlikely in the context (e.g., *tiger*). At the grammatical level, the first noun was the direct object of the sentence; in correction sentences, it was corrected with the second noun. In coordinate sentences, the second was only added by using ‘and’.

The participants were presented with the four competitors described above on a screen while listening to sentences in the two conditions in a counterbalanced manner; that is, the correction disfluency sentence (e.g., “In the yard I saw a dog—no, a rabbit”) and the coordinated copulative sentence (e.g., “In the yard I saw a dog and a rabbit”).

Experimental design

The duration of each trial was 7600 ms, and the time was set to the onset of the coordination or correction words (Figure 1). A fixation point was presented from -3600 to -2600 ms; the context sentence (“In the yard, I saw a...”) was presented from -2600 to -1000 ms. The first noun (e.g., *dog*) was heard at -1000 ms; the adverb *no* or the conjunction *y*, depending on the type of sentence, was introduced at 0 ms. The second noun (e.g., *rabbit*) was heard at 2000 ms. Finally, a grey screen was presented from 3000 to 4000 ms. Participants hence saw the images of the four competitors from 4600 ms while they listened to the corresponding sentence.

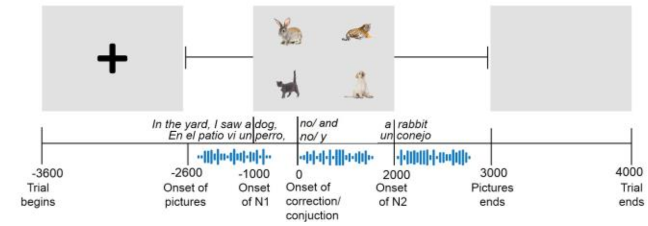


Figure 1. Example of an experimental trial.

Procedure

Upon the arrival of the participants, parents were given a questionnaire of sociodemographic data and an informed consent. After the responsible tutor finished the questionnaires, the eye-tracking activity was carried out in a Tobbi TX-120. The session started after a five-point calibration process.

Data processing and statistical analysis

The data processing and statistical analysis were implemented in R (CoreTeam, 2019). The Tobii I-VT Fixation Filter was used to compute the fixation to each competitor. We excluded trials with less than 25% valid data during the picture presentation. One participant was excluded because did not preserve at least 50% of the trials. On average, the remaining participants conserved ~15 trials (*SD* = 1.19). For data analysis, we defined two analysis windows by averaging the probability of fixation over time, taking a relative zero point at the onset of the coordination/correction words: an early prediction window of 0 to 2000 ms and a late window from 2000 to 4000 ms.

To compare the data, we performed a binomial mixed effect model using the mean probability of fixation of the associative distractor as a dependent variable. The fixed factors were Group (24 and 30 months), Condition (Coordination and Correction sentences), and Window (Early and Late prediction windows). The random factors included the slope of the main effects and interaction between the Condition and Window for the subjects and the slope of the window for the trials. This is the maximum structure based on us within subject/trial variables.

Results

All main effects and interactions were significant (Table 1), including the main interaction among Group, Condition, and Window.

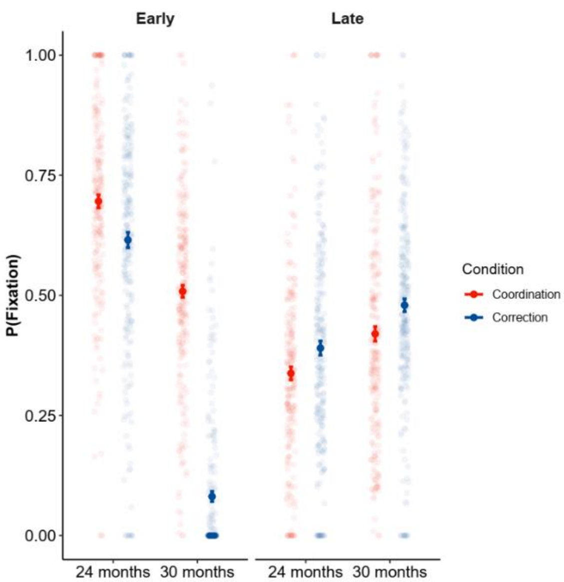
As seen in Figure 2, 24-month-old infants had a high probability of fixation to the associated distractor in the early window, as opposed to the late window, in which the probability of fixation to the associative distractor decreased in both conditions. In contrast, 30-month-old infants presented a pattern of decreasing fixation to the associative distractor in the coordination condition.

However, the 30-month-old infants presented an increasing pattern of fixation towards the associative distractor in the correction condition, that is, they began to see the associated distractor from the early window, but these fixations increased significantly in the late window.

Table 1. Binomial mixed model stats

Fixed	β	*SE*	*Z*	*p*
Intercept	0.86	0.09	9.04	<0.001
A	-0.84	0.1	-8.25	<0.001
B	-0.33	0.01	-20.85	<0.001
C	-1.56	0.14	-10.7	<0.001
A:B	-2.21	0.02	-84.71	<0.001
A:C	1.21	0.15	7.66	<0.001
B:C	0.53	0.02	23.01	<0.001
A:B:C	2.25	0.03	64.49	<0.001

A: Group; B: Condition; C: Window.



Discussion

We designed an eye-tracking experiment to explore whether 24- and 30-month-old toddlers can anticipate semantic information in the face of a correction disfluency and a copulative coordination sentence. Consistent with previous studies, we hypothesized that 30-month-olds would present an early prediction in coordination sentences but a late prediction in correction sentences. Conversely, we hypothesized that 24-month-old toddlers would make early predictions in both conditions.

Figure 2. Fixation probability across group, condition, and window.

The results support our hypothesis. We argue that the late prediction in 30 months is related to the development of system 2 of prediction. Since 30-month-old toddlers need to process contextual and syntactic information to predict semantic information, this processing is slower. By contrast, they used system 1 to predict the coordination sentences. So, the information only spreads from the first noun to the associative distractor. Similarly, early prediction in 24-month-old toddlers suggests that they use system 1 to make predictions. They probably cannot use contextual clues or the speaker's intentions to make predictions as reported by Kidd et al. (2011).

Our results suggest that the two prediction mechanisms are modified during development and from the acquired linguistic skills.

Conclusions

Our results indicate that the prediction mechanism relying on system 2, context and the speaker's intentions emerges from around 30 months of age. However, at this age, it is a slow predictive process that may be modified in later stages of development. Before, at 24 months, toddlers employed system 1 to make predictions.

Future research should explore the development of prediction in later stages and with different types of grammatical structures.

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