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How First and Second Language Learners Use Predictive Cues in Online Sentence Interpretation in Spanish and English

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1. Introduction

Adults listening to their native language can rapidly interpret the meaning of speech as it flies by. Here we ask how younger and older language learners compare with fluent adults in their ability to make use of morphosyntactic and semantic cues to establish reference as they listen to fluent speech. The efficiency of speech processing by young children learning Spanish as a first language and adults learning Spanish as a second language (L2 adults) is compared with that of adult native speakers of Spanish (L1 adults).

To begin making sense of speech, language learners must attend to specific regularities within the ambient language—a process that for first language learners begins in infancy. As infants in the first year of life gain exposure to the language used by their caregivers, they discern regularities in patterns of sounds and form detailed phonetic categories (e.g., Kuhl, 2004). But learning about speech sounds is just the beginning of "becoming a native listener" (Werker, 1989), and little is known about how language-specific processing strategies take shape beyond the first year as children learn to interpret words in combination. In the extensive literature on word learning, a traditional approach using offline methods has emphasized knowledge and representation of new words (e.g., Carey & Bartlett, 1978). Here we ask a different question: how do language learners begin to make use of their emerging linguistic knowledge to facilitate interpretation of known words in fluent speech?

Research on how adults make sense of spoken language has led to several important insights. One major discovery is that adults process speech incrementally, using information bit by bit as soon as it is made available, not waiting until the end of a word or sentence to begin interpretation (e.g., Marslen-Wilson & Zwitserlood, 1989). For example, as listeners hear increasing segments of the word *trespass*, there is a certain point where no other English word competes for recognition, and adults interpret the most likely word candidate incrementally. A second major discovery is that adults integrate probabilistic information from multiple sources—not just phonetic information, but also prosodic, semantic, structural and discourse-level information. A growing literature using eye-tracking techniques (e.g., Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) reveals how visual context also affects listeners' interpretation of speech from moment to moment.

Developmental studies have now begun investigating incremental processing and cue integration in very young children. Like adults, children use their eyes to gather information relevant to understanding speech from early in infancy, and eye-tracking techniques have enabled researchers to monitor the time course of young language learners' processing (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998; Trueswell, Sekerina, Hill, & Logrip, 1999). Recent studies with English-learning children show that speed and efficiency in word recognition improve dramatically over the first three years (Fernald, Perfors, & Marchman, 2006). As children gain language experience with age, they initiate eye movements even before the acoustic offset of nouns, revealing incremental processing at the word level. Other research has explored young children's online interpretation of words in combination. For example, 2-year-olds expect an object name to follow an article (Zangl & Fernald, in press). When an unstressed adjective occurs instead, they "listen through" the prenominal word and wait for the following noun before responding; however, if the adjective is stressed and novel, children often misinterpret the word as a potential object name (Thorpe & Fernald, 2006). This tendency of English-learning 2-year-olds to "false alarm" in response to stressed novel words preceded by the article *the* shows that they are integrating prosodic information with knowledge of the distributional patterns of English determiners to predict what kind of word is coming next.

In Spanish, the definite articles *la* [fem.] and *el* [masc.] provide additional information about noun class and number of the subsequent noun. From the perspective of learning, memory and processing, grammatical gender might seem to be a potentially costly system. However, it is also possible that cues to grammatical gender might facilitate adults' speech processing, an hypothesis that has been investigated using online methods to measure the speed of identifying words with and without gender marking. For example, Bates, Devescovi, Hernandez, and Pizzamiglio (1996) found faster word recognition by Italian-speaking adults when adjective-noun pairs were matched for gender than when they were not. ERP measures have also shown that adults use gender information in real time to identify words and build sentence meaning (e.g., Wicha, Moreno, & Kutas, 2004). One previous study has used an eye-tracking paradigm to investigate grammatical gender in word recognition (Dahan, Swingley, Tanenhaus, & Magnuson, 2000). French-speaking adults viewed objects with names that differed in gender but had similar phonological onsets (e.g., *vase* [masc.] and *vache* [fem.]). Participants heard gender-uninformative commands (e.g., *Cliquez sure les* [neutral/plural] *vases*) or gender-informative commands (e.g., *Cliquez sur le* [masc./singular] *vase*). Dahan et al. found that listeners responded faster to nouns appropriately marked for gender, and that gender-marked articles eliminated interference from phonological competitors, suggesting that gender-marked articles affect lexical access directly by constraining the set of candidates considered as possible referents.

To extend this research to young children learning a language with grammatical gender, Lew-Williams and Fernald (in press) monitored the eye

movements of Spanish-learning 3-year-olds as they looked at pairs of objects with names of either the same or different grammatical gender. A group of native Spanish-speaking adults was also tested in this paradigm. While listening to simple sentences, both children and adults were faster to orient to a target image when the gender-marked article was potentially informative about the identity of the subsequent noun. Thus in this task testing awareness of morphosyntactic cues in online comprehension, young Spanish-learning children were able to take advantage of grammatical gender in the article to establish reference more quickly, just like adult native speakers of Spanish.

The finding that young language learners make rapid use of grammatical gender in spoken word recognition motivated two additional questions. First, would adults learning Spanish as L2 show efficiency in processing comparable to that of children learning Spanish as L1? In one previous study exploring L2 learners' processing of grammatical gender, participants were monolingual French speakers, and early and late highly proficient English-French bilinguals (Guillelmon & Grosjean, 2001). All participants had 20 years of immersion in a French community and were highly fluent speakers. In an auditory naming task, participants repeated a noun within a short phrase that was either preceded by gender marking or not. Monolinguals and early bilinguals were significantly faster in repeating the noun when prenominal gender marking was present. There were two noteworthy findings for the late bilinguals. First, they were slower overall in processing speed. Second, and more surprisingly, they showed no processing advantage at all on gender-marked trials. These findings suggest that young adults learning L2 are less able to make efficient use of morphosyntactic cues in online processing, as compared to native speakers and early L2 learners (see also Scherag, Demuth, Rösler, Neville, & Röder, 2004).

A further question of interest was how children and L2 learners would compare on a different processing task involving cues to reference that are more semantic in nature. Altmann & Kamide (1999) exposed adults to visual scenes with an agent, a target object and various distracter objects. When hearing sentences with contextually constraining verbs such as *eat*, adults were more likely to orient immediately to a potential referent that was thematically related to the verb (e.g., a cake) than to a distracter object that was not (e.g., a ball). Fernald (2004) found that English-learning 26-month-olds also oriented more rapidly to the appropriate referent when the target noun was preceded by a related verb (e.g., *Eat the cookie*) than when it was preceded by an unrelated verb (e.g., *Take the cookie*). Examining how listeners use verb information in online sentence interpretation offers another way to explore how fluent adults compare with both younger and older language learners in their ability to use predictive cues in spoken language understanding.

In the present research we compared the speech processing efficiency of native Spanish-speaking adults (L1 adults) with that of young Spanish-learning children and adults learning Spanish as a second language (L2 adults) in two different online processing tasks. Both tasks provided listeners with predictive cues that could potentially be used to identify the referent more efficiently:

gender-marked articles provided morphosyntactic cues in Experiment 1, and verb thematic information provided semantic cues in Experiment 2.

2. Method

The "looking-while-listening" (LWL) procedure (Fernald et al., 1998; Fernald et al., 2006) was used with both child and adult participants in Experiments 1 and 2. In this online procedure for monitoring the time course of spoken language understanding, participants view two pictures while listening to prerecorded speech naming one of the pictures. On any trial, there are two main responses in this referential context. If participants are looking at a target picture (e.g., a ball) and they hear the sentence *Find the ball*, they should continue looking at the ball because no speech information directs them elsewhere. If they are looking at the distracter picture (e.g., a shoe) as they hear the same sentence, they should shift their gaze to the target image. Participants' eye movements are coded offline, frame by frame (with 33 millisecond resolution) by coders blind to trial type. These responses can be used to calculate reaction time (RT), the latency to initiate an eye movement toward the target image. Shifts during the first 300 ms are not included in analyses, since this is approximately how long it takes to program an eye movement (Haith, Wentworth, & Canfield, 1993). In Experiment 1, RT was calculated from the point in the speech stream where relevant acoustic information became available, i.e., the onset of the gender-marked article. In Experiment 2, it was the verb preceding the noun phrase that was of particular interest; thus RT was measured from the onset of the verb.

3. Experiment 1

3.1. Participants

The first two groups of participants were those described in Lew-Williams and Fernald (in press), consisting of 26 monolingual Spanish-learning children (M = 37.7 months, range = 34-42 months), with a mean productive vocabulary of 537 words, and 26 monolingual Spanish-speaking adults (M = 28.0 years). These adults were all parents of children in the study, mostly recent immigrants from Mexico with a mean 9.5 years of education. Child and L1 adult participants reside in a low-income community that is 60% Latino. The L2 adult sample consisted of 33 native English-speaking college students learning Spanish as a second language (M = 20.2 years) with a range of 1-10 years of Spanish instruction and a mean age of 12.7 years when first exposed to Spanish.

3.2. Speech and Visual Stimuli

Speech stimuli were simple Spanish sentences using one of two sentence frames, *Encuentra… (Find)* or *¿Dónde esta… (Where is)* (M = 914 ms), followed by one of eight article-noun phrases*: la pelota (ball), la galleta (cookie), la vaca (cow), la rana (frog), el zapato (shoe), el carro (car), el pájaro*

(bird), and *el caballo (horse)*. Articles were always unstressed, as is common in Spanish (Alarcos Llorach, 1994). Half the nouns were feminine and half were animate. Mean duration of articles was 280 ms and mean duration of nouns was 720 ms. Each test sentence was immediately followed by a sentence intended to maintain participants' attention, e.g., *¿Te gusta?* (Do you like it?). Visual stimuli were colorful digital images of animals and objects presented on grey backgrounds and displayed side-by-side in the LWL procedure.

Participants were exposed to two trial types: *same-gender trials*, where the images depicted objects with names of the same grammatical gender (e.g., la pelota-la galleta), and *different-gender trials*, where the images depicted objects with names of different gender (e.g., la pelota-el zapato). In this latter case the gender-marked article was potentially informative about the object that was the upcoming referent of the sentence. Four counterbalanced orders of 16 same-gender, 16 different-gender and 8 test trials were used in the experiment.

3.3. Results and Discussion

Figure 1 shows the time course of comprehension by the three groups of participants (data for children and L1 adults adapted from Lew-Williams & Fernald, in press). The plot includes only those trials where participants started on the distracter at article onset and shifted to the target. From this subset of trials, we calculated the latency of shifting to the target for each participant on same- and different-gender trials. The x-axis shows time from article onset and the y-axis shows the mean proportion of looking to the target. Each point represents an independent calculation of where children on average are looking.

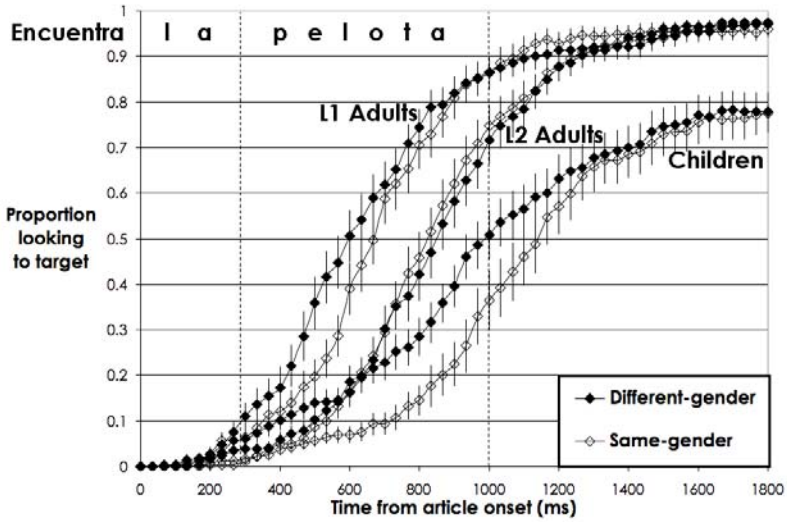

Figure 1: Time course of children's, L1 adults' and L2 adults' looking to the target image on same-gender and different-gender trials. Vertical dashed lines indicate offsets of the article and noun.

Table 1 contains RTs for each trial type. A difference score for each group was calculated by subtracting mean RT on different-gender trials from mean RT on same-gender trials. A positive difference score indicates faster processing on different-gender trials.

Table 1: Mean RT (in ms) on same-gender and different-gender trials and the difference score for each group of participants.

	Same-gender	Different-gender	Difference Score
Children	931	843	88
L2 Adults	792	799	-7
L1 Adults	690	615	75

Mean RTs were analyzed in a 2 (trial type: same-, different-gender) x 3 (group: children, L2 adults, L1 adults) mixed ANOVA. There was a significant main effect of trial type, $F(1, 80) = 13.0$, $p < .001$, indicating that participants were faster overall to identify the named referent on different-gender trials than on same-gender trials. Planned comparisons revealed that this effect was significant for children, $t(23) = 2.9$, $p < .01$, and for L1 adults, $t(25) = 4.0$, $p < .001$. L2 adults, however, responded with equivalent RT regardless of trial type, $t(32) = .3$, $p > .05$. There was also a significant main effect of group, $F(2, 80) = 23.8$, $p < .001$, indicating that the three groups differed in absolute processing speed; L1 adults were fastest overall, and children were slowest, with L2 adults in between. The most interesting finding was revealed by the significant group x trial type interaction, $F(2, 80) = 4.6$, $p < .02$: both children and L1 adults responded significantly faster on different-gender trials, but L2 adults did not. Thus although the L2 adults were considerably faster overall in lexical access than the 3-year-old Spanish-learning children, these late learners were less efficient than the children in making use of morphosyntactic information in online processing, i.e., they were unable to take advantage of the gender-marked article to identify the referent more rapidly on different-gender trials.

Experiment 1 showed that children learning Spanish as L1 exploited the information carried by short, unstressed gender-marked articles in rapid language interpretation—a processing advantage characteristic of adult L1 speakers but not of L2 learners. The grammatical gender task used here reveals efficient interpretation of morphosyntactic cues, but semantic cues offer a different way of listening ahead. Experiment 2 investigated how children, L1 adults and L2 adults use verb thematic information in both Spanish and English.

4. Experiment 2

4.1. Participants

In Experiment 2, three groups of participants listened to Spanish sentences and three groups listened to English sentences. Participants listening to Spanish sentences were 40 monolingual Spanish-learning children (M = 29.0 months, range = 25-37 months), with a mean productive vocabulary of 338 words

(Hurtado, Marchman, & Fernald, in prep); 29 native Spanish-speaking university students (M = 19.9 years); and 33 native English-speaking university students learning Spanish as L2 (M = 20.2 years), with a range of 1-10 years of Spanish instruction. Participants listening to English sentences were 32 monolingual English-learning children (M = 26.6 months, range = 26-27 months), with a mean productive vocabulary of 449 words (Fernald, 2004); 33 native English-speaking university students (M = 20.2 years); and 29 native Spanish-speaking university students who learned English as L2 (M = 19.9 years), with a mean age of 5.1 years when first exposed to English.

4.2. Speech and Visual Stimuli

In the LWL procedure, participants viewed two images (e.g., a ball and a cookie) and heard two types of sentences. On unrelated-verb trials, sentences contained a semantically uninformative verb, e.g., *Encuentra la galleta* (*Find the cookie*). On related-verb trials, sentences contained a semantically informative verb, e.g., *Cómete la galleta* (*Eat the cookie*). In the letter case, the verb provided disambiguating referential information prior to the name of the referent itself. Each test session consisted of 8 unrelated-verb, 8 related-verb, and additional filler trials.

Spanish and English test sentences consisted of a verb, a definite article and a noun. Half the verbs were semantically unrelated to the noun and half were related: *Encuentra/Cómete la galleta* (*Find/Eat the cookie*), *Mira/Avienta la pelota* (*Look at/Throw the ball*), *Dame/Tómate el jugo* (*Give me/Drink the juice*), and *Busca/Lee el libro* (*Look for/Read the book*). Spanish verbs ranged in length from 800-833 ms and English verbs ranged in length from 600-633 ms. When testing in Spanish, paired images depicted objects with names that were matched for grammatical gender; thus, listeners could use only the verb—but not the gender-marked article—to anticipate the upcoming referent.

4.3. Results and Discussion

Tables 2 and 3 show RTs for each group on each trial type. The third column in each table shows a difference score, calculated by subtracting mean RT on related-verb trials from mean RT on unrelated-verb trials. The same trend in efficiency of processing was observed in both Spanish and English: native speakers showed greater efficiency of processing than L2 learners, and L2 learners showed greater efficiency of processing than children.

Table 2: Spanish sentences: RTs and difference scores (in ms) by group

	Unrelated-verb	Related-verb	Difference Score
Children	1324	1243	81
L2 Adults	1188	1074	114
L1 Adults	1036	886	150

Table 3: English sentences: RTs and difference scores (in ms) by group

	Unrelated-verb	Related-verb	Difference Score
Children	1342	1180	162
L2 Adults	1070	818	252
L1 Adults	1028	663	365

For participants listening to Spanish sentences, a 2 (trial type: unrelated-verb, related-verb) x 3 (group: children, L2 adults, L1 adults) mixed ANOVA revealed a significant main effect of trial type, $F(1, 91) = 9.0$, $p < .005$, showing that participants responded more rapidly overall on related-verb trials than on unrelated-verb trials. Planned comparisons revealed that all three groups of participants oriented to the target image significantly faster on related-verb trials: children, $t(25) = 2.4$, $p < .025$, L2 adults, $t(29) = 2.5$, $p < .02$, and L1 adults, $t(25) = 3.5$, $p < .005$. Thus, participants used semantically informative verbs to more rapidly identify the as-yet-unnamed referent of the sentence. The ANOVA also revealed a significant main effect of group, $F(2, 91) = 8.9$, $p < .001$, indicating that the three groups varied by speed of processing, consistent with Experiment 1. The trial type x group interaction was not significant. Unlike the results of the first experiment where children and L1 adults could use predictive morphosyntactic cues but L2 adults could not, we found comparable performance across groups in participants' use of semantic cues in establishing reference.

Similarly, for participants listening to English, a 2 x 3 mixed ANOVA revealed a main effect of trial type, $F(1, 63) = 32.5$, $p < .001$, with significant effects for children, $t(28) = 3.0$, $p < .005$, L2 adults, $t(14) = 3.9$, $p < .005$, and L1 adults, $t(18) = 9.9$, $p < .001$. There was also a main effect of group, $F(2, 63) = 32.1$, $p < .001$, revealing comparable group differences in processing speed, with no significant interaction. Difference scores for participants listening to English sentences were larger than those observed for Spanish sentences, likely due to the differing lengths of the Spanish and English verb stimuli.

Experiment 2 showed that Spanish-learning children, adults learning Spanish as a second language, and native Spanish-speaking adults were faster to interpret sentences containing verbs that were semantically related to subsequent nouns. This pattern of findings was also found for participants listening to English sentences. Furthermore, speed of processing differed across the three groups, with increasingly faster processing from children to L2 adults to L1 adults in both Spanish and English.

5. General Discussion

Experiment 1 focused on the Spanish grammatical gender system to explore the use of morphosyntactic cues in spoken language processing. Spanish-learning children and native Spanish-speaking adults took advantage of informative gender-marked articles to more rapidly identify the referents of subsequent nouns. Adults learning Spanish as a second language did not

demonstrate this same efficiency in processing. Experiment 2 focused on verbs to explore Spanish and English speakers' use of semantic cues in spoken language processing. Unlike Experiment 1, L2 adults did demonstrate efficiency of processing; that is, in both Spanish and English, they were faster to identify referents when listening to sentences that contained semantically informative verbs. This effect varied across the three groups, such that L2 adults were less efficient than L1 adults, but more efficient than children. In terms of processing speed, L2 adults were slower than L1 adults in identifying highly familiar words in simple sentence frames, even after years of immersion in the second language, and children were substantially slower than both groups of adults.

Two main themes emerge from these findings. First, there was gradual improvement with age and experience, observed in processing speed differences across the participant groups, and in trials testing the use of semantic cues. The most reasonable explanation for the absolute processing speed findings is that practice hearing a noun helps a listener recognize it faster. Zevin & Seidenberg (2004) measured the speed of naming written words, taking several factors into account such as age of acquisition, concreteness and imageability of target words, and the cumulative frequency of exposures to target words. The total amount of exposure to words was the most important factor in skilled word naming, above and beyond the influence of other factors. In the present studies, L1 adults had the most experience hearing the target nouns, resulting in more rapid processing than L2 adults and children. Furthermore, L2 adults showed faster processing of words than children. While children and L2 adults may have somewhat comparable exposure to the target nouns, they differ in other important factors, such as the maturity of the nervous system and the level of awareness of being in an experiment. These factors may account for the observed differences in processing speed. Indeed, age-related increases in processing speed are seen across linguistic and nonlinguistic tasks (Kail, 1991).

For trials testing the use of semantic cues, the factors that account for gradual improvement with age and experience differ from those that help explain group differences in processing speed. Importantly, what does it mean to use semantic cues? As listeners, we actively build world knowledge about relations between actions and the verbs we hear during those actions, and between objects and the nouns we hear while attending to those objects. As children, we gradually learn these links with more experience; that is, we accumulate massive practice at hearing a word like *eat* and searching for something edible. Given the rough translational equivalence between Spanish and English for simple verbs, experience with verbs may transfer across languages, explaining why L2 learners show greater efficiency of processing than children. In sum, differences in real-world knowledge help explain the stepwise increase in efficiency of processing semantic cues from children to L2 adults to L1 adults.

However, with regard to the use of morphosyntactic cues, the story is quite different. The second major theme emerging from the present findings is the

advantage of early language experience observed in trials testing online interpretation of grammatical gender. The results are consistent with well-established findings showing that L2 learners have more difficulty with syntactic judgments than with semantic judgments (Clahsen & Felser, 2006; Hahne, 2001; Friederici, Steinhauer, & Pfeifer, 2002; Johnson & Newport, 1989). But *why* do the L2 adults in Experiment 1 not show efficient processing of the gender-marked articles *la* and *el*? There are two classes of explanations for this pattern. First, the critical period hypothesis, based on biological learning models, suggests that learning is privileged during special periods of plasticity. While some theorists favor the explanation that children are especially biased to learn syntax (e.g., Neville & Bavalier, 2000), which is consistent with the present findings, another compelling argument can be made about the regularities between gender-marked articles and the nouns. This account stresses the importance of language input and the distributional regularities within that input. Children and L2 learners have radically different language learning environments. Children often find themselves in highly interactive environments with a caregiver, where caregivers may repeat simple phrases that expose children to the high co-occurrence statistics between Spanish articles and nouns (e.g., *Es una pelota. ¿Ves la pelota? ¡Mira la pelota!*, 'It's a ball. Do you see the ball? Look at the ball!'). While the definite article *la* is a weak cue for *pelota* or any given feminine noun, *pelota* is almost always preceded by one of a small set of predictable feminine determiners (including *la*), and never by *el* or other masculine determiners. In the LWL procedure, if a child is looking at a ball and hears the masculine article *el*, this is inconsistent with what the child is accustomed to hearing when looking at a ball. With this inconsistency at the determiner, she may reject a mismatch and shift to the other candidate referent.

The nature of children's language learning environment leads them to develop very strong associations between gender-marked articles and nouns, possibly to the extent that they initially treat the article as a prefix of the noun (Carroll, 1989) or as a proclitic that appears phonetically as a bound morpheme (Hayes, 1989), such that the article and noun are perceived as a single phonological word (Costa & Caramazza, 2002). L2 learners, however, may hear an article and noun uttered in conjunction only a limited number of times. A substantial amount of their exposure to Spanish may involve lists of vocabulary, where each noun is followed by a parenthetical *f* or *m* denoting the noun class. Furthermore, they may develop rules of thumb for memorizing noun class information and gain relatively little practice at listening to and using language outside of a classroom setting. This could lead L2 learners to simply wait until the onset of the noun to identify potential referents. The massive differences in the nature and amount of input to children and L2 adults shed light on why L2 adults may not as readily use gender-marked articles in rapid sentence interpretation.

The present research explored how children, adult native speakers and adult second language learners in a simple referential context make use of morphosyntactic and semantic regularities in natural language interpretation. In

the morphosyntactic task, we found that Spanish-learning children with only a few hundred words in their productive vocabulary could more rapidly identify referents using informative prenominal gender marking. Native Spanish-speaking adults also showed this efficiency of processing, but adults learning Spanish as a second language did not. Semantic cues, however, develop more gradually: L1 adults demonstrated greater efficiency of processing than L2 adults, who in turn showed greater efficiency of processing than children, reflecting group differences in the nature and amount of language learning experiences.

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