Alien vs. Book: Humanoid sources elicit stronger grammar-source associations

Within a language, grammatical rules vary across conversational domains, individuals, and dialects. For instance, Standard American English speakers may encounter sentences like *The kitchen needs cleaned*, which is licit in some dialects in Appalachia and the midwestern US though not in Standard American English. Most psycholinguistic models would predict that language users can learn to comprehend this new regularity and indeed, some research on syntactic adaptation suggests that these adaptations may occur after short periods of exposure. However, less research has addressed how adult comprehenders learn to associate grammatical regularities with relevant context (e.g., the person who produces them). This study investigated the mechanisms of exposure-driven grammar learning in native English-speaking adults by examining brain responses to sentences that deviated systematically from English syntactic rules (e.g., *The ship was making noises...* vs. *The ship was makes noises…*; Table 1). The deviant sentences ("Novel Grammar") were produced exclusively and consistently by one of two humanoid (i.e., alien) or inanimate (i.e., book) sources while the other source produced only standard English grammar ("Standard Grammar") sentences. These manipulations allowed us to test the hypotheses that (1) participants would learn that the Novel Grammar is used frequently in the context of the experiment; (2) participants would learn that the Novel Grammar is used specifically by only one source; (3) participants' ability to learn which source uses the Novel Grammar would be superior for humanoid than for inanimate sources.

63 healthy young adult, native English-speaking participants read sentences in rapid serial visual presentation (RSVP) format, while 64-channel scalp EEG was recorded. Sentences were presented in an exposure phase and a test phase (Figure 1). The exposure phase presented 70 Standard Grammar sentences and 70 Novel Grammar sentences. Standard and Novel Grammar sentences were presented in distinct colors (e.g., Standard: green font; Novel: purple font). Moreover, Standard and Novel Grammar sentences were preceded by images depicting the putative sources of the sentences (e.g., Standard: green alien; Novel: purple alien). For each participant, sources were either two cartoon aliens or two unusually-shaped books (Figure 2).

The test phase presented 24 Novel and 24 Standard Grammar sentences. Sentences were accompanied by a single source, which was one of the two sources from the Exposure phase (some saw the Standard Grammar source and others saw the Novel Grammar source).

During the exposure phase, Novel Grammar sentences elicited a P600 ERP effect, relative to the Standard Grammar sentences ($p<0.001$, further statistics in captions of figures), which indicates that participants perceived the Novel Grammar forms as ungrammatical (Figure 3). The P600 ERP effect was larger in the first than the second half of the exposure phase ($p<0.001$), suggesting that participants have adapted to the presence of the Novel Grammar. The humanoid status of the source did not modulate this effect ($p=0.798$). This result suggests that presenting humanoid sources do not induce stronger adaptation to an unfamiliar grammar pattern than presenting inanimate sources.

During the test phase, the Novel Grammar P600 effect was larger for the Standard Grammar source than for the Novel Grammar source ($p=0.001$). This finding indicates that participants learned that the Novel Grammar forms were licit specifically in the context of the Novel Grammar sources. Moreover, the source-specific learning effect was modulated by the humanoid status of the source ($p=0.008$): The learning effect was significant for participants who were exposed to humanoid sources ($p<0.001$) but not for those exposed to inanimate sources ($p=0.603$). This finding suggests that humanoid sources do induce stronger associations between grammar and source than inanimate sources.

While a statistical account of language learning would predict that comprehenders would learn the association between grammar and source equally well in the humanoid and inanimate source conditions, this was not the case. We suggest this effect is the result of a connection between language learning processes and socio-cognitive processes that direct preferential attention to humanoid features.

Standard Grammar	*The spaceship I took to get here was making suspicious noises last night.*
Novel Grammar	*The spaceship I took to get here was makes suspicious noises last night.*

Table 1. Example sentences in standard American English grammar and the Novel Grammar.

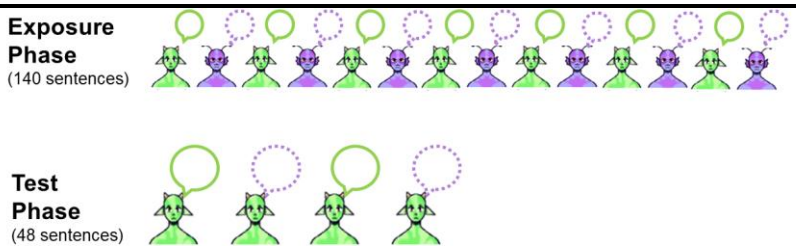

Figure 1. In the exposure phase, the source (purple or green) and grammar type (standard or novel) are perfectly correlated in 14 chunks of 10-sentences. In the test phase, one source now produces both Standard and Novel Grammar sentences, 24 sentences of each, in 12 sentence chunks. Only alien sources shown here, but participants would see aliens OR books.

Figure 2. Humanoid (alien) and non-humanoid (book) sources. Each subject saw alien OR book sources.

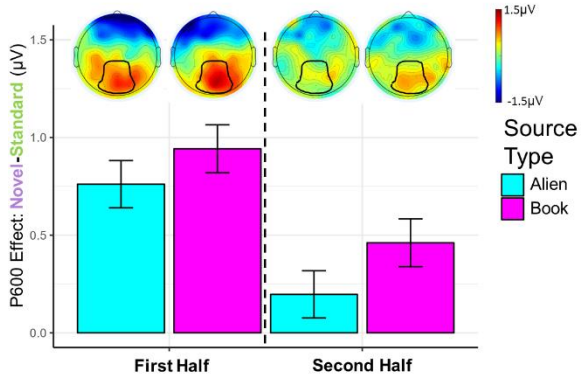

Figure 3. Exposure Phase Results. The ERP difference wave amplitude (Novel Grammar words minus Standard Grammar words) at nine posterior electrodes outlined on the scalp maps (CP1, CPz, CP2, P1, Pz, P2, PO3, POz, PO4) from 500-996ms post word onset, controlling for electrode, during the first (left) and second (right) halves of the exposure phase, distinguishing between participants who saw alien sources (blue) and book sources (pink). There was a significant P600 effect overall ($F_{1, 2135}$=94.26). The P600 effect was larger in the first half of the exposure phase ($F_{1, 2135}$=18.47). There was no significant interaction between the change in P600 between the first and second halves and the humanoid status of the source ($F_{1,2135}$=0.58).

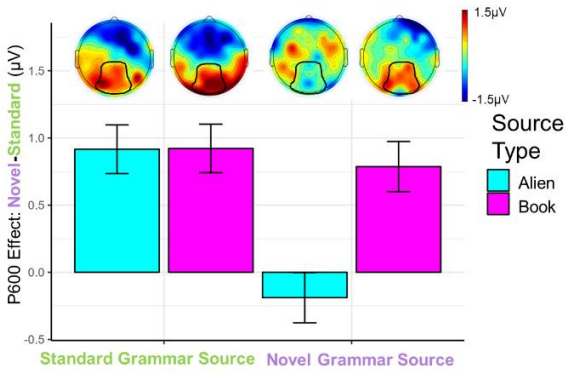

Figure 4. Test Phase Results. The ERP difference wave amplitude (Novel Grammar words minus Standard Grammar words) at nine posterior electrodes outlined on the scalp maps (same as Figure 3) from 500-996ms post word onset, controlling for electrode, for participants shown sources associated with Standard Grammar (left) and Novel Grammar (right), distinguishing between participants who saw alien sources (blue) and book sources (pink). There was a significant interaction between the P600 effect size and the source's grammar (the grammar associated with that source in the exposure phase), ($F_{1, 986}$=10.21). Participants shown the Standard Grammar source showed a significant P600 effect ($F_{1, 986}$=18.05), while those shown the Novel Grammar source did not ($F_{1, 986}$=0.27). The humanoid status of the source modulated this effect ($F_{1, 986}$= 6.96).