Producing during language learning affects comprehension

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The relationship between production and comprehension processes has become increasingly theoretically important (e.g., Pickering & Garrod, 2013). Opinions on the nature of the relationship range from minimally overlapping systems to full involvement of production in comprehension processes. Comprehension is known to affect production (Bock *et al.*, 2007), but evidence for the reverse is scant. However, the memory literature suggests several reasons to hypothesize that production could affect learning, in turn affecting comprehension if there is transfer between systems: (1) Comprehension involves recognition, while production involves recall, providing a stronger learning experience (Roediger & Karpicke, 2006). (2) Production is often more attention-demanding (Boiteau *et al.*, 2014), which may improve learning. (3) Hearing one's speech during production may also boost memory and learning (the Production Effect; MacLeod *et al.,* 2010). (4) The serial order planning involved in language production—ordering components of the to-be-produced utterance and holding them in memory during planning and production—may strengthen learning of serial order and dependencies among items, such as gender and number agreement. Our study sought to balance factors (1-3) across production vs. comprehension learning to investigate production in dependency learning, potentially affecting comprehension and informing the nature of the production-comprehension relationship.

English speakers (n=122) learned an artificial language set in an alien cartoon world (Fig. 1a). Participants learned 20 words of 7 different word types, gradually building up from single words to full sentences over the course of a 60-minute learning session. Four word types (Det, Adj, N, V) were marked with suffixes coding for number and a gender-like category (Fig. 1a; to conserve space, only number is shown, and Fig. 2 data are collapsed over dependency type; effects hold over both dependencies). Participants were randomly assigned to either a Production or Comprehension learning condition. Both conditions interleaved passive spoken language exposure with an active task. Comprehension participants performed a matching task, indicating whether an auditory phrase matched a picture onscreen. The Production task was describing a picture aloud in the artificial language. Both tasks were followed by feedback in the form of the picture paired with the correct auditory phrase. Thus to reduce factors (2-3) above, both tasks required an explicit choice (picture judgment/production), contained auditory information that might or might not match a picture (speech in the matching task/the participant's speech), and immediate auditory feedback. Moreover, to reduce factor (1), after training, we excluded all participants who did not reach 80% in a vocabulary screening test (8 comprehension and 10 production participants excluded). The remaining participants completed several further comprehension tests: a Forced Choice (FC) task with items testing Vocabulary in phrases and Suffix understanding (Fig. 1b), an Error Monitoring (EM) task with items testing Word Order and Suffix agreement errors (Fig. 1c).

Data were analyzed with mixed effects regression models (logit for accuracy data). Accuracy scores on the FC Vocabulary in phrases test (no significant differences between learning conditions, Fig. 2a) were used as a covariate in all further tests to control for vocabulary knowledge and thus further balance factor (1). Production participants were significantly faster, though not more accurate, than comprehension participants on EM Word Order items (Fig. 2c-d). Critically, in both the FC items testing Suffix understanding and the EM items testing Suffix agreement, Production participants were significantly faster and more accurate than Comprehension participants (Fig. 2e-h). Together, these results provide evidence for our hypothesis that production specifically benefits the learning of grammatical dependencies between words, beyond any differences in vocabulary knowledge. This informs theories of shared representations between comprehension and production processes: we show here that production practice can improve comprehension performance at the morphological level, which is consistent with significant overlap between production and comprehension representations.

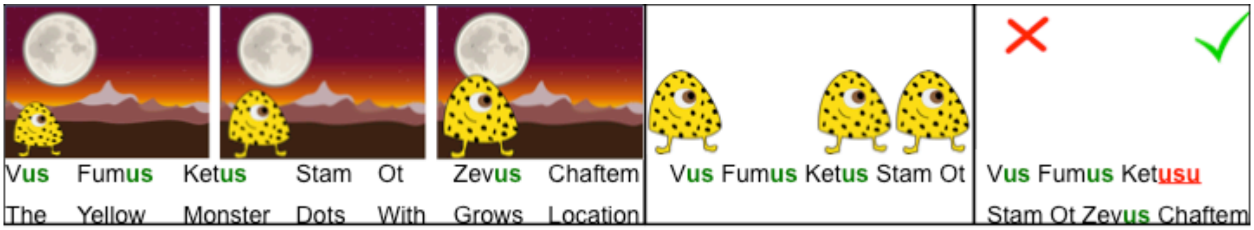

Figure 1. Example trials. In the real experiment, all language input was auditory, and participants never saw the written language. Aspects of the language were randomized so that each participant learned a unique language. a) Participants learn the language during passive exposure trials by seeing videos (represented here by still frames) and hearing phrases. b) Forced Choice Suffix item testing number understanding (**us** = singular, correct answer on the left) c) Error Monitoring Suffix item with a number agreement error on the third word (**usu** = plural); the correct response is the red **X**, indicating that the sentence contained an error.

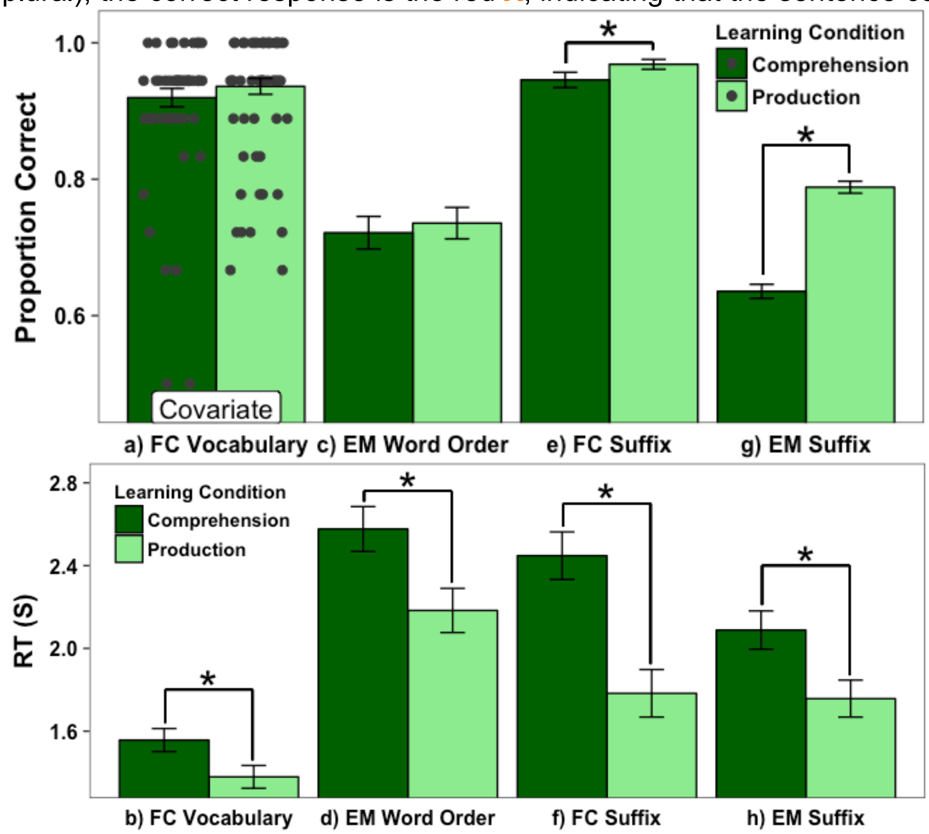

Figure 2. Accuracy and Speed for each of the trial types for both Learning Conditions (*p<0.05). FC=Forced Choice task (e.g., Fig. 1b), EM=Error Monitoring (e.g., Fig. 1c). In a) grey dots represent individual participant scores, which were taken as covariates on all other tests.

References

Bock, K., Dell, G. S., Chang, F., & Onishi, K. H. (2007). Persistent structural priming from language comprehension to language production. *Cognition*, *104*, 437–458.

Boiteau, T.W., Malone, P.S., Peters, S.A., & Almor, A. (2014). Interference between conversation and a concurrent visuomotor task. *JEP: General*, *143*, 295–311.

Roediger, H.L., & Karpicke, J.D. (2006). Test-enhanced learning. *Psych. Science, 17*, 249-255.

MacLeod, C.M., Gopie, N., Hourihan, K.L., Neary, K.R., & Ozubko, J.D. (2010). The production effect: Delineation of a phenomenon. *JEP: Learning, Memory & Cognition, 36,* 671-685.

Pickering, M.J., & Garrod, S. (2013). An integrated theory of language production and comprehension. *Behavioral and Brain Sciences*, *36*, 329–347.