L1 Lexical Semantic Knowledge Shapes Statistical Word Learning

Benjamin Zinszer (bzinszer@gmail.com)
Vic Tianlan Wen (twen1@swarthmore.edu)
Adrian Ferguson (nfergus1@swarthmore.edu)
Shinz Jo Ooi (sooi1@swarthmore.edu)
Swarthmore College, 500 College Ave
Swarthmore, PA 19081, USA

Shuchang "Coco" Liu (cliu1@haverford.edu)
Haverford College, 370 Lancaster Ave
Haverford, PA 19041, USA

Abstract:

Learners' performance on cross-situational statistical learning (CSSL) paradigms generally decreases when novel word-object input diverges from simple 1-to-1 mappings. Natural language learning reflects a similar limitation: Bilinguals often rely on direct translation of words from the first language (L1) to the second (L2) before learning L2-specific lexical semantic structures. We looked at the interface between learners' existing L1 lexical semantics and input from a brief CSSL task structured to simulate cross-language differences. When mappings violated English object naming norms, English monolinguals learned them more slowly than English-consistent mappings. Accuracy on in a 9-AFC test phase correlated with the English naming norms for the depicted objects.

Keywords: statistical learning; CSSL; lexical semantics; cross-linguistic; language learning

Introduction

Cross-situational statistical learning (CSSL) is a short experimental paradigm for testing mechanisms that support lexical semantic (word-to-world) learning (Roembke, Simonetti, Koch, & Philipp, 2023), but monolingual learners in CSSL studies do not readily acquire more than one set of word-object mappings unless explicitly cued to this structure (Poepsel & Weiss, 2014). The unique lexical semantic structures of bilinguals in two natural languages also indicates a single, highly interactive lexical semantic system (e.g., Ameel, Storms, Malt, & Sloman, 2005; Ervin, 1961). Early in second language learning, bilinguals rely more on direct word-word translation from the first language (L1) to the second (L2) than on L2 language-specific lexical semantic structure (Dong, Gui, & MacWhinney, 2005; Zinszer, Malt, Ameel, & Li, 2014).

Over time, changes in a bilingual's lexical semantic system reflect the distributional properties of input in both languages (Ameel, Malt, Storms, & Van Assche, 2009; Zinszer et al., 2014), much like CSSL on a shorter timeline. However, we are aware of only one study attempting to directly bridge existing lexical semantic structures from a natural L1 into a CSSL task: English speakers learn new verbs of motion more consistently when the novel verbs align with English lexicalization biases (George, Berry, Ciaccio, & Weiss, 2024). In the present study, we ask whether English monolingual learners will find simple object-word mappings more difficult to acquire via CSSL if the underlying structures are inconsistent with their existing English-based structures.

Method

We used Cloud Research's mTurk Toolkit to recruit 24 native speakers of U.S. English with no significant experience speaking a second language (mean age: 42 years, range: 25-76 years, 14 men and 10 women).

Stimuli

Images and pseudowords We selected thirty 400x400 pixel photographs of objects with high name agreement from Zinszer's (2014) study of translation ambiguity to meet the constraints of the experimental and control conditions described below. We pseudo-randomly generated a list of 24 CVCV pseudowords, spoken and recorded by a native English speaker stressing the second syllable to make them sound more unfamiliar.

Image-to-pseudoword mappings Names for images were assigned to violate English lexical categorization patterns in two ways: (1) Two images that share an English name were assigned different pseudoword names, the Expand condition, and (2) two images that did not share an English name were assigned the same pseudoword, the Collapse condition. Mappings in the experimental conditions were drawn from Mandarin naming norms of the same images, so that the to-be-

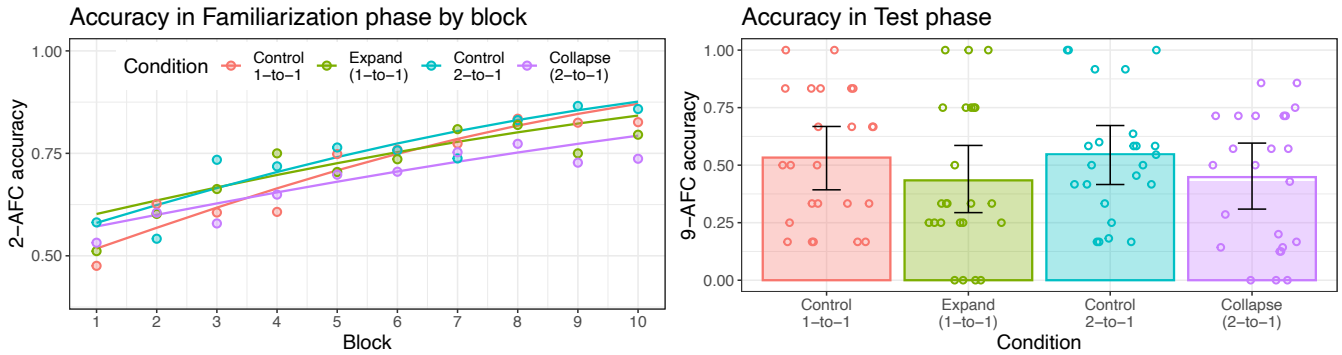

Figure 1: Mean accuracy (dots) and estimated marginal effects (lines & columns) in each phase of the task.

learned structures are known to be learnable, while being unfamiliar for English speakers (see examples in Table 1 below). Across the 24 participants, images were rotated across the Expand and Collapse conditions.

These conditions resulted in different numbers of images per word (Expand, one image per word, or 1-to-1; Collapse, 2-to-1), so we created two Control conditions in which pseudowords were assigned to images consistent with English naming patterns. In Control 1-to-1, one image was paired with a single pseudoword. In Control 2-to-1, two images with the `same dominant name in English were paired with the same pseudoword name in the task. Control images were selected for distributions of naming norms as the Experimental images: name entropy, image typicality, object familiarity, and visual complexity.

Procedure

In the familiarization phase, participants learned four Expand words, four Collapse words, six Control 1-to-1 words, and six Control 2-to-1 words. Familiarization trials were divided into 10 blocks of 2-alternative forced-choice (2-AFC) trials without feedback. In each block, all 20 pseudowords were heard once with a corresponding image as target and a distractor image corresponding to another pseudoword. A 9-AFC test phase followed with one trial for each of 30 target images and eight randomly selected distractor images.

Table 1: Example pseudowords and images used to create either the Expand or Collapse condition.

Expand	Collapse	English	Chinese	Image
not used	mau'li	backpack	包	
kai'nau	mau'li	bag	包	
ni'sai	*not used*	bag	袋	

Results

We estimated mixed-effects binomial regression models and marginal effects for all trials in the familiarization and test phases using the `lmerTest` (Kuznetsova, Brockhoff, & Christensen, 2017) and `emmeans` (Lenth, 2023) packages for R. Because the naming norms were not perfectly balanced between conditions, we included them as fixed effects in the models and report estimated marginal effects of the target conditions while holding norms at their mean values with multivariate *t*-statistic correction. Analysis code and data are shared on OSF: https://osf.io/8v9h6/

Mappings in the experimental conditions were learned more slowly than control conditions across the 2-AFC trials (Condition*Block, p=0.024). Figure 1 illustrates condition-level average accuracy and the estimated marginal slopes. Given a significant interaction between condition and size (Experimental vs. Control, 2-to-1 vs. 1-to-1; p=0.010), we examined accuracy of each condition in the final familiarization block. Estimated marginal mean of accuracy in Collapse (79.2%) was significantly lower than in Control 2-to-1 (87.6%, p<0.001), but this difference was not significant for Expand vs. Control 1-to-1 (84.2%, 87.1%, p=0.1862).

In the 9-AFC test phase, we found only a marginally significant difference in estimated mean accuracy between the experimental (44%) and control conditions (54%, p=0.082) and no difference in accuracy between the size (p=0.771) when naming norms were held at their average values. Given a significant interaction between name entropy and condition (p=0.036) and the over-representation of 0-entropy objects in the stimulus set, we also compared conditions at one standard deviation above the mean name entropy (0.59). Here, estimated accuracy of experimental (40%) and control conditions (60%) significantly differed (p=0.006).

Discussion

Performance in a CSSL task was systematically shaped by lexical semantic norms of participants' first language (L1). Dong et al. (2005) observed that bilingual learners relied largely on L1 lexical semantic relationships when making judgments about meanings of L2 words, and Zinszer et al. (2014) described this transition from L1- toward L2-like lexical semantics in terms of the distributional regularities of the input: name agreement and competitor names identified in each language. Likewise, here we found that L1-violating structures were learned more slowly and accuracy was sensitive to specific naming norms obtained from the L1 for target objects. Like George et al. (2024), we found evidence for an interface between established L1 lexical semantic knowledge and the word-to-world mappings learned in CSSL.

Acknowledgments

This work was supported by a Faculty Research Grant from Swarthmore College (PI: Zinszer).

References

Ameel, E., Malt, B. C., Storms, G., & Van Assche, F. (2009). Semantic convergence in the bilingual lexicon. *Journal of Memory and Language, 60*(2), 270-290.

Ameel, E., Storms, G., Malt, B. C., & Sloman, S. A. (2005). How bilinguals solve the naming problem. *Journal of Memory and Language, 53*(1), 60-80.

Dong, Y., Gui, S., & MacWhinney, B. (2005). Shared and separate meanings in the bilingual mental lexicon. *Bilingualism: Language and Cognition, 8*(3), 221-238.

Ervin, S. M. (1961). Semantic shift in bilingualism. *The American Journal of Psychology, 74*(2), 233-241.

George, N. R., Ciaccio, S., Berry, L., & Weiss, D. J. (2024). The effect of lexicalization biases on cross-situational statistical learning of novel verbs. *Language and Cognition*, 1-19.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest Package: Tests in linear mixed effects models. *Journal of Statistical Software, 82*(13), 1-26. doi:10.18637/jss.v082.i13.

Lenth, R. (2023). *emmeans: Estimated marginal means, aka least-squares means.* R package v1.8.7. https://CRAN.R-project.org/package=emmeans

Poepsel, T. J., & Weiss, D. J. (2014). Context influences conscious appraisal of cross situational statistical learning. *Frontiers in Psychology, 5*, 88133.

Roembke, T. C., Simonetti, M. E., Koch, I., & Philipp, A. M. (2023). What have we learned from 15 years of research on cross-situational word learning? A focused review. *Frontiers in Psychology, 14*, 1175272.

Zinszer, B. D. (2014). Lexical semantic variation and cross-language interaction in categorization. Doctoral dissertation. https://etda.libraries.psu.edu/catalog/23595

Zinszer, B. D., Malt, B. C., Ameel, E., & Li, P. (2014). Native-likeness in second language lexical categorization reflects individual language history and linguistic community norms. *Frontiers in Psychology, 5*, 103809.