# Phonetic substance in alternation learning: comparing learning bias across linguistic domains

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A growing body of research takes an interest in the domain-generalness of learning bias. One direction to look at is the comparison between phonology and syntax. Although studies in both domains describe the major sources of learning bias as structural complexity and naturalness [1, 7, 8], scholars do not agree on whether and how the nature of the sources differs across the two domains. Heinz and Idsardi [4, 5] stated that syntactic patterns are inherently more complex than phonological patterns. On the other hand, Do et al. [3] argued that only phonological naturalness is grounded in physical phonetic properties. The current study contributes by examining and comparing the realization of both structural bias and naturalness bias in the acquisition of syntactic and phonological patterns.

We recruited native Hong Kong Cantonese speakers for online artificial language learning experiments. Participants were randomly assigned to one of 8 experimental conditions – 4 syntactic (Table 1) and 4 phonological (Table 2). The syntactic conditions were modified from the four-way word order variation with {adjective, noun} phrases and {numeral, noun} phrases in [2]. Each condition was given two labels: 1) whether the word order of the two types of phrases was harmonic and 2) whether this word order was semantically natural. For the phonological conditions, a four-way tonal process variation was constructed with tonal assimilation and dissimilation so that it is structurally comparable with the syntactic variation. Likewise, the conditions were distinguished with 1) whether the type of tonal processes applied to low and high tones were harmonic and 2) whether the tonal processes were phonetically natural. Participants were instructed to memorize descriptions of bare (e.g., 'bear') and colored/multiple (e.g., 'a red bear' or 'four bears') alien objects with visual and auditory stimuli and were tested on their acquisition thereafter. The experiments consisted of three blocks. The first two blocks focused on familiarizing participants with nouns (e.g., 'bear') and modifiers (e.g., 'red/four'), while the final block assessed how well participants acquired the target patterns (word order or tonal alternation of 'a red bear' or 'four bears'). The production data from 151 successful participants was coded and cross-checked by native Cantonese speakers and included in the analysis.

Results are shown in Fig. 1. The analysis was conducted on the accuracy rates of the four conditions in noun testing, modifier testing, and target alternation testing. Pairwise comparisons of the conditions in noun testing and modifier testing did not show any significant differences ($p > 0.189$). Likewise, all pairs of comparison in the target testing of the syntactic conditions exhibited no significant difference in post hoc tests ($p > 0.595$). In contrast, in target testing of the phonological conditions, learners in the structurally disharmonic and phonetically unnatural condition performed significantly worse than those in the structurally harmonic and phonetically natural condition ($p = 0.008$) or the structurally harmonic but phonetically unnatural condition ($p = 0.005$).

The acquisition of the syntactic variation was nearly perfect, indicating that neither structural complexity nor naturalness played a role in the syntactic learning of our participants. This differed from the results in [2] because our study employed a categorial design where learners could easily reproduce linguistic variants to match input statistics [6, 9, 10, 11]. However, when it came to phonological acquisition, we observed poorer learning when the target pattern was structurally complex and phonetically unnatural, suggesting the presence of learning bias in the phonological learning conditions. We explain the diverging manifestation of learning bias in phonology and syntax with the hypothesis by Wilson [12] that learning bias in phonology is motivated by phonetic substance, and, accordingly, learning bias in syntax is not. Importantly, in our study, the phonetic substance becomes relevant to phonological learning when the input grammar is structurally complex.

**Table 1.** Word order variation

| | Noun(H)-Adjective(H)→H-H | Adjective(H)-Noun(H)→H-H |
|---|---|---|
| Noun(H)-Numeral(H)→H-H | Harmonic Natural | Disharmonic Unnatural |
| Numeral(H)-Noun(H)→H-H | Disharmonic Natural | Harmonic Unnatural |

**Table 2.** Tonal process variation

| | Modifier(H)+Noun(H)→H-H | Modifier(H)+Noun(H)→H-L |
|---|---|---|
| Modifier(H)+Noun(L)→H-H | Harmonic Natural | Disharmonic Unnatural |
| Modifier(H)+Noun(L)→H-L | Disharmonic Natural | Harmonic Unnatural |

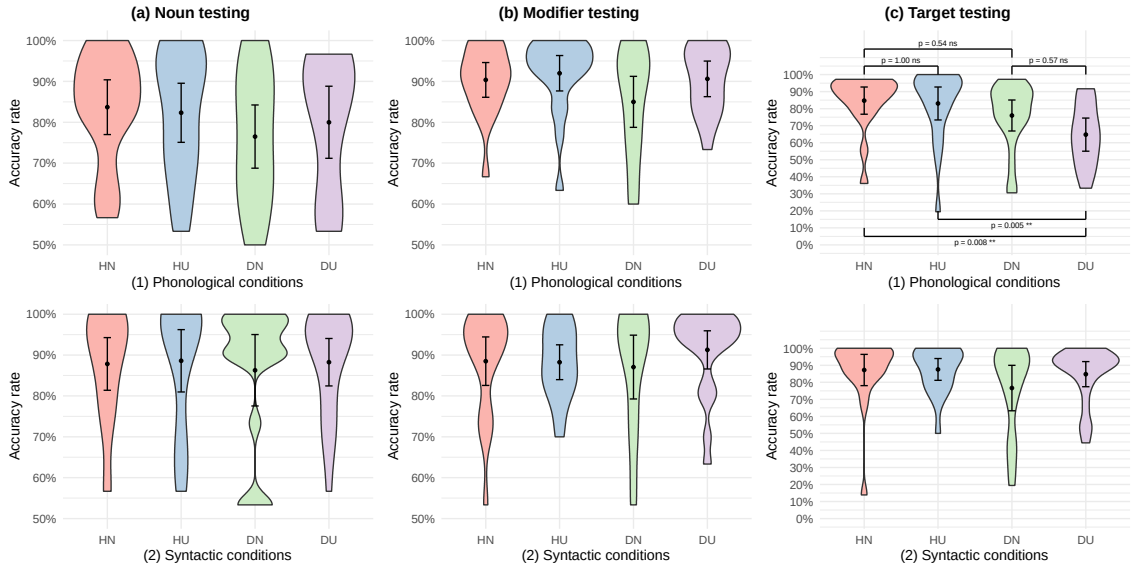


**Fig. 1.** Accuracy rates across conditions in three tests. Conditions from left to right: Harmonic Natural (HN), Harmonic Unnatural (HU), Disharmonic Natural (DN), Disharmonic Unnatural (DU).

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