

RESEARCH ARTICLE**Applied linguistics and cognitive processing Skills in Language Learning and Teaching: A case study of EFL Students**

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Abstract

Applied linguistics and cognitive processing Skills in Language Learning and Teaching, it is a languages exhibit numerous statistical universals due to language relatedness, innate properties, cognitive biases, functional pressures, and diachronic processes, despite their diverse nature. This research utilizes artificial language learning to explore the cognitive foundations of word order universals, a challenge that is often difficult to establish solely from historical and typological data, as causal links are difficult to establish. The study presents three artificial language learning experiments that investigate the connection between cognition and cross-category harmony, a statistical typological universal that describes the correlation of word order across different types of phrases within a language. The study examines the learning bias in harmony between two pairs of phrase types: verb phrase and ad positional phrase, a strong case of cross-category harmony in typology, and verb phrase and noun phrase consisting of an adjective and a noun, which has been previously rejected. The study reveals that learners exhibit a weak bias towards harmony between verb and object order and ad position and noun order, primarily due to high semantic similarity between adjectives and verbs, despite a preference for harmony between verb and object order and ad position and noun order. The students have selected at the EFL-University Hyderabad they are EFL students. They have come from various universities and they came to India to participate a training course it was an experimental study.

The study reveals that the preference for cross-category harmony in adjectives is not solely based on syntactic concepts like head and dependent, but also on a general cognitive bias favouring consistent order and cross-category similarity, rather than solely influenced by active adjectives.

The study presents three experiments examining the learning bias for a specific order of numeral, numeral classifier, and noun. Typological research indicates that only orders where numeral classifiers are adjacent to numerals are attested among the six possible ways. The study distinguishes between different syntactic status analyses of numeral classifiers, focusing on whether they combine with numerals first or nouns first. However, typological evidence is not reliable due to geographical constraints and potential language contact in numeral classifiers. The study conducted three artificial language learning experiments to investigate whether learners show a preference for word order

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patterns predicted by two competing analyses and if their preference matches the typology tendency observed. Results showed that learners do not have a reliable preference for these predicted word order patterns. The research suggests that the absence of bias across participants may not indicate a universal underlying structure for the phrase consisting of three elements across languages. However, mixed evidence suggests that cognition may partially shape the distribution of language structures, such as harmony. An artificial language approach helps us understand the role of cognition in shaping language features, enabling us to adjudicate between various factors, such as classifier order and language contact.

Keywords: Applied Linguistics, Artificial Language Learning ,Cognitive Processing ,Cross-Category Harmony ,Word Order Typology

Introduction:

Applied linguistics and cognitive processing Skills in Language Learning and Teaching, it is a Human languages exhibit significant diversity across all levels of the language system, but this diversity is not without limitations, as some linguistic patterns are repeated in different languages, while others are rare or unattested. Since Greenberg's 1963 work on word order, numerous typological universals have been generalized through cross linguistic comparisons. Two examples from Greenberg's work include the prepositional nature of languages with dominant VSO order, as observed in both word order and morphology. Languages with normal SOV order are postpositional, with a higher than chance frequency. No language has nonzero allomorphs in the plural, while some express the singular only by zero. The Universal 35 in Greenberg 1963 outlines typological universals that limit language variation, such as the placement of ad positions in languages with different basic word orders.

VSO languages, such as Irish, strongly use prepositions, while SOV languages, like Japanese, primarily use postpositions. Additionally, there is an asymmetric coding of singular and plural meanings across languages, with zero marking for singular in English and less frequent for plural. Linguistics aims to understand the origin of universals in human languages. Various explanations have been proposed, including language relatedness, innate properties, cognitive biases, functional pressures, and diachronic processes. These explanations aim to explain the unique characteristics of human languages. The text briefly discusses various methods for explaining typological universals, highlighting that genealogical and areal relatedness are crucial sources of data non-independence in typological samples, as highlighted by Bickel and Guzmán Naranjo & Becker.

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Languages with shared historical origin and those in contact often exhibit greater similarity due to shared features from the ancestral language, while languages in contact exhibit similarities beyond random chance due to mutual influence through processes like borrowing or copying.

Long-term contact can lead to the formation of a Linguistic Area in genetically unrelated languages. This issue of data non-independence in language samples has been a concern for typologists. To address this, various sampling and statistical methods, such as stratification sampling and diversity, have been proposed to mitigate the influence of data non-independence in typological samples.

The use of these methods revealed that universal cross-linguistic similarities were actually caused by genealogical and areal factors, such as the relation between verb+object order and noun+adjective order. The assumption that the order between verb and object is correlated with the order between noun and adjective in verb-object languages (VO) and noun-object languages (OV) has been challenged by Dryer's research using stratification sampling, revealing no global correlation. Dryer explains that the misunderstanding stems from the dominant word order patterns in different regions: VO languages in south-western Europe, southeast Asia, sub-Saharan Africa, and Australia have the N-Adj order, while most OV languages in Asia have the Adj-N order.

GuzmánNaranjo& Becker (2022) utilized hierarchical phylogenetic regression models to investigate the potential impact of verb-object order on affix position, despite no observed patterns outside specific regions, despite the lack of rigorous testing. GuzmánNaranjo& Becker (2022) compared a model with verb+object order as a predictor to one that included verb+object order, genealogical relations, and areal closeness, based on Dryer's data. The two models show different conclusions: the model with verb+object order as the only predictor suggests verb+object order affects affix position, while the model with all three predictors suggests no effect. The study reveals that the impact of verb+object order on affix position can be overestimated when genealogical and areal biases are not controlled, leading to a false correlation.

Typological universals, which do not stem from genetic or areal relatedness, can be attributed to an innate Universal Grammatical (UG) of human language. This hypothesis suggests that children possess a universal language faculty, resulting in all languages being nearly identical, largely fixed by the initial state. The Principles and Parameters framework explains a child's a priori language knowledge as a combination of universal principles applicable to all languages and specific parameters determined by specific languages, such as word order correlation. The Head-directionality parameter, a binary parameter, can only be set to head-initial or head-final in a language. In head-initial languages, syntactic heads consistently precede their complements, while in head-final languages, syntactic heads follow their complements. VSO languages are head-initial. Adpositions in SOV languages are head-final, with the syntactic head (verb) following its complement (object). This means that the head ad position should also follow its complement in adpositional phrases, reflecting the innate Universal Grammar, which is the natural world order correlation between the two. The

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explanation imposes strict limitations on human language, as all languages' grammars are derived from Universal Grammar, making any conflicting grammars biologically impossible.

The explanation suggests that the language faculty is a specific module of the human mind, independent of other cognitive and perceptual abilities, and its constraints are domain-specific, referring only to human language. The text suggests that typological universals are influenced by human cognition biases, including those in language learning, processing, and communication. It suggests that language structures that are easier to learn, process, or produce are more likely to be preferred by individual learners or speakers. Cultural evolution can lead to individual biases becoming typological universals at the population level. Language learning plays a role in this process, with research suggesting that learning biases of individual learners partially drive the formation of typological universals. Learners exhibit biases in language learning, aligning with cross-linguistic tendencies. The simplicity bias suggests that learners prefer simpler explanations and consistently place similar objects in the same position, demonstrating a linearization bias in non-linguistic domains. This bias is similar to correlations between head and complement order in linguistic phrases.

This research focuses on the role of learning in explaining language universals. Previous studies on natural language acquisition have shown patterns in language learning that are somewhat consistent with typology, as demonstrated by Jakobson, Clark, Luján et al., Clark, van Lier, and Diessel&Tomasello. Jakobson (1968) was a pioneer in observing the correlation between children's first language acquisition patterns and typology, demonstrating that the order of phoneme acquisition is similar to global tendencies, such as the existence of fricatives and stops. Hawkins (1987) proposes the Universal Consistency Principle, stating that children typically acquire stops earlier than fricatives, arguing that any stage in first and second language acquisition should align with universals based on synchronic evidence. The Noun Phrase Accessibility Hierarchy is a widely recognized typological universal that has been studied extensively to determine its impact on first and second language acquisition.

Jäger&Wahle (2021) argue that Dunn et al. (2011)'s results cannot be used to determine if word order correlation patterns are universal, as they do not compare models that differ in their assumption of correlations across language families. Jäger&Wahle (2021) conducted a re-assessment of eight word order features to determine if there are consistent correlation patterns across languages, using a more representative sample of 1,626 languages, including both large families and small isolate languages. The study used two models for word order pairs: a universal model, where the word order correlation is consistent across all lineages, and a lineage-specific model, where the correlation varies in each lineage. The universal models were found to be more accurate in many instances. The study confirmed previous typological research's findings on cross-category harmony in human languages, indicating consistent correlations between thirteen phrases pairs.

Over the past few decades, numerous explanations have been proposed to explain the existence of cross-category harmony in various types of phrases. This concept has been central to

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the debate in linguistics and cognitive science about the extent to which language is influenced by the human cognitive system. Existing explanations can be categorized into cognitive explanations and historical or diachronic explanations. Cognitive explanations suggest that cross-category harmony is influenced by linguistic or cognitive factors, reflecting a high-level head-dependent rule in the minds of language learners and users. Vennemann's Natural Serialization Principle (1974) suggests that languages serialize operator-operand pairs in a consistent abstract word order schema, either operator before operand or operand before operator. This concept is also reflected in the Head-direction parameter in the Principles and Parameters linguistic framework. The theory suggests that a language can set a high-level parameter to head-initial or head-final, resulting in cross-category harmony across phrases. A learner can observe a single instance of SVO order and determine the appropriate parameter setting.

The Head-direction parameter, a domain-specific constraint on human language, predicts language types. However, it has been criticized for widespread exceptions and not all types of heads across phrase types have correlated order, as cross category harmony is a statistical universal. Dryer's Branching Direction Theory, developed in 1992, explains non-correlation in language by focusing on alignment of categories that share the property of being phrasal or not, rather than syntactic notions of heads and dependents. This theory suggests that harmony is not based on these concepts. Lexical and phrasal categories in language are related to the order of verbs and objects, with nouns and adjectives not necessarily aligning with the order of verbs and objects. However, if verbs and nouns are syntactic heads, these categories would likely align, as per Dryer 1992 and Jäger & Wahle 2021. The theory suggests that adjectives and nouns in noun phrases are lexical categories, meaning they don't align with verbs. However, this theory still faces challenges, as the exact alignment in phrases with a correlation tendency remains an open question.

Experiment 1 focuses on the harmony between verb and object and adposition and noun order. Typological survey data indicates that languages align verbs with adpositions and objects with nouns in adpositional phrases. These orders significantly outnumber alternative orders, as shown by Dryer (2013h). The former two orders are referred to as harmonic, while the latter is non-harmonic, following previous literature on harmony. The cross-linguistic trend for harmony has been validated by various methods controlling for genetic and areal relationships between languages, as raw counts can be misleading. The study investigates the robust trend of learners favoring harmony, i.e., consistent order for verbs and adpositions in phrases, by testing the hypothesis of individual learners' bias.

The study involves training learners on the order of verb and object in a new artificial language, and then requiring them to produce adpositional phrases based on their knowledge of the lexicon, without explicit evidence about the order between adposition and noun. Our hypothesis predicts that learners trained on VO order will infer PrepN order, while those trained on OV order will infer NPost order. However, alternative explanations for harmony do not make this prediction, as diachronic explanations do not predict analogy between phrases. The cognitive explanation of

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dependency-length minimization does not predict inferences in the task, as participants are not required to produce or comprehend utterances with both phrases present together.

The experiment targeted native English and native Mandarin speakers, who are likely to favor the harmonic VO and PrepN order when learning a new artificial language, given English's harmonic VO and PrepN order. The study aimed to test an additional population with active experience of non-harmony in this domain, as they may favor any harmonic pairing of orders, given their experience with harmony in this domain. Mandarin is a non-harmony, VO language with prepositions denoting thematic roles and postpositions denoting specific locations, as it is considered a VO language, as noted by various researchers.

(3) (zai)

atmendoor *(hou) behind kan read shu book

'read a book behind the door'

In (3), the object shu ('book') is followed by the verb kan ('read'). There are two adpositions: a preposition zai ('at') and a postposition hou ('behind'). The preposition can be omitted in certain contexts. The study demonstrates that when a phrase is used in isolation, the preposition zai ('at') is optional, while the postposition hou ('behind') is required, as shown in (3) and (4), respectively. Mandarin speakers have experience with both harmony (PrepN order) and disharmony (NPost order) in this domain, with obligatory postpositions potentially reinforcing the non-harmonic order. The experiment's results may be influenced by participants' native language, resulting in a weaker harmonic preference for Mandarin learners trained on VO order or a weaker bias compared to English speakers. A strong preference for harmony, regardless of native language background or participants' training on VO or OV order, indicates a cognitive bias towards harmony between these two types of phrases. Table 2.1 summarizes the predictions of a harmony bias and L1 effect for both English and Mandarin speakers in Experiment 1, based on the conditions of Harmony L1, Harmony L1, VO PrepN, PrepN, PrepNNPost, and PrepNNPost.

The study predicts the order of adposition and noun in Experiment 1 based on harmony bias or L1 effect for both populations. It suggests that English speakers may prefer NPost in the OV condition if they prefer harmony over specific L1-like orders. The study emphasizes the significance of Mandarin participants who have experienced non-harmony in this domain, and the experiment, including hypotheses, predictions, and analysis plan, was preregistered at the Open Science Framework for both English and Mandarin speakers. The study employed the extrapolation paradigm, where learners are exposed to new language examples but critical evidence for the structure of interest is held out, requiring them to extrapolate from their learning to the held-out data during the critical test. The experiment involved learners learning nouns, verbs, adpositions, and relative order of verbs and objects in a miniature artificial language. In a critical test, they were asked to produce utterances with adpositions and 52 nouns.

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The lack of information on adposition and noun order allows for both prepositionnoun and noun-postpositon orders, indicating learners' preference for harmonic order between these two phrase types during the testing phase. The artificial language consists of four inanimate nouns, four verbs (kick, push, point, punch), and four adpositions (behind, in front of, left of, and right of). Some adpositional meanings can be expressed using postpositions in Mandarin, making them non-harmonic with the verb phrase order (VO). Participants were given novel objects to avoid translating into their native language, and all lexical items were disyllabic and phonotactically possible in both English and Mandarin. The correspondence between artificial words and meanings was randomized for each participant. The text provides a comprehensive description of the artificial language, including its noun verbs, adpositions, and a lexicon, presented orthographically to participants.

Participants were randomly assigned to either VO (head-initial phrases) or OV (headfinal phrases) conditions. In VO, they were trained on head-initial phrases with a verb followed by an object noun, while in OV, they were trained on headfinal phrases with an object noun followed by the verb. The language lacks overt subject nouns, with verb phrases consisting of a verb and an object, and the subject noun is omitted. The same boy performs the action and is used to illustrate adposition meanings. The language used in Zhao & Fedzechkina (2020) was presented to participants both auditorily and orthographically, differing from the language used in this study with overt subjects and agents. A Vietnamese native speaker pronounced words, making them novel to English and Mandarin speakers. Sound files of verb phrases were obtained by concatenating verbs and nouns. Figure 2.1 illustrates visual stimuli, including nouns, verbs, and verb phrases as images of a novel object, a boy's action (e.g., punching), and the action on the object. The training involved illustrating adposition meanings through four images of a boy standing at the same position relative to an object.

These images were used to elicit specific adpositional phrases during a critical test. The direction of the action on the object was counterbalanced, with half of the images being rightward and the other half being flipped.

The experiment, presented using PsychoPy, involved participants learning a new language for 40 minutes. They were seated in a quiet room, wore headphones, and played experimental audio through headphones. The experiment had five phases. The study involved noun training, verb training, verb phrase training, adposition training, and adpositional phrase testing. Participants were trained on nouns in isolation for the first phase, with 10 trials for each of the four nouns presented in random order. Participants were exposed to a novel object and its corresponding label in a new language, and instructed to repeat the word after hearing it. After exposure trials, they were tested on their learning, with eight trials for each of the four nouns presented in random order. Participants were shown a picture of an object and asked to say the word for it, and their responses were recorded. Feedback was provided in the form of correct responses, regardless of whether the response was correct or incorrect. In Phase II, participants were trained on verbs in isolation, following the same

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procedure and trial number as the noun 55 training and testing phase. They were instructed to learn a word describing the boy's actions in each trial.

Phase III involved participants training and testing verb phrases, with each verb phrase presented in random order. Participants were instructed to see a picture of a boy performing an action to an object and hear the corresponding utterance to describe the action. The study involved verb phrase training and noun and verb training. After training, participants were presented with two matching testing phases. Each trial involved four pictures of a boy performing an action to an object. Participants were asked to choose the picture that matched the description of the utterance. The study involved matching trials where the correct picture was marked with a checkmark, and the non-matching picture with a cross. Participants were also given a correct sound if their answer was correct, and an incorrect sound if it was incorrect. Participants were tested on verb phrase production, with two trials for each of 16 verb phrases presented in random order. During each trial, participants were shown a picture of a boy performing an action to an object they had previously seen. Participants described a boy's performance and recorded their responses. Feedback was provided on each testing trial, regardless of correctness. In Phase IV, participants were trained on adpositions in isolation, followed by testing in isolation. The training phase involved identical procedures and trials, with participants shown four pictures at a time in each trial, with the boy maintaining the same position relative to an object, as depicted in Figure 2.1. Participants were trained to identify a boy in pictures, and during testing, 56 participants were shown four more pictures and asked to identify the boy's location.

In Phase V Adpositional phrase testing, participants were presented with a picture of a boy positioned relative to an object, with four trials for each of 16 adpositional phrases. They were instructed to describe the full picture with two words and their productions were recorded.

Participants completed an experiment and were asked to translate artificial verbs and adpositions into their native language, list any languages they use, and rate their proficiency. No feedback was provided. The experiment involved 52 native English and 44 native Mandarin speakers from the University of Edinburgh, who were compensated with £8 for completing the experiment. Participants with an average accuracy below 75% in non-critical testing phases were excluded from data analysis ($N = 4$). One participant was excluded due to failure to follow instructions, producing only one word at the critical testing phase. Five English participants were excluded due to their Mandarin proficiency in the post-experimental questionnaire, resulting in 86 total participants (native English speakers, native English speakers, native Mandarin speakers, native Mandarin speakers, and native Mandarin speakers, with VO condition and OV condition).

The study involved critical and non-critical testing phases, requiring participants to create a novel phrase type with an adposition and noun, as well as testing vocabulary learning for all categories and verb phrase word order. The study found high accuracy (over 95%) in all non-critical testing phases, with a focus on the critical testing phase, where each production was coded as either harmonic or non-harmonic based on the participant's training condition. The study coded PrepN order

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as harmonic in the VO condition and non-harmonic in the OV condition, with 30 productions conducted, with English speakers having 5 productions in the VO condition and 1 in the OV condition. The study excluded 12 populations with single or two words that couldn't be identified from analysis, focusing on the proportions of harmonic order produced by the two populations in the VO and OV conditions, as shown in Figure 2.2.

The study compared the probability of producing harmonic order in adpositional phrases among English and Mandarin-speaking participants using a Bayesian hierarchical logistic regression model, fitted using Stan modelling language and the brms package in R. The study analyzed the harmonic order in adpositional phrases, the condition (VO vs. OV, sum-coded), and the population (English vs. Mandarin, sum-coded), and their interaction, with the dependent variable being the order produced in the adpositional phrase. The model in this paper included both by-participant and by-item random intercepts, which are the two most common random intercepts in all models. The study compares the proportion of responses using harmonic order in the adpositional phrase across two conditions and populations in Experiment 1, with harmony corresponding to PrepN in the VO condition and NPost in the OV condition. Error bars indicate 95% confidence intervals. Harmonic responses are more frequent than non-harmonic ones, regardless of condition and population. To investigate this, four sampling chains were run for 3500 iterations with 1750 warm-up iterations, yielding 7000 samples for each parameter in the posterior distribution, based on previous research's divergent outcomes.

The study reports expected values for each effect based on the model's estimated coefficients and 95% credible intervals. The model posterior distribution supports three results: native Mandarin speakers likely have a weaker preference for harmonic order than native English speakers, but this difference is not reliable ($\beta^{\wedge} = -2.14$, CI = [-7.46, 2.56]). The study found that learners' preference for harmonic order in the OV condition is weaker than in the VO condition, and the difference is likely to be larger for English speakers than for Mandarin speakers, but this difference is not reliable. The model estimated the mean probability of harmonic order in adpositional phrases in English and Mandarin-speaking participants, with 95% confidence intervals around these probabilities. The study found that both English and Mandarin-speaking participants produced harmonic order in adpositional phrases in both VO and OV conditions. The VO condition had a $\beta^{\wedge}$ of 26.33, CI of 13.95 to 46.62, while the OV condition had a $\beta^{\wedge}$ of 20.39, CI of 9.76 to 37.64, and CI of 8.73.

In Experiment 1, native English and Mandarin speakers were taught a new lexicon with verbs, nouns, and adpositions. They were taught either VO order or OV order in the verb phrase. The study found that English has harmonic order between PrepN and VO phrase types. Mandarin has VO order but optional prepositions and obligatory postpositions for meanings tested. The order is potentially nonharmonic, NPost and VO. A bias for harmony is predicted in both populations, indicating a strong typological tendency for harmony between these phrase types. The study found that both English and Mandarin speakers had a similar bias for harmony in the VO condition, despite the differences in their language proficiency. This suggests that both languages can effectively communicate

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harmony. Mandarin-speaking learners tend to produce harmonic orders when taught the VO order and NPost order, regardless of L1 knowledge. However, the preference for harmonic order is stronger in the VO condition, where the verb phrase follows the native language order, indicating a strong bias for this order.

The study suggests that English speakers may be influenced by the parallel nature of VO and PrepN to English, while Mandarin speakers may be influenced by L1 experience, with the bias predicted to be for NPost. In Mandarin, postpositions are mandatory for location information, while prepositions are optional. It is predicted that Mandarin learners may prefer non-harmonic NPost order in the VO condition. The study suggests that the impact of L1 experience on this task may not be strong, and that native Mandarin speakers may find PrepN order more salient, as prepositions are more frequent in discourse, despite being optional. The study found that despite the possibility of NPost order with VO, Mandarin speakers did not exhibit reduced harmony in our task. The study found that native Mandarin-speaking participants were proficient English speakers, suggesting that the harmonic order of their L2 may influence their behavior. The study analyzed proficiency ratings in English from 1 to 10 on a scale.

The study used a hierarchical Bayesian logistic regression model to predict the likelihood of Mandarin-speaking participants producing harmonic order in ad positional phrases, considering their English proficiency, VP order training, and interaction. The study used four sampling chains for 5000 iterations, with 2500 warm-up iterations for each chain. The model posterior distribution showed no reliable effect of English proficiency on harmonic order probability. It was also confirmed that learners acquired ad positional meanings as intended, not as verbs. The study analyzed learners' responses to a post-experiment questionnaire, which asked them to translate artificial adpositions into their native language, to understand their interpretation of cross-category harmony. The study reveals that English speakers mostly translated artificial adpositions into English adpositions, while 16 Mandarin speakers' responses were relatively consistent, as shown in Table A.19 and Table A.20 in Appendix A.3. The study primarily translated artificial adpositions as postpositions or nouns, or "zai+...+Postposition/Noun" in some cases. In Mandarin, zai can function as both a verb and an adposition when used alone.

The interpretations cannot be differentiated, but the non-verbal nature of most responses suggests learners treated the meanings as intended. Experiment 1 reveals that learners exhibit a cognitive bias towards harmonic order between verb phrases and ad positional phrases, aligning verbs with ad positions and object nouns with nouns in ad positional phrases, regardless of their native language's harmonic or mixed nature. Harmony in phrase types may be a result of cognitive bias, but its exact nature is unclear. Harmony can be based on alignment of lexical and phrasal categories or elements of the same syntactic category, and is often discussed as holding between syntactic heads. The precise nature of this bias is less clear. The task involved lexical phrases, but participants may have used their language experience to align these categories. The exact set of nouns

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was used as dependents for each type of phrase, suggesting learners may have based their alignment on the same syntactic category or set of words.

Harmony between verb phrases and adjective and noun orders is a potential concept, as there is a shared category of nouns that could drive harmonic ordering. However, the evidence for harmony between these two types of phrases is less clear in typology. Experiment 2 investigates participants' extrapolation of verb phrase order to phrases with nouns and adjectives. The study aims to determine if the cognitive bias for harmonic order is based on alignment based on a shared syntactic category or set of words, resulting in similar results to Experiment 1. Participants may not extrapolate as well in Experiment 1 if there is a weaker or non-existent harmony tendency in these two types of phrases. Experiment 2 uses the same design and procedure as Experiment 1, testing extrapolation of verb and object order to noun and adjective order. Different hypotheses about harmony drive contrasting predictions, highlighting the importance of alignment in categorizing sets.

Harmony can be influenced by two factors: the order of syntactic categories and the head-dependent distinction. If harmony is based on the order of identical categories, learners may align verbs with adjectives, while if it's based on the head-dependent distinction, nouns should not align with nouns. Dryer (1992) argues that there is no consistent alignment between verbs and nouns or verbs and adjectives, as neither noun nor adjective are sufficiently phrasal to align with the object in a verb phrase, as evidenced by typological data. The study investigates if participants show a consistent pattern of alignment between nouns across two phrase types or between verbs and nouns due to uncertainty. The study aims to determine if consistent extrapolation across participants, regardless of the alignment pattern, is driven by noun alignment, as found in Experiment 1, where participants were taught the order of verb and object. Participants were taught novel adjective meanings and tested on describing a picture with both adjectives and nouns, focusing on English-speaking participants.

Experiment 2 followed the same procedure as Experiment 1, but with an adjective training and testing phase. Participants were shown a picture with four objects of the same color in the adjective training and testing phase, and the final critical extrapolation testing phase involved producing phrases with adjectives and nouns. Participants in an experiment were instructed to hear a word describing a color and then shown a picture with a single object in one of the colors they had seen in training. 43 native English speakers from the University of Edinburgh participated and received £8 as compensation. Participants with less than 75% accuracy in non-critical testing phases were excluded from the analyses, resulting in a total of 42 participants (VO condition: 20, OV condition: 22). English speakers have VO order and AdjN order, which involve noun alignment across phrases. However, head-dependent alignment assumes the noun as the head of a noun phrase. The experiment will evaluate whether either pattern is consistent in behavioural responses.

The study found high accuracy (above 96%) in all non-critical testing phases, with a focus on the final critical testing phase where participants had to produce a novel phrase type with a noun and adjective, coded as either AdjN order or NAdj order. The study found that adjectives align more

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with verbs and nouns across two types of phrases, as shown in Figure 2.4, which shows the proportion of noun phrase productions involving consistent placement of nouns and verb alignment. The plot compares AdjN order in the VO condition and NAdj order in the OV condition, showing the proportion of responses with harmonic alignment of the verb with the adposition produced by English speakers in Experiment 1. We compared Experiment 2's results with Experiment 1's results using a Bayesian hierarchical logistic regression model. The model estimates the probability of harmonic alignment between categories in English speakers across experiments and conditions, following our preregistered analysis plan.

The study extrapolated from VO to PrepN and OV to NPost for adpositional phrases in Experiment 1, and from VO to AdjN and OV to NAdj for noun phrases in Experiment 2, using sum coded predictors and four sampling chains for 3000 iterations, yielding 6000 samples for each parameter in the posterior distribution. The model indicates that the preference for harmonic alignment between verb phrases and noun phrases is weaker than between verb phrases and adpositional phrases ($\beta^* = -8.55$, $CI = [-19.69, -1.03]$). The study found that the preference for harmonic alignment between two phrase types in the OV condition was weaker than in the VO condition. The difference in producing a harmonic alignment was likely larger in the adpositional phrase than in the noun phrase, but not reliable. The study estimated the probability of English-speaking participants producing orders aligning nouns across the verb phrase and noun phrase in two conditions, and found that participants tend to produce AdjN order when trained on the verb (VO) condition ($\beta^* = 18.41$, $CI = [2.99, 42.01]$).

Participants struggled to produce harmonic NAdj order when trained on the OV condition, indicating a lack of reliability. The study also examined the impact of self-reported language experience and learners' responses in translating artificial adjectives into their native language. Participants likely learned color adjectives in English, as they translated these words into English. The 68 self-reported language experience models failed to converge, but the responses of learners with different second language experiences were similar across the two conditions, as shown in Appendix A.2. Experiment 2 involved teaching native English speakers a novel lexicon of verbs, nouns, and adjectives, and determining the order of the verb phrase in VO or OV order, and then testing how they extrapolated this order to noun and adjective phrases. The experiment was compared to Experiment 1, where participants were asked to extrapolate verb phrase order to phrases containing a noun and an adposition.

The study compares learners' treatment of two phrases with a strong typological tendency for harmony, such as verbs with adpositions and nouns with nouns, to a pair of phrases without such harmony, where verbs are not more likely to align with nouns or adjectives. Participants in Experiment 2 showed no preference for consistent alignment between verbs and adjectives, nouns with nouns, or verbs with nouns, contrasting with the clear preference for consistent alignment between verbs and adpositions in Experiment 1. Participants in Experiment 2 were more likely to produce AdjN order in the VO condition, likely reflecting learners' L1 order. Both Experiments

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required participants to override their L1 order to align nouns across phrase types. In Experiment 1, participants reliably produced NAdj order, but in Experiment 2, they did not, indicating no consistent ordering preference influenced by the order of the verb phrase across individual learners.

Nouns are typically considered heads in noun phrases, aligning with verbs rather than object nouns in verb phrases. However, typological data indicates no word order correlation between the two phrase types, regardless of whether adjectives or nouns are considered the equivalent to align with verbs. The results align with typology and suggest that participants' harmony bias in Experiment 1 is not solely due to a preference for placing nouns in the same place across phrases, but also varies across different phrase types. Experiment 3 investigates why participants align nouns with nouns when other categories, such as verbs and adpositions, were not, and tests the intuition that adpositions are more similar to verbs than adjectives, focusing on the effect of similarity. The active verbs used in Experiments 1 and 2 are a common historical source for adpositions across languages, considered a distinctive stage on a diachronic cline from independent predicate to grammatical marker, as per Givón 1979, Heine & Kuteva 2002, and Dryer 2019.

The relationship between spatial relations and adpositions is evident in the way spatial meanings are expressed across languages, with serial verb constructions being a canonical way to convey spatial meanings, involving one verb for motion and another for direction (Aikhenvald 2006b).

Verbs and adpositions share distributional properties, such as complement-taking and phrasal, while adjectives do not typically have this property or a diachronically consistent link with verbs. However, some adjectival meanings are commonly derived from verbs, such as 'twisted' or 'broken'. Experiment 3 investigates the impact of semantic similarity between adjectives and verbs on the preference for harmonic ordering between them. Experiment 3 examines learners' tendency to align verbs in a verb phrase with adjectives in a noun phrase across stative and active adjectives, two subtypes of adjectives with significant semantic differences.

Stative adjectives, describing physical properties, have the semantic property [-activity], while active adjectives, derived from verbs, are [+activity]. Active adjectives are more similar to active verbs from a semantic standpoint. Cognitive bias for cross-category harmony is influenced by semantic similarity between elements, such as a single shared category like noun. The preference for alignment between verb phrase order and noun phrase order is stronger when the adjective in the noun phrase is active compared to stative. This text discusses the concept of cross-category harmony, focusing on verbs and adjectives as potential aligning elements. It suggests that traditional notions assume adjectives in noun phrases are heads and nouns are dependents, but remains open about their roles. The classic distinction of harmony is often used, but some well-known research on harmony has used alternative distinctions to better explain typological data. In Experiment 2, participants in the VO condition used AdjN, while those in the OV condition used NAdj, suggesting that the alignment of verbs and adjectives might occur under specific conditions. The study investigates if

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semantic similarity between verbs and adjectives influences participants' behavior, excluding syntactic similarity.

In Experiment 3, a different set of stative adjectives, texture adjectives, are used, including 'spotted', 'stripped', 'checkered', and 'woven', to explore these differences. Previous research indicates that color adjectives are highly salient, potentially leading some participants to prioritize the adjective first, regardless of their verb phrase order, resulting in a failure to use NAdj order in the OV condition, as per previous studies. The study aims to replicate Experiment 2 findings using texture adjectives, with lower salience adjective meanings. It also includes a replication of Experiments 1 and 2, and manipulates participants' extrapolation to adpositional phrases, stative adjectives, texture adjectives, or active adjectives.

The study found high accuracy (above 93%) in all non-critical testing phases, with a focus on the final critical testing phase where participants had to produce a novel phrase type, with each production coding as harmonic or non-harmonic based on the order of the verb phrase. The study hypothesizes that manipulating verb similarity with adposition or adjective affects extrapolation. For the VO training condition, PrepN or AdjN order is treated as harmonic, while NPost or NAdj order is treated as harmonic. The analysis excluded 259 productions with only one or two words, as they could not be identified as active adjectives (79 in VO condition, 33 in OV condition), stative color adjectives (21 in VO condition, 40 in OV condition), stative texture adjectives (16 in VO condition, 22 in OV condition), and adpositions (7 in VO condition, 41 in OV condition).

The study compares the preference for harmonic order between verb and noun phrases across texture and color stative adjectives using a Bayesian hierarchical logistic regression model with default priors, aiming to determine if the use of harmonic order in noun phrases differs depending on the stative adjective type. The study involved four sampling chains running for 3000 iterations, with a 1500 warm-up iteration for each chain, yielding 6000 samples for each parameter in the posterior distribution, focusing on the subtype of stative adjective and condition. The model showed no significant difference in harmonic order usage across stative color and stative texture adjectives. To analyze, data from both types was combined into a single stative adjective extrapolation phrase type. Experiment 3, with these conditions collapsed, is shown in Figure 2.5. The study used a Bayesian hierarchical logistic regression model to assess the likelihood of English speakers producing harmonic order across different extrapolation phrase types and verb phrase training conditions, as in previous experiments. The verb phrase training predictor was sum coded, while the extrapolation phrase type predictor was Helmert coded, allowing for multiple contrasts to be evaluated in a single model by testing each level against the mean of previous levels. The study compares active adjective+noun vs. stative adjective+noun and adpositions vs. the mean of active and stative adjective+noun. Four sampling chains were run for 6000 iterations, yielding 12000 samples for each parameter in the posterior distribution.

The model indicates that learners' preference for harmonic order in OV training conditions is weaker than in VO training conditions. Additionally, learners' preference for harmonic order between

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verb phrase and noun phrase is stronger when the adjective is active compared to stative, but this difference is not reliable. The study found that learners' preference for harmonic order between verb phrases and adpositional phrases is stronger than between verb phrases and noun phrases with adjectives. The difference in preference for harmonic order is larger for stative adjectives than active adjectives across verb phrase training conditions. The study reveals a reliable difference in harmonic order between two verb phrase training conditions for stative adjectives ($\beta^{\wedge} = -6.29$, $CI = [-9.26, -3.93]$), active adjectives ($\beta^{\wedge} = -0.93$, $CI = [-5.18, 2.95]$), and adpositional phrases ($\beta^{\wedge} = 0.65$, $CI = [-3.82, 5.26]$), but not reliable for active adjectives. The interaction is driven by these differences.

The study analyzed the probability of harmonic order in different training conditions and re-run the model with treatment coding. Results showed participants preferred harmony between verb phrase and adpositional phrase in both verb phrase training conditions (VO condition: $\beta^{\wedge} = 17.75$, $CI = [11.54, 24.82]$). The study found a preference for harmony between verb phrases and active adjective+noun in both verb phrase training conditions (VO condition: $\beta^{\wedge} = 10.22$, $CI = [5.33, 15.70]$; OV condition: $\beta^{\wedge} = 8.75$, $CI = [3.87, 14.16]$). The study found that the preference for harmony between verb phrase and stative adjective+noun was reliable only in the verb-object (VO) condition, not in the object-object (OV) condition. The study analyzed the impact of self-reported language experience and learners' responses in translating artificial phrases into their native language using a Bayesian hierarchical logistic regression model.

Conclusion

The study investigated the relationship between second language order and verb phrase training conditions and their interaction, finding no reliable effects of second language experience across training conditions, as indicated in Appendix A.2. in reference book 2. Our models for the adpositional phrase condition failed to converge, but all participants with different second language experiences produced harmonic order, except for one participant, as shown in Figure A.2 in Appendix A. The study found that learners often translated artificial phrases into English as noun phrases or adpositional phrases, indicating they likely perceived them as such in their native language. Cross-category harmony is a statistical typological universal that refers to the correlation between word order and alignment of specific elements across different phrase types. This study uses artificial language learning experiments to explore the link between individual-level cognition and the typological tendency for cross-category harmony, addressing various hypotheses about harmony, including cognitive biases and diachronic processes.

The study reveals a preference for harmony between verb and object order and adposition and noun order, indicating a strong typological preference for harmony between phrase types. However, the study also reveals that harmony is influenced by the alignment of linguistic categories. The study reveals no bias in alignment between verbs in a verb phrase and stative adjectives in a modified noun phrase, despite the presence of the syntactic category of nouns in both types of phrases. However, a weak bias arises when adjectives have active, verb-like meanings. The study indicates that the cognitive bias towards cross-category harmony is not solely influenced by

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syntactic notions like head and dependent, nor by the presence of a shared category, but rather by the fine-grained similarity of both categories in a pair of phrases. The concept of similarity may be the basis for diachronic processes that promote harmony, potentially unifying previously contrasting explanations.

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