

Syntactic universals in the lab: New methods and approaches

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Lecture 3: Domain of universals in cognition

Domain-general vs. specific biases underlying typological universals of syntax?

MAIN ISSUES AND APPROACH.

1. Are the biases underlying typological universals domain-specific?
2. What are the implications of this for our understanding of the language faculty (narrowly and broadly construed)?
3. *ALL Approach*: controlled experiments comparing evidence for biases in linguistic and non-linguistic input

Regularization

REGULARIZATION ON LINGUISTIC VS. NON-LINGUISTIC VARIATION¹

- Research question: Do we find regularization in matched linguistic and non-linguistic tasks? Does increasing the probabilities to be tracked result in more regularization?
- Experimental manipulation
 - Linguistic vs. non-linguistic stimuli
 - Single vs. multiple frequency learning
 - Ratios: 0:10, 1:9, 2:8, 3:7, 4:6, 5:5
- Design of the language
 - "Lexical" items: 12 CVC nonce words (linguistic), 12 marbles (non)
 - Visual stimuli: 6 novel objects (linguistic), 6 containers (non)
- Procedure
 - *marbles1*: single frequency learning, non-linguistic
 - * Training: observe 10 draws of two marbles from container at fixed ratio (x10)
 - * Testing: produce 10 likely draws by choosing marble (x10)
 - *marbles6*: multiple frequency learning, non-linguistic
 - * Training: observe 10 draws from each of 6 containers with fixed ratio (x60)
 - * Testing: produce 10 likely draws from each container (x60)
 - *words1*: single frequency learning, linguistic
 - * Training: observe one object named with two words at fixed ratio (x10)
 - * Testing: produce 10 likely naming events (x10)
 - *words6*: multiple frequency learning, linguistic
 - * Training: observe 6 objects each named by two words with fixed ratio (x60)
 - * Testing: produce 10 likely naming events for each object (x60)
- Participants: 573 Amazon Mechanical Turk workers (\$0.10-\$060)

¹ V. Ferdinand, Inductive evolution: cognition, culture, and regularity in language, Ph.D. thesis, University of Edinburgh (2015)



Figure 1: Stimuli.



Figure 2: Example stimuli set from marbles6 condition.

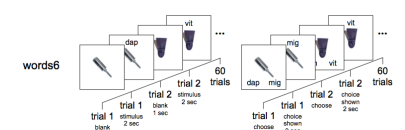


Figure 3: Example trials from words6 condition.

- Results/conclusions
 - Probability matching in marbles₁ (single frequency learning non-linguistic condition)
 - In all other conditions, regularization, with most in multiple frequency learning linguistic condition (words₆)
 - Entropy results show reduction in *Shannon Entropy* (a measure of how much information is needed to encode a message, here the set of participants productions) from observation to production.
 - Additional statistical analysis reveals independent and non-interacting effect of both domain and number of frequencies being tracked.
 - Suggests linguistic-specific and independent contributions to regularization behavior
 - Learned? Evidence from additional experiments suggests more regularization when learning multiple regular forms compared to when learning multiple more variable forms. Findings from related work ² suggest similar effect when learning a novel verb in the context of other verbs which show alternations in argument word order vs fixed order.

HARMONY? Is harmony (consistent head order) domain-general? Do we have any evidence for this? What about Christiansen (2000)...

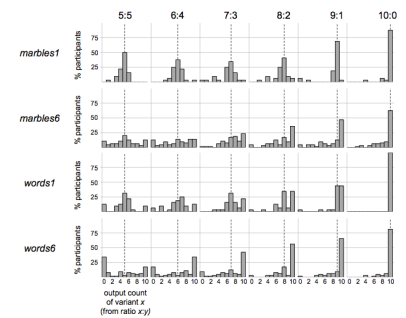


Figure 4: Raw production results across conditions.

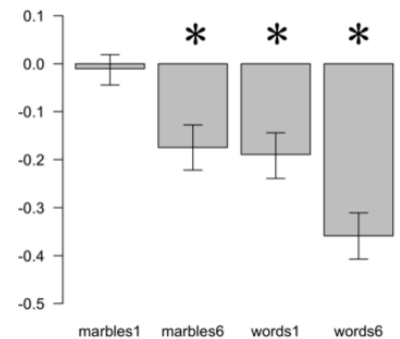


Figure 5: Change in entropy from observation to production.

² E. Wonnacott, E. L. Newport, M. K. Tanenhaus, *Cognitive Psychology* 56, 165 (2008)

Subjacency

WHAT IS SUBJACENCY?

- Subjacency: locality constraint(s) on movement
 - Original formulation: no (cyclic) movement past more than one X at a time
 - X was initially IP and NP, but this was the subject of debate
 - New reformulation: *Phase-Impenetrability Condition* (X is (at least) vP and CP).
 - Example violations:
 1. Sara heard (the) news that everybody likes cats. →
 $[_{CP} \text{What}_i [_{IP} \text{did S } [_{VP} \text{hear } [_{CP} \text{that } [_{IP} \text{everybody } [_{VP} \text{likes } [_{NP} t_i]]]]]]?$
 $*[_{CP} \text{What}_i [_{IP} \text{did S } [_{VP} \text{hear } [_{NP} \text{the news } [_{CP} \text{that } [_{IP} \text{everybody } [_{VP} \text{likes } [_{NP} t_i]]]]]]]]?$
 2. Sara asked why everyone likes cats. →
 $[_{CP} \text{Who } [_{IP} \text{did S } [_{VP} \text{ask } [_{CP} \text{why } [_{IP} \text{everybody } [_{VP} \text{likes } [_{NP} \text{cats}]]]]]]?$
 $*[_{CP} \text{What}_i [_{IP} \text{S } [_{VP} \text{ask } [_{CP} \text{why } [_{IP} \text{everybody } [_{VP} \text{likes } [_{NP} t_i]]]]]]?$

SUBJACENCY WITH NON-LINGUISTIC INPUT³

- Research question: Is subjacency the result of domain-general cognitive biases to do with sequence learning?
- Design of the "language"
 - Lexical items: letters representing grammatical categories (Z, X=nouns; V, M=verbs; S=complementizer; Q=wh-word)
- Procedure
 - *Training*: exposure to letter strings (10 of the critical type-(5/6), 20 other, two rounds through)
 - *Testing*: judgment of letter strings (28 of the critical type, 32 other; half grammatical according to the condition)
 - Critical test strings controlled for global similarity to training items, novelty of fragments and fragment positions compared to training items, chunk strength, frequency of initial and final fragments
- Experimental manipulation
 - Natural, unnatural, and control (only completed test)
- Participants: 60 native English-speaking undergraduates
- Results
 - Better accuracy for non-critical sentence types in the natural condition
 - Marginally better accuracy for critical, subjacency-relevant types in the natural condition
 - "[T]he presence of the subjacency violations in the UNNAT language affected the learning of the language as a whole, not just the [critical] items."

"Subjacency, in effect, keeps rules from relating elements that are 'too far apart from each other', where the distance apart is defined in term of the number of designated nodes that there are between them."

F. Newmeyer, *Language & Communication* 11, 3 (1991)

³ M. R. Ellefson, M. H. Christiansen, *The Proceedings of the 22nd Annual Conference of the Cognitive Science Society* (Lawrence Erlbaum, Mahwah, NJ, 2000), pp. 645–650

NAT	
Sentence	Letter String Example
1. N V N	Z V X
2. Wh N V	Q Z M
3. N V N comp N V N	Q X M S X V
4. N V Wh N V N	X M Q X M X
5. Wh N V comp N V	Q X V S Z M
6. Wh N V Wh N V N	Q Z V Q Z V Z

UNNAT	
Sentence	Letter String Example
1. N V N	Z V X
2. Wh N V	Q Z M
3. N V N comp N V N	Q X M S X V
4. N V Wh N V N	X M Q X M X
5*. Wh N V N comp N V	Q X V X S Z M
6*. Wh N V Wh N V	Q Z V Q Z V

Figure 6: Natural and unnatural language grammars.

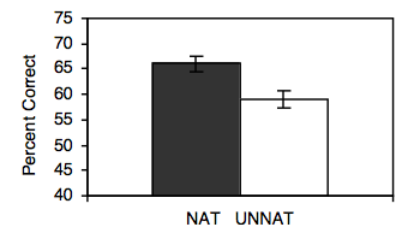


Figure 7: Accuracy for non-critical sentence types.

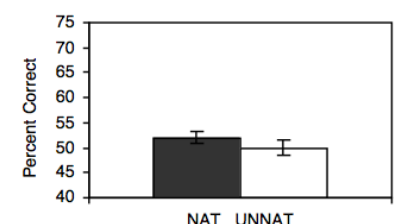


Figure 8: Accuracy for critical sentence types.

Differential case marking

CASE MARKING PATTERNS

- Typological universal: when case marking systems differentially mark nouns, the following hierarchies are typically observed:
 - *Animacy scale*: human > animate > inanimate
 - *Definiteness scale*: personal pronoun > proper name > other
 - *Person scale*: first, second > third

EFFICIENCY IN CASE MARKING AND WORD ORDER⁴

- Research question: Will learners deviate from inefficient input case systems to make the language more communicatively efficient?
- Design of the language
 - Lexical items:
 - Grammar: flexible word order SOV (60%), OSV (40%), optional case marking on object (60%)
 - Sentences: all transitive, actor always animate (human), undergoer either animate ($\rightarrow$ *ambiguous*) or inanimate ($\rightarrow$ *unambiguous*)
- Procedure
 - 4 sessions on consecutive days, 45 minutes each
 - Training:
 - * Noun exposure: view static pictures of people and objects one at a time, listen to labels (x30), then short tests
 - * Sentence exposure: view videos depicting actions (one at a time), listen to accompanying sentence and repeat (x80)
 - Testing:
 - * Comprehension test: hear a novel sentence with two static pictures of the referents described in the sentence, identify the doer of the action (x80)
 - * Production test: see a novel transitive scene and describe it in the language (verb prompt; x80)
- Experimental manipulation
 - Case marking equally likely for animate and inanimate objects in input
- Participants: 29 native English-speaking undergraduates (\$5 each day, \$25 bonus)
- Results/conclusions
 - Significantly more case markers on atypical (animate) objects than on typical (inanimate) objects across all days of testing
 - Objects were more likely to be case-marked if the constituent order was OSV
 - Additional experiment showed opposite pattern of case-marking with subjects (more likely marked when inanimate), suggesting result is not due to better learning of case marking with (more salient) animate items.
 - *"Our results suggest that language learners are biased toward communicatively efficient linguistic systems and restructure the input language in a way that facilitates information transfer, in line with recent information-theoretic approaches to language production"*

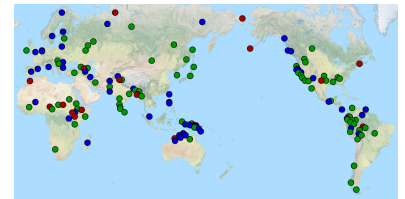


Figure 9: Symmetrical, additive-asymmetrical (e.g. pronouns not nouns), subtractive-asymmetrical (e.g. nouns not pronouns) case marking in WALS.

⁴ M. Fedzechkina, T. F. Jaeger, E. L. Newport, *Proceedings of the National Academy of Sciences* **109**, 17897 (2012)

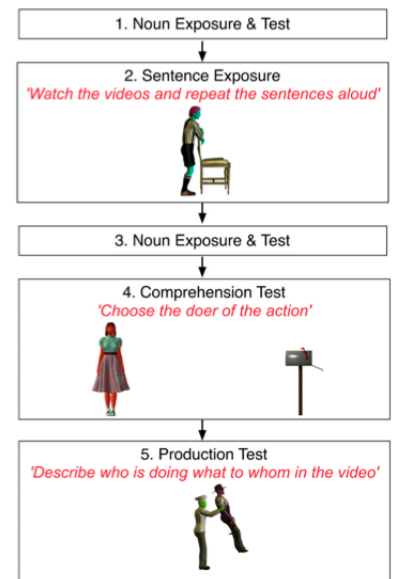


Figure 10: Task procedure and examples.

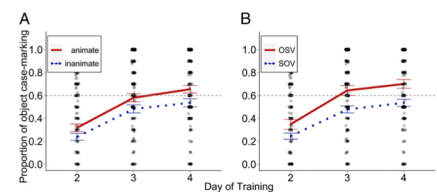


Figure 11: Use of case marking by object animacy.

Suffixing preference

SUFFIXING PREFERENCE WITH LINGUISTIC INPUT⁵

- Research question: Can learners more successfully acquire word categories when they are indicated by a suffix compared to a prefix?
- Design of the language
 - Lexical items: 12 category words, 2 affixes (from [gæ], [mɪ], [vɛ], [dʌ])
 - Auditory stimuli: artificially generated
- Procedure "pay attention to the patterns within the language"
 - Training:
 - * Familiarization: heard all root words alone, then all affixes
 - * Sentence training: heard 18 "sentences" comprised of 2 content word + affix pairs (x4), instructed to repeat aloud
 - Testing:
 - * Judgment: y/n judgment, grammatical vs. ungrammatical (wrong affix)
 - * Card sorting: sort words (without affixes) into equal groups
- Experimental manipulation
 - Suffix vs. prefix
- Participants: 24 native English-speaking undergraduates
- Results
 - Suffix condition more accurate (0.80 vs. 0.67) in judgments
 - Only suffix condition better than chance in card sorting

⁵ M. C. St. Clair, P. Monaghan, M. Ramscar, *Cognitive Science* 33, 1317 (2009)

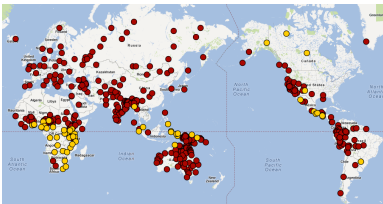


Figure 12: Suffixing vs. prefixing in WALS.

Frequency	Category A	Category B
High	Tweand Dreng Klimp	Foth Vawse Suwch
Low	Gwemb Prienk Blint	Zodge Thorsh Shufe

Figure 13: Items in each category (note phonological regularities).

SUFFIXING PREFERENCE WITH NON-LINGUISTIC INPUT⁶

- Research question: Is there a "suffixing" preference in non-linguistic stimuli?
- Design of the stimuli
 - Lexical items: 25 triads consisting of a 2-syllable artificial "target" word and two test words with an added syllable (pre-, post-, or infix)
 - Musical items: 25 triads consisting of a 2-note target sequence and two test sequences with an added note (pre- or post-)
 - Visual items: 25 triads consisting of a 2-shape target sequence and two test sequences with an added shape (pre- or post-)
- Procedure:
 - Label-extension task [presentation of an altered word-form to investigate whether this word-form variant is extended to the familiar object or to a different object]
 - Judgment task [Hear/see target item followed by two test items, decide which of the test items was more similar to the original target word.]
- Experimental manipulation
 - Pre-, post- (or infix) additional syllable
 - Stimulus type: word, musical sequence, visual sequence
- Participants: 20 native English-speaking undergraduates per condition
- Results: Clear preference for post-changed test items in all stimuli conditions
"This preference may be wired into the mechanism that processes temporal information, and it is reflected in language's use of inflectional morphology."

⁶ J. M. Hupp, V. M. Sloutsky, P. W. Culicover, *Language and Cognitive Processes* 24, 876 (2009)

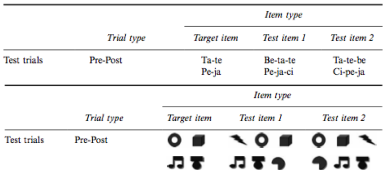


Figure 14: Example linguistic and visual stimuli.

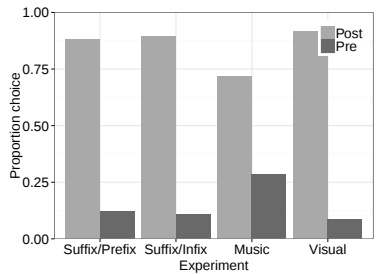


Figure 15: Choice of pre- vs. post-changed items.