A PSYCHOLINGUISTIC STUDY OF THE SYNTAX–SEMANTICS INTERFACE

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TODAY'S TALK IS BASED ON

MY DOCTORAL THESIS

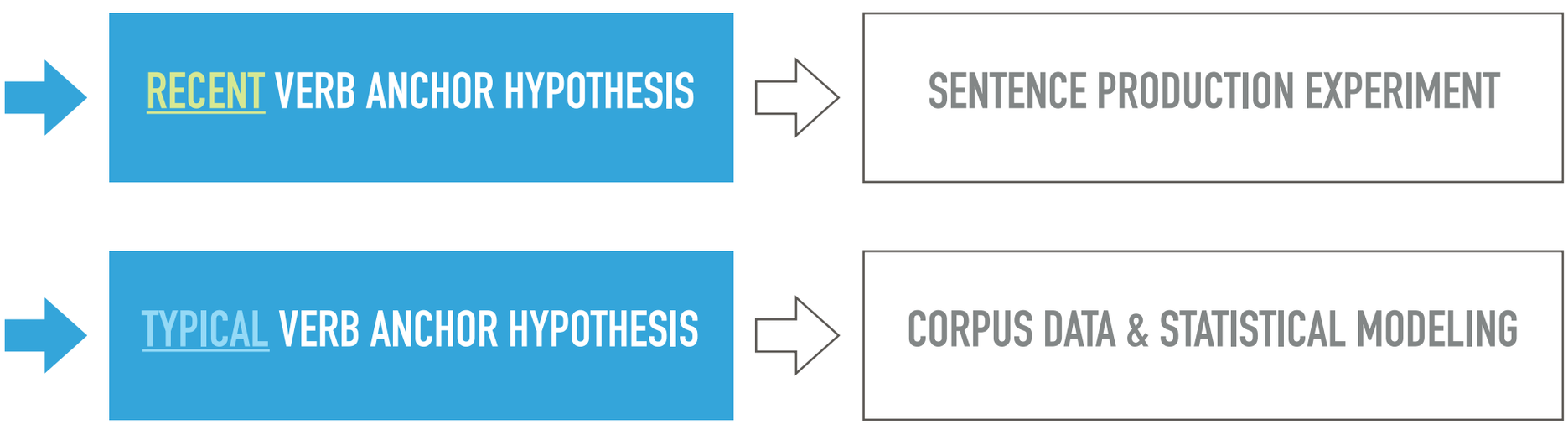
Exploring the cognitive underpinnings of the correspondence between verb meaning and syntax

- September 2016
- Department of Linguistics. State University of New York at Buffalo
- Committee: Jean-Pierre Koenig (chair), Gail Mauner & Douglas Roland

AGENDA

- ***Correspondence between verb meaning and syntax***
  - What linguistic phenomena does it refer to?
  - Why is it important in the study of language?

- **Exploring the cognitive mechanisms behind the phenomena**
  - Verb anchor hypotheses (*recent* & *frequent* verb anchors)

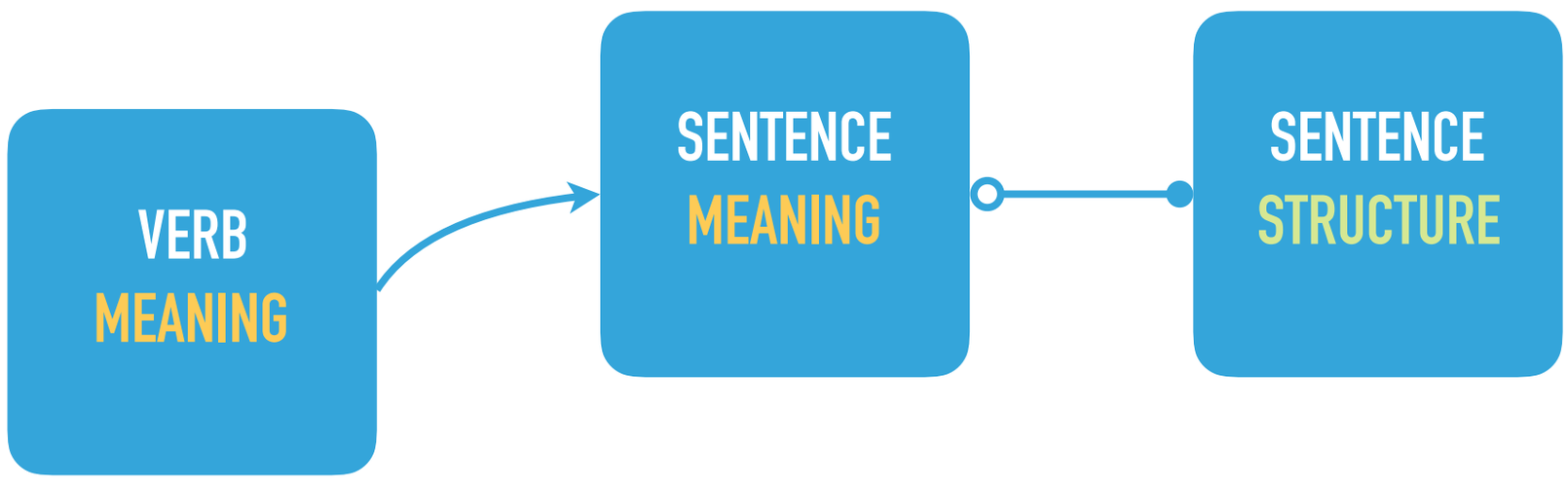


INTRODUCTION

THE ‘CORRESPONDENCE’ PHENOMENA

ONE OF THE ROBUST LINGUISTIC OBSERVATIONS

- Syntactic properties of a sentence is highly correlated with its semantic properties.
  - Namely, similar sentential meanings occur in similar syntactic contexts.
  - Sentence meaning is most strongly modulated by verb meaning.



AN EXAMPLE – *HIT, TOUCH, BREAK & CUT* (PINKER, 1989)

CONATIVE

[NP_{agt} VERB at NP_{pat}]

*Bill **hit** at the dog.*
**Bill touched at the cat.*
**Bill broke at the cup.*
*Bill **cut** at the bread.*

BODY-PART POSSESSOR ASCENSION

[NP_{agt} VERB NP_{pat} on $NP_{body\text{-}part}$]

*Bill **hit** the dog on the leg.*
*Bill **touched** Mavis on the ear.*
**Bill broke Tom on the leg.*
*Bill **cut** Brian on the arm.*

MIDDLE

[NP_{pat} VERB Adv]

**That wall hits easily.*
**This wire touches easily.*
*This glass **breaks** easily.*
*This bread **cuts** easily.*

	Conative	BPA	Middle
hit	o	o	x
touch	x	o	x
break	x	x	o
cut	o	o	o

AN EXAMPLE (CONT'D) – *WHAT MAKES THE DIFFERENCES?* (PINKER, 1989)

hit ~ bash, kick, pound, tap, whack, …

#CONTACT #MOTION

touch ~ pat, stroke, tickle, …

#CONTACT

break ~ crack, rip, shatter, snap, …

#CHANGE-OF-STATE

cut ~ hack, saw, scratch, slash, …

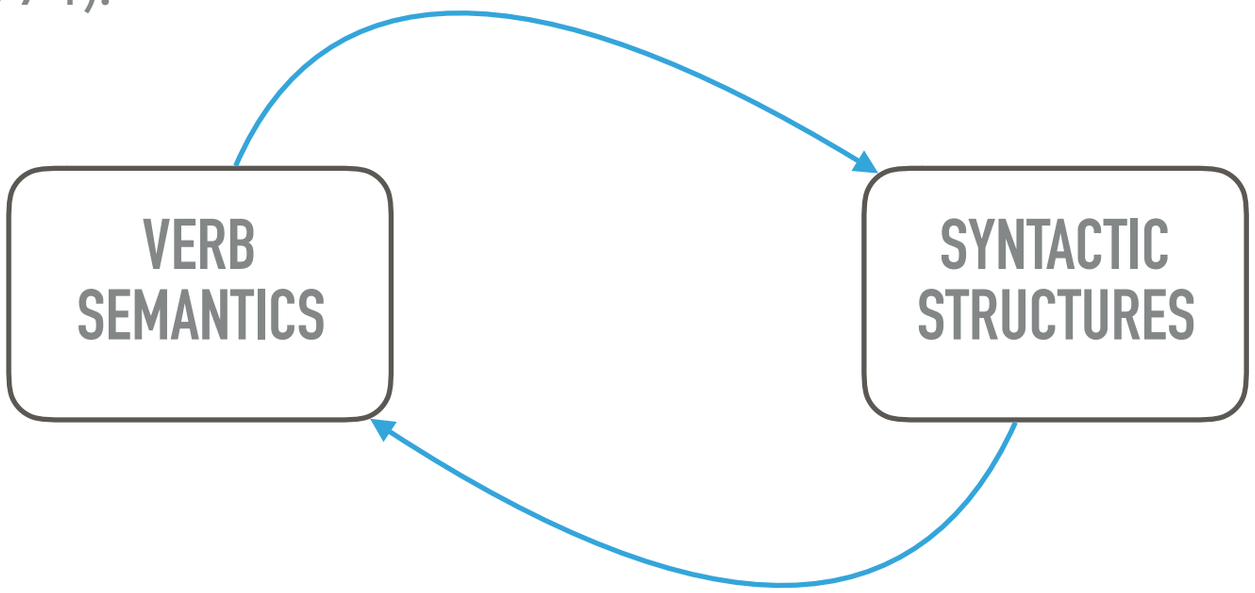
#CONTACT #MOTION #CHANGE-OF-STATE

	#MOTION Conative	#CONTACT BPA	#CHANGE-OF-STATE Middle
hit	o	o	x
touch	x	o	x
break	x	x	o
cut	o	o	o

THEORETICAL APPROACHES

LEXICALISTS

The syntactic properties of lexical items depend crucially and in regular ways on the meanings of those lexical items (Green, 1974).



CONSTRUCTIONISTS

Constructions are associated with particular meanings independent of the lexical items which instantiate them (Goldberg, 1995).

DO THE LINKINGS HAVE TO BE THE WAY THEY ARE?

- A language consists of arbitrary mappings between form and meaning. (contra predictability)
- The correspondence seems to be a “reasonable” system that speakers can rely on.
  - Linking between appx. 4,000 verbs and appx. 50 syntactic frames
- Is the correspondence-based system *the one and only possible choice* or *a natural consequence of human cognition*?

LITTLE LEXICAL BASIS: EXAMPLES

- Structures may have little basis in verb meaning
  - [NP$_{agt}$ VERB (Implicit patient)] e.g., *Jen <u>ate</u> all day.*

    bake, drink, dust, eat, fish, read, sing, wash, write,… [object predictability]

- [*THERE* VERB NP$_{subj}$] *e.g., There <u>developed</u> a problem.*

  appear, spread, climb, develop, grow, amble, pass, stand, … [low agency?]

The correspondence between verb meaning and syntax is not an *a priori* necessity but **a phenomenon that requires an *explanation***.

THEORY AND PROCESSING COMPLEMENT EACH OTHER.

> Suppose that someone succeeds in writing a **grammar** which correctly enumerates the sentences of a language and assigns them the right structural descriptions. Such a grammar would *ipso facto* correctly represent the **substance** of a fluent speaker's knowledge of this language.
>
> But it would not necessarily represent the form of this knowledge in the sense of actually corresponding to **the system of rules which is internalized by the speaker** and constitutes part of **what enables him to produce and understand** arbitrary utterances in the language. (p. 171)

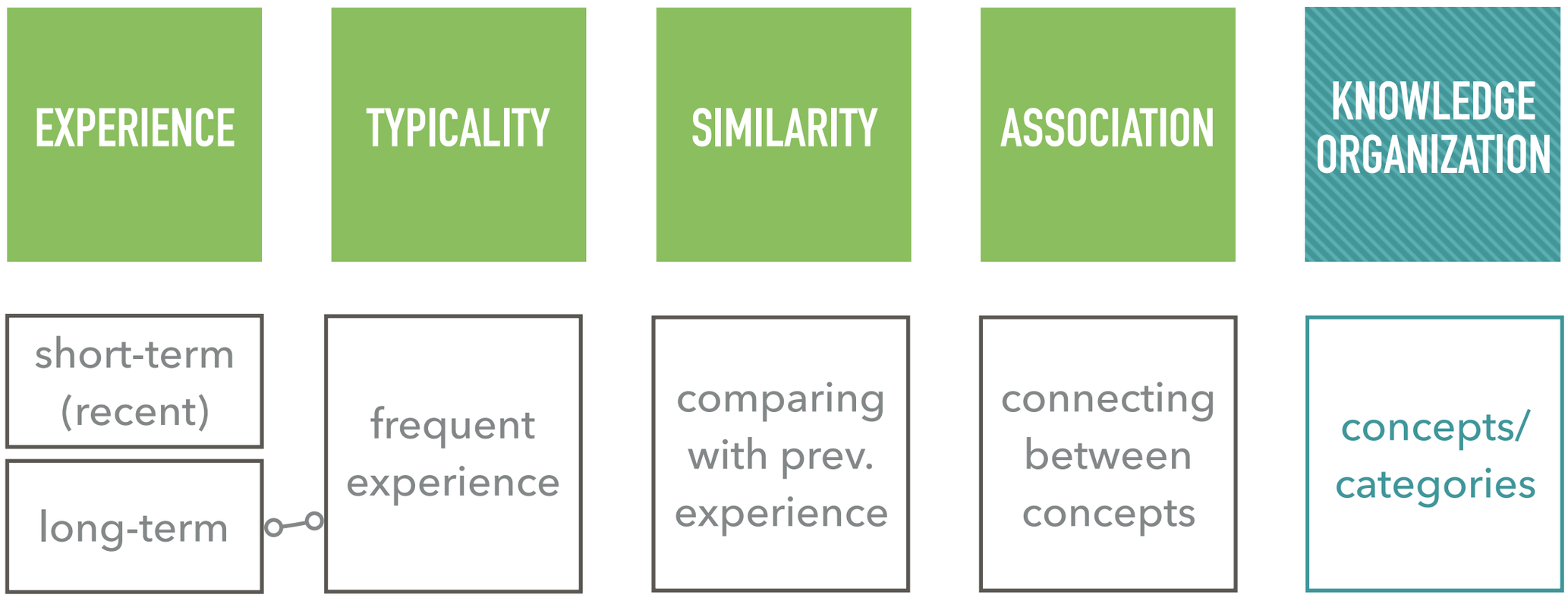
Kiparsky (1968)

PURPOSE OF THE PRESENT INVESTIGATION

- By combining both perspectives, we may be able to find clues to *why* grammars have to be the way they are.

VERB ANCHOR HYPOTHESIS

ORGANIZING CONCEPTS & CATEGORIES IN COGNITION



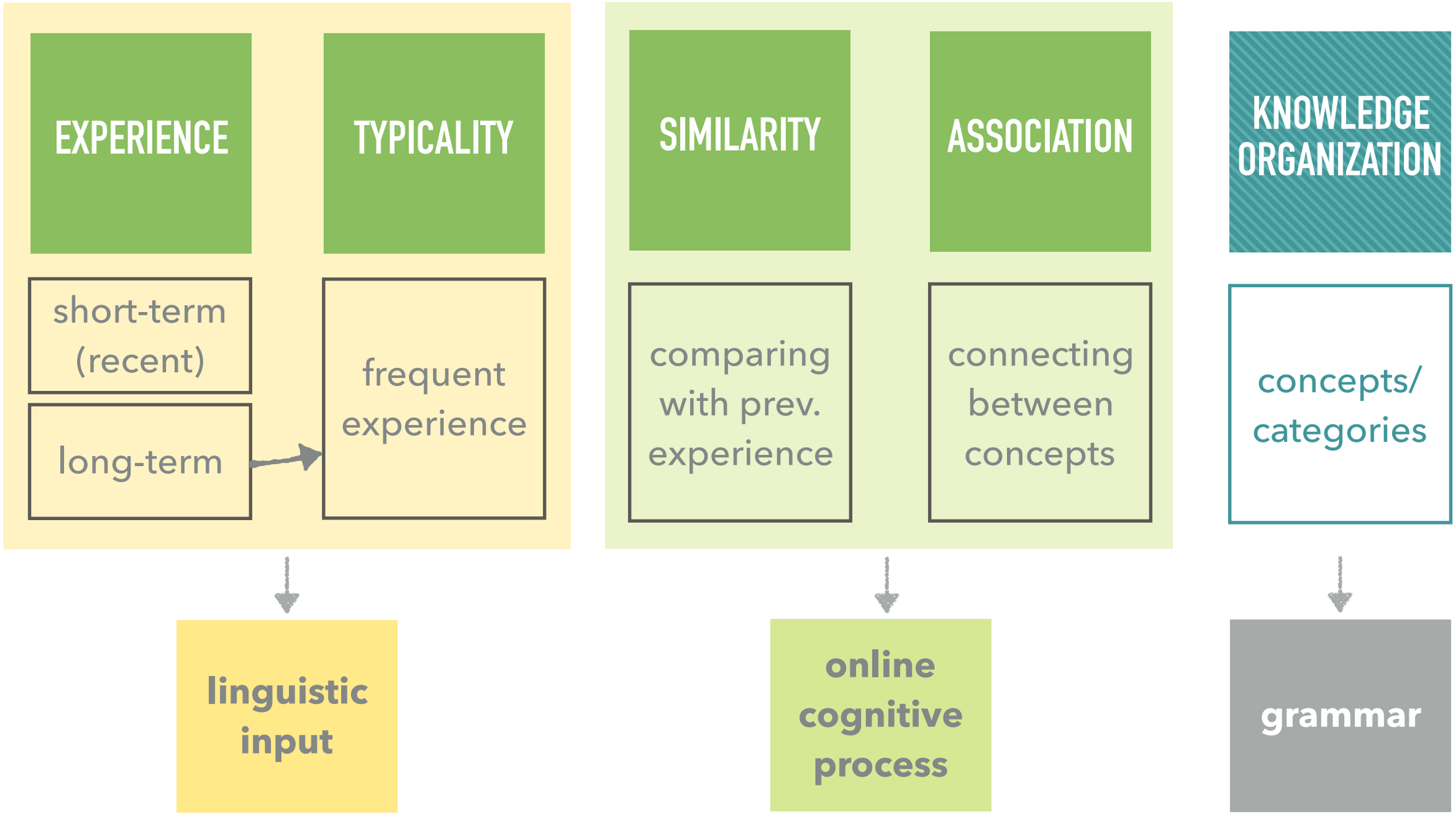
PREVIOUS RESEARCH

FROM PROCESSING, ACQUISITION, DIACHRONIC CHANGE TO LINGUISTIC TYPOLOGY

- **Linguistic input matters.** (exemplar or usage-based view)

  - The processing of a linguistic item can be ***facilitated by prior experience with the same or similar items***, even by experience with the ***single*** prior occurrence of an item in an experimental setting. (e.g., Bock, 1986)
  - ***Repeated*** experience with, or ***frequent*** occurrences of, an item in natural language use was also shown to affect online sentence processing (e.g., Trueswell, 1996).
  - Historical studies have also shown that the ***frequency of use*** is a major determinant of diachronic changes in phonology, morphology, semantics and syntax (e.g., Bybee, 2007; Krug, 2000).
  - Within- and across-language variations, ***language processing and use*** can, to a large extent, explain typological patterns and that grammar can be viewed as "conventionalizations of the patterns and ***preferences*** ... in the performance of language" (Hawkins, 1994, 2011)

COGNITION AND SENTENCE PROCESSING



PROCESSING A SENTENCE AS INPUT

PROCESSING INPUT

Jen gave her assistance a signed letter.

COGNITIVE PROCESSES

GIVE'

speakers' online mapping

NP_{AGT} VERB NP_{REC} NP_{THM}

SEMANTIC CATEGORY

ASSOCIATION

SYNTACTIC CATEGORY

LEXICAL VERB TRIGGERS SYNTACTIC STRUCTURE

PRIME: DONATE is associated with NP_{AGT} VERB NP_{THM} TO NP_{REC}

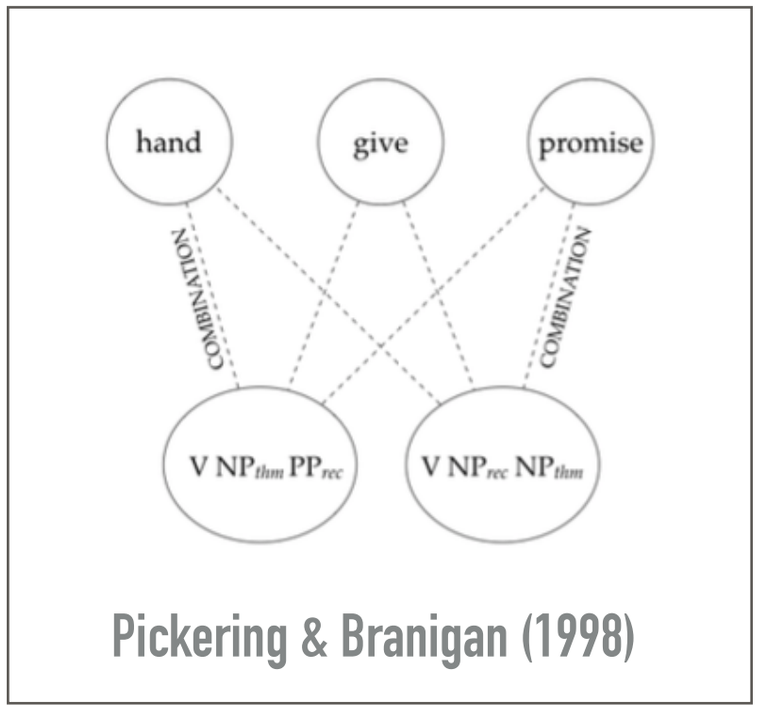
TARGET: GIVE

- NP_{AGT} VERB NP_{REC} NP_{THM} — *Jen gave her assistance a signed letter.*
- NP_{AGT} VERB NP_{THM} TO NP_{REC} — *Jen gave a signed letter to her assistance.*

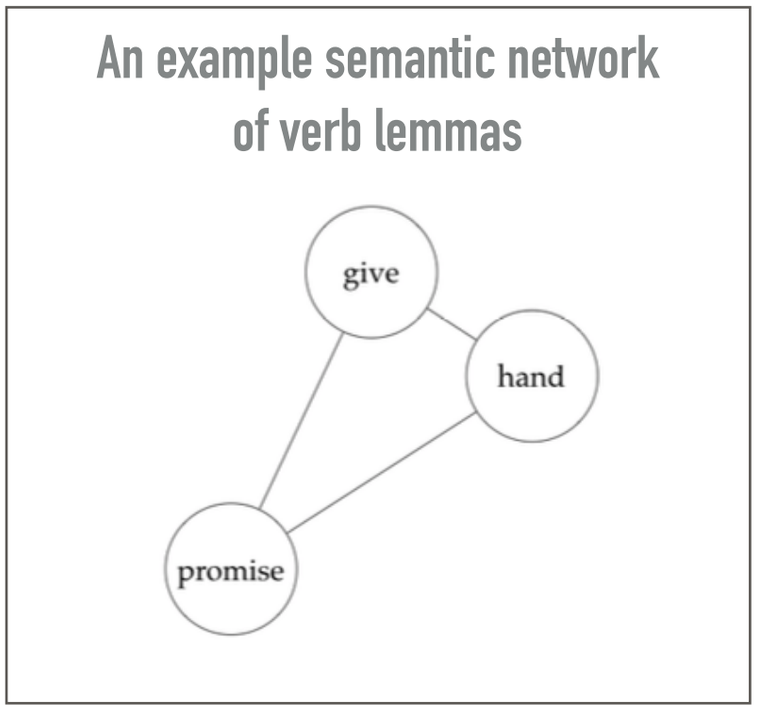
VERB SERVES AS SEMAMTIC ANCHOR TO SYNTACTIC STRUCTURE

- In the context of recency and frequency effect, Verb Anchor Hypothesis branches into two sub-hypotheses.
  - ***Recent anchor*** from recently acquired verb-syntax association
  - ***Typical anchor*** from frequently occurring verb-syntax association

VERBS SEMANTIC NETWORK MATTERS

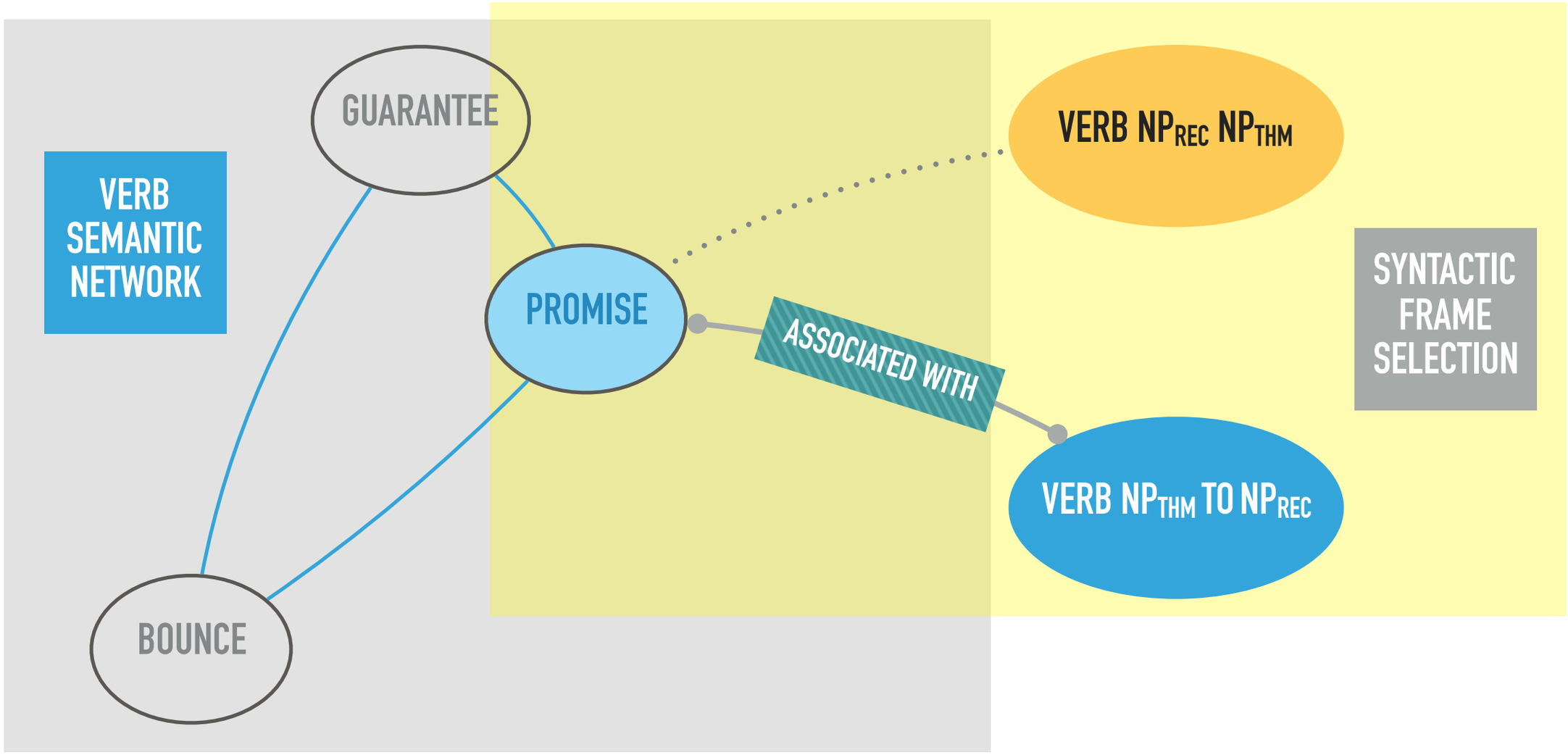


Pickering & Branigan (1998)



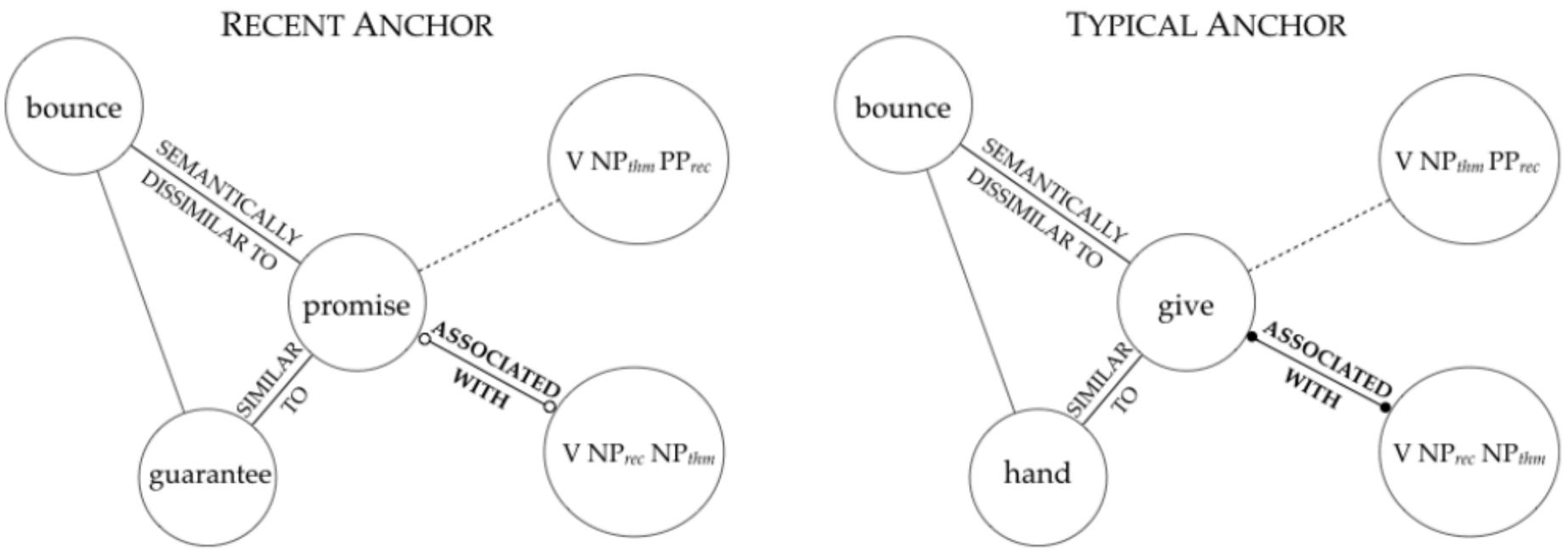
- Need a mechanism to explain the ***interplay*** between the prior association of a verb and a syntactic frame and the activation of a verb's associated semantic network upon retrieval of its meaning

VERB-AS-SEMANTIC-ANCHOR HYPOTHESIS



- The hypothesis predicts the more similar a verb is to ‘promise,’ the more likely the verb is to occur in [V NP to NP].

TWO SUB-HYPOTHESES



Recent **sentence experience**	***Repeated*** **sentence experience**
short-term & immediate effects	long-term & constant frequency effects
Psycholinguistic experiment	Statistical modeling on natural corpora

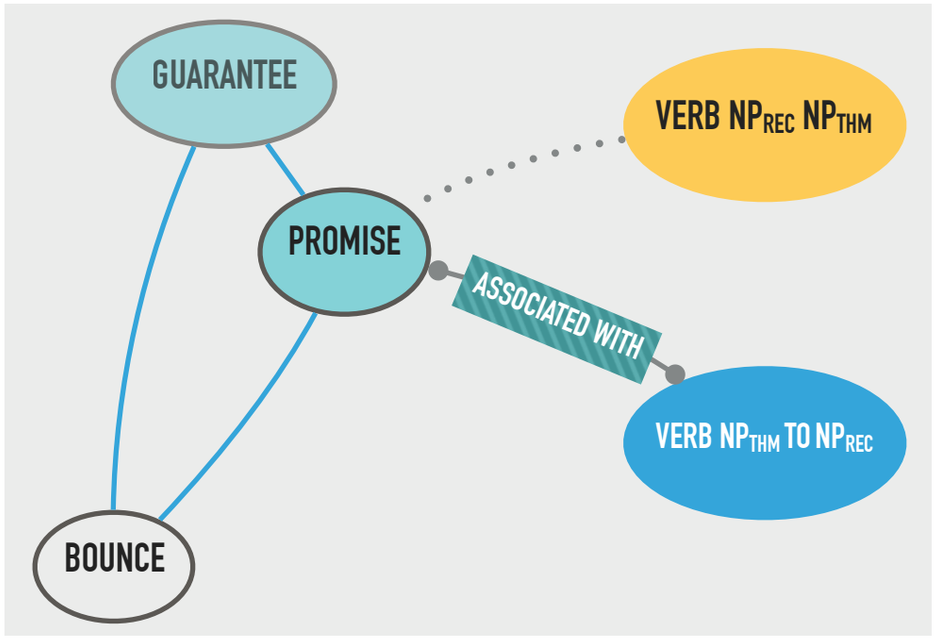
EXPERIMENTAL INVESTIGATION

RECENT VERB ANCHOR HYPOTHESIS

VERB ANCHOR BY RECENT SENTENCE EXPERIENCE

- The 'anchor' status is acquired via ***immediate*** sentence experience.

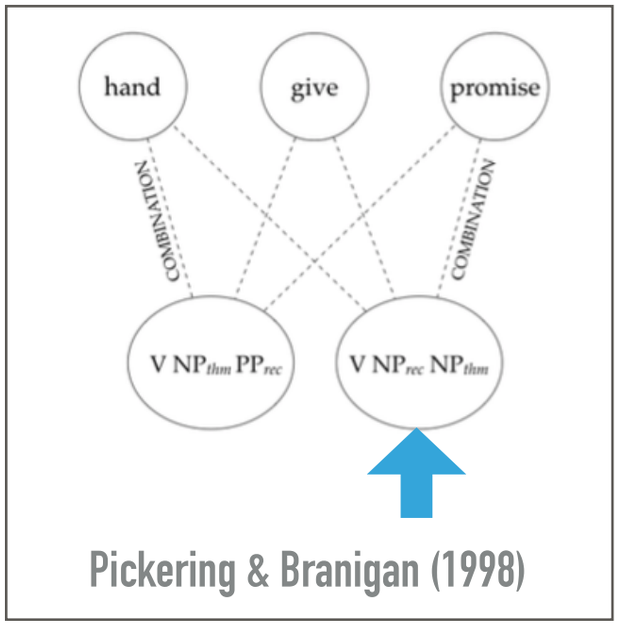
- Recent experience with a sentence makes **the verb and its underlying frame co-activated**, and also makes the **association link** between them stronger and highly accessible.



- If my hypothesis is correct, we can expect that in subsequent sentence production speakers are more likely to use the same syntactic frame with verbs that are semantically similar to the anchor than with verbs that are semantically dissimilar to the anchor.

SPEAKERS REUSE RECENTLY EXPERIENCED STRUCTURE

- Syntactic (or structural) priming (Bock, 1986)
- Processing a prime *Jen gave her assistance a signed letter* activates [V NP NP].
  - When given either *hand* or *promise* in a target
  - The speaker is more likely to select the same frame *A man handed/promised his client a letter*, while another option [V NP PP] *A man handed/promised a letter to his client* is available.
  - Psychological evidence of abstract syntactic structures



Pickering & Branigan (1998)

❖ Based on this paradigm, we can test our hypothesis by manipulating **verb similarity between prime and target sentences**.

RSVP & TWO-SENTENCE RECALL (GRIFFIN & WEINSTEIN-TULL, 2003)

SEQUENCE

READ SENTENCE 1 (TARGET)

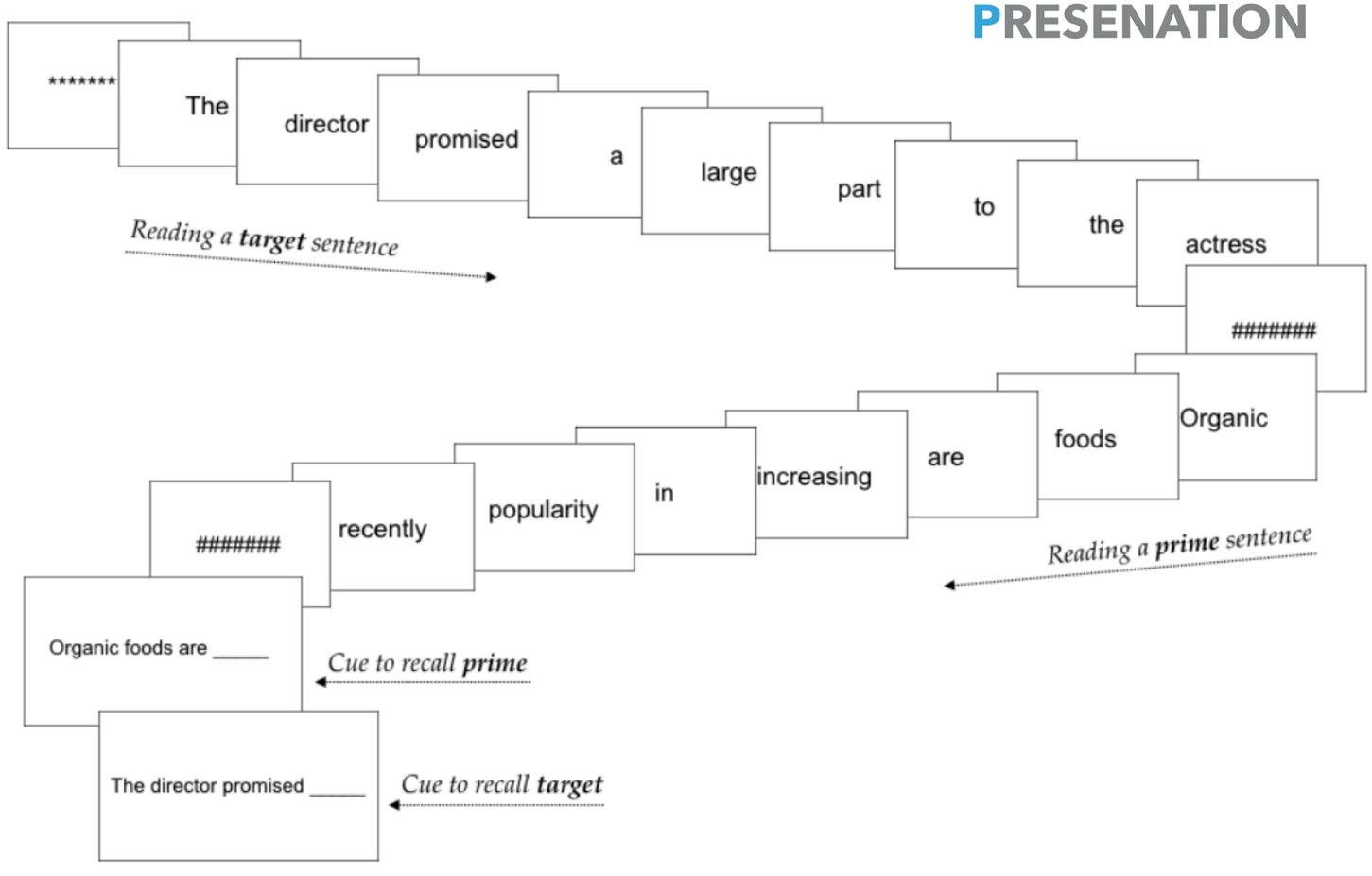
READ SENTENCE 2 (PRIME)

RECALL SENTENCE 2 (PRIME)

RECALL SENTENCE 1 (TARGET) ★

Same as prime? or not?

RAPID
SERIAL
VISUAL
PRESENATION



Ready?

PRIME Organic foods are increasing in popularity recently

TARGET The director promised a large part to the actress PO

AS READ

SHIFT The director promised the actress a large part DO

Ready?

PRIME The CEO guaranteed all employees a Chrismas bonus DO

TARGET AS READ The director promised a large part to the actress PO

SHIFT The director promised the actress a large part DO

EXAMPLES MATERIALS – DATIVE ALTERNATION

- Example trial in Experiment 1

TARGET	(read in PO)	The director *promised* a large part to the actress.
	Intransitive Control	Organic foods are increasing in popularity recently.
PRIMES (3 types)	High-similarity DO	The CEO *guaranteed* all employees a Christmas bonus.
	Low-similarity DO	The ball boy *bounced* the player a new ball.

- NORMING STUDY

		Low-similarity pairs *(e.g., promise - bounce)*	**High**-similarity pairs *(e.g., promise - guarantee)*
DATIVE Verbs	Rating (StdDev)	1.82 (*SD* = 0.53)	5.33 (0.94)
	Rating range	1.20 ~ 3.15	3.80 ~ 6.55

(1=completely different; 7=almost synonymous)

EXAMPLES MATERIALS – LOCATIVE ALTERNATION

- Example trial in Experiment 2

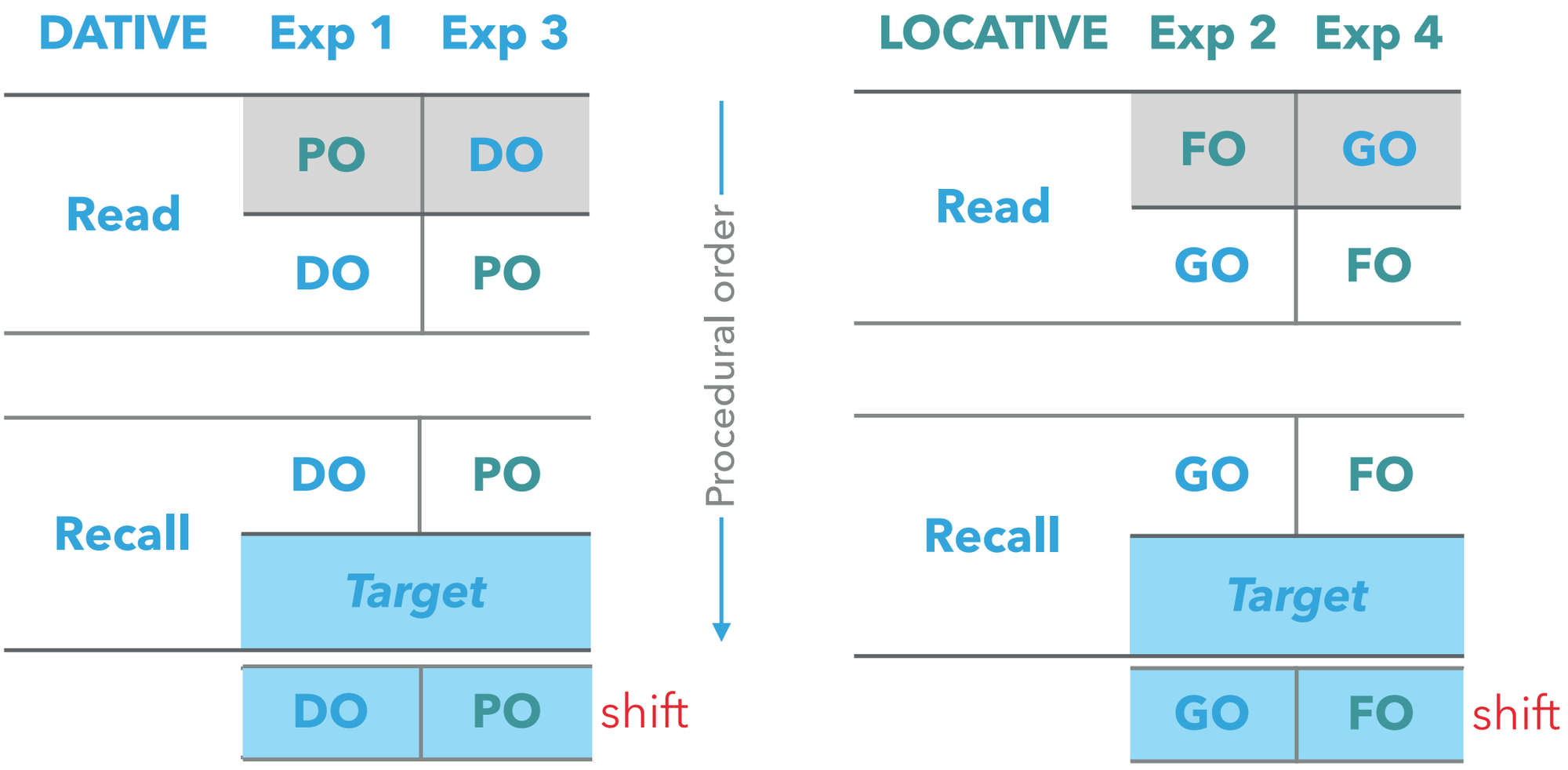
TARGET	(read in FO)	The kid *smeared* mom's lipstick on her face.
	Intransitive Control	The congressman decided to run for the next election.
PRIMES (3 types)	High-similarity GO	The New Yorker *spread* a toasted bagel with cream cheese.
	Low-similarity GO	The freight driver *loaded* the huge truck with lots of boxes.

- NORMING STUDY

		Low-similarity pairs *(e.g., smear - load)*	**High**-similarity pairs *(e.g., smear - spread)*
LOCATIVE Verbs	Rating (StdDev)	1.87 (SD = 1.10)	5.38 (1.38)
	Rating range	1.31 ~ 2.50	4.06 ~ 6.25

(1=completely different; 7=almost synonymous)

READ & RECALL ORDERS



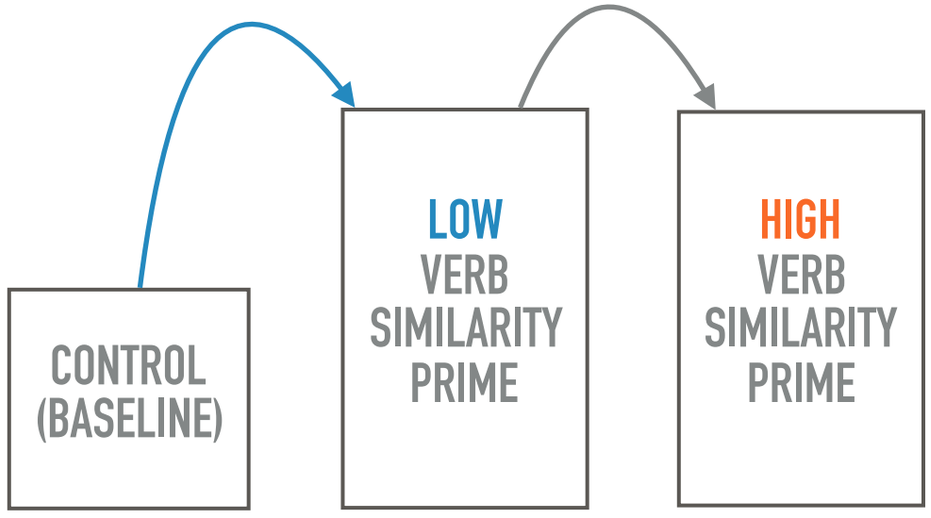
PREDICTIONS (FOR EXPOSITORY PURPOSES)

PREVIOUS RESEARCH

*Syntactic priming occurrs with ***no*** semantic overlap.

Syntactic Priming **(REPLICATION)**

Not tested yet; Increase not predicted

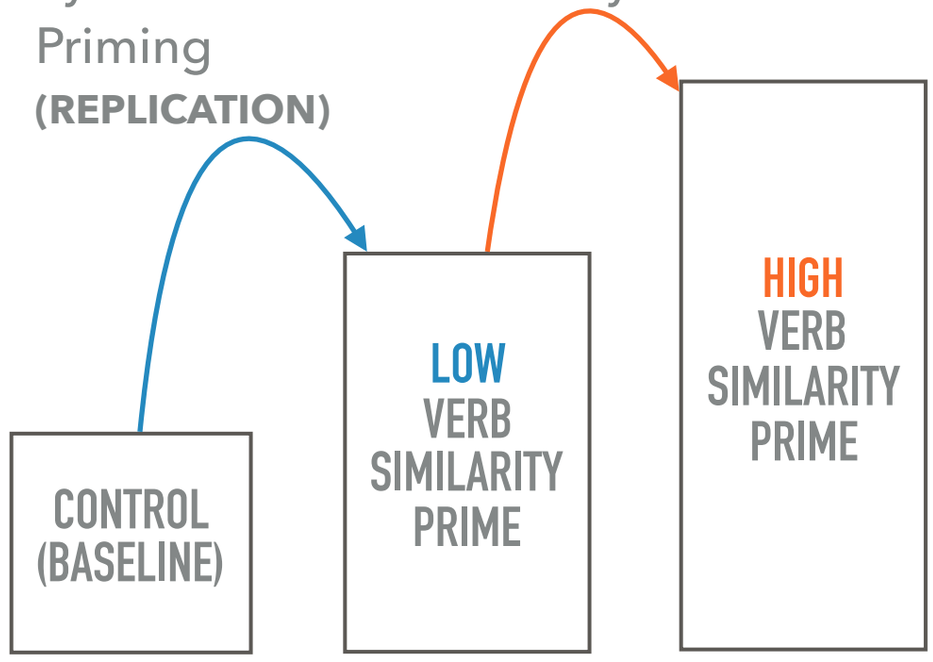


PREDICTION IN THIS STUDY

*Verb similarity affects syntactic priming.

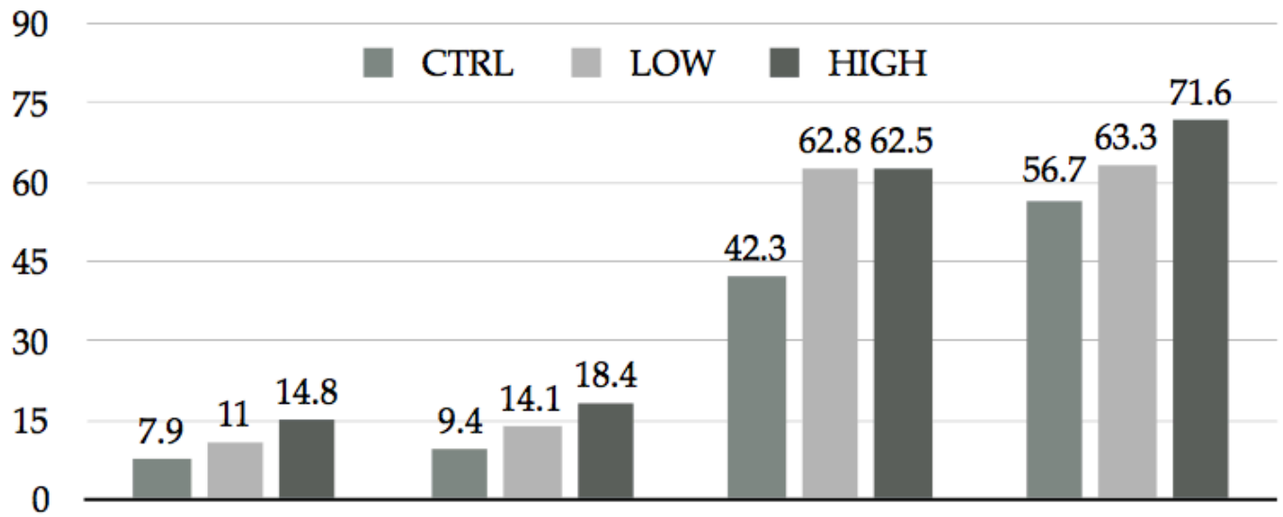
Syntactic Priming **(REPLICATION)**

High verb similarity effects



SUMMARY OF THE RESULTS

PERCENTAGES OF TARGET SHIFTS



FIXED EFFECTS IN 4 MODELS

Predictor (Binned vs. Scalar)		Exp1	Exp 2	Exp 3	Exp 4
Tabulated similarity conditions	Ctrl vs. Low	0.679 (.115)	0.943 (.013)	1.196 (.000)	0.629 (.010)
	Ctrl vs. High	0.796 (.033)	1.167 (.002)	1.403 (.000)	1.191 (.000)
	Low vs. High	0.117 (.783)	0.223 (.560)	0.206 (.502)	.561 (.034)
Similarity as continuous vb	Similarity rating (on a scale of 1~7)	0.132 (.039)	0.178 (.010)	0.215 (.000)	0.206 (.000)

META-ANALYSIS

- Model with 3 predictors in a single mixed logit model

Effect	Estimate	*SE*	*z* value	*p*	
Intercept	-1.888	0.18	-10.17	.000	***
Low-similarity vs. Control	-0.521	0.13	-4.08	.000	***
Low-similarity vs. High-similarity	0.291	0.13	2.21	.026	*
Preferred frame (or dispreferred)	2.613	0.13	19.84	.000	***
Dative (or locative)	-0.318	0.21	-1.54	.124	

Verb Similarity

Preferred: shift to PO shift to FO

Formula: Shift ~ Condition + Preferred + Dative + (1 | Subject) + (1 | Item)

Significance levels: '.' < .1, '*' $p < .05$, '**' $p < .01$, '***' $p < .001$

CONCLUSION

The more similar a target verb is to its prime verb, the more likely it is to occur in the same syntactic frame.

VERB SEMANTIC SIMILARITY MODULATES SYNTACTIC FRAME SELECTION ONLINE.

THE RESULTS CONFIRM THE RECENT VERB ANCHOR HYPOTHESIS.

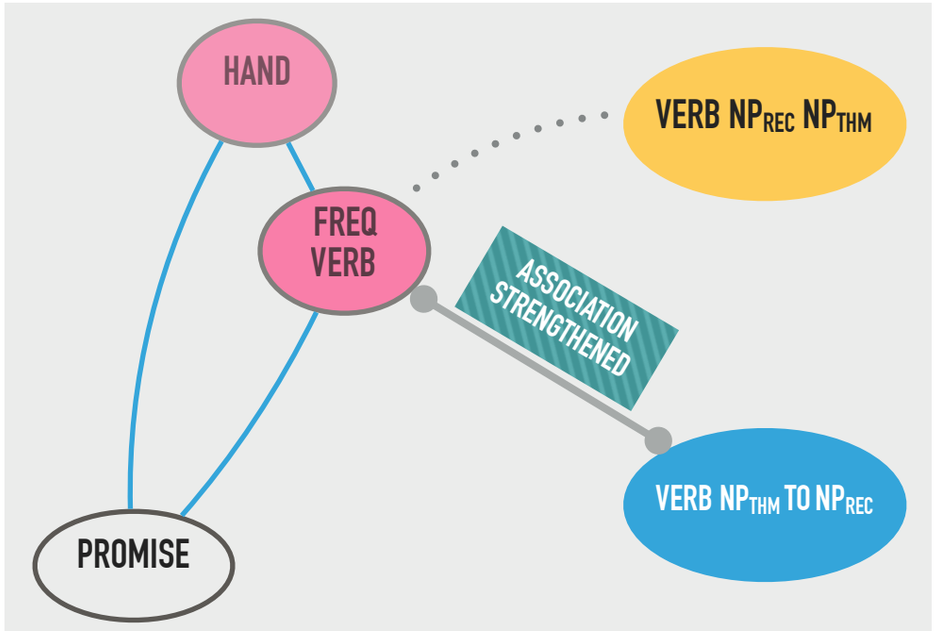
CORPUS & STATISTICAL MODELING

TYPICAL VERB ANCHOR HYPOTHESIS

VERB ANCHOR BY FREQUENT EXPERIENCE

- The 'anchor' status via ***frequent*** and ***repeated*** experience

- Frequent experience **strengthens association link** between a particular verb and a particular frame
  - Higher resting activation level = more accessible / learning).



- Typical Verb Anchor Hypothesis
  - The more semantically similar a verb is to the typical anchor, the more likely it is to occur in the same syntactic frame.

VERB FREQUENCY DISTRIBUTION IN DATIVE ALTERNATION

- Collected DO and PO sentences with 127 alternating verbs from a version of British National Corpus automatically parsed by the Charniak parser (Charniak, 1997)
- Overview of the frequency distribution in the data

Verb	Tokens					Proportions
	DO		PO		DO + PO	DO:PO
give	15,311	59%	8,402	22%	23,713	65:35
other 104 verbs	10,762	41%	28,928	78%	39,690	27:73
Total	26,073	100%	37,330	100%	63,403	41:59

HOW TO TEST THE TYPICAL ANCHOR HYPOTHESIS

- **Logistic regression modeling** on the corpus (production) data
  - The outcome (binary) variable for all models
    - ➡ Code each and every collected sentence from the corpus with the structure (DO vs. PO)
  - The (major) predictor variable
    - ➡ Measure semantic similarity between the main verb and the typical anchor verb '*give*' using Latent Semantic Analysis

MODEL 1 - *WITH A SINGLE PREDICTOR*

PREDICTOR
(INDEPENDENT VB)

- Verbs' semantic similarity to 'give' (verb within each sentence)

OUTCOME
(DEPENDENT VB)

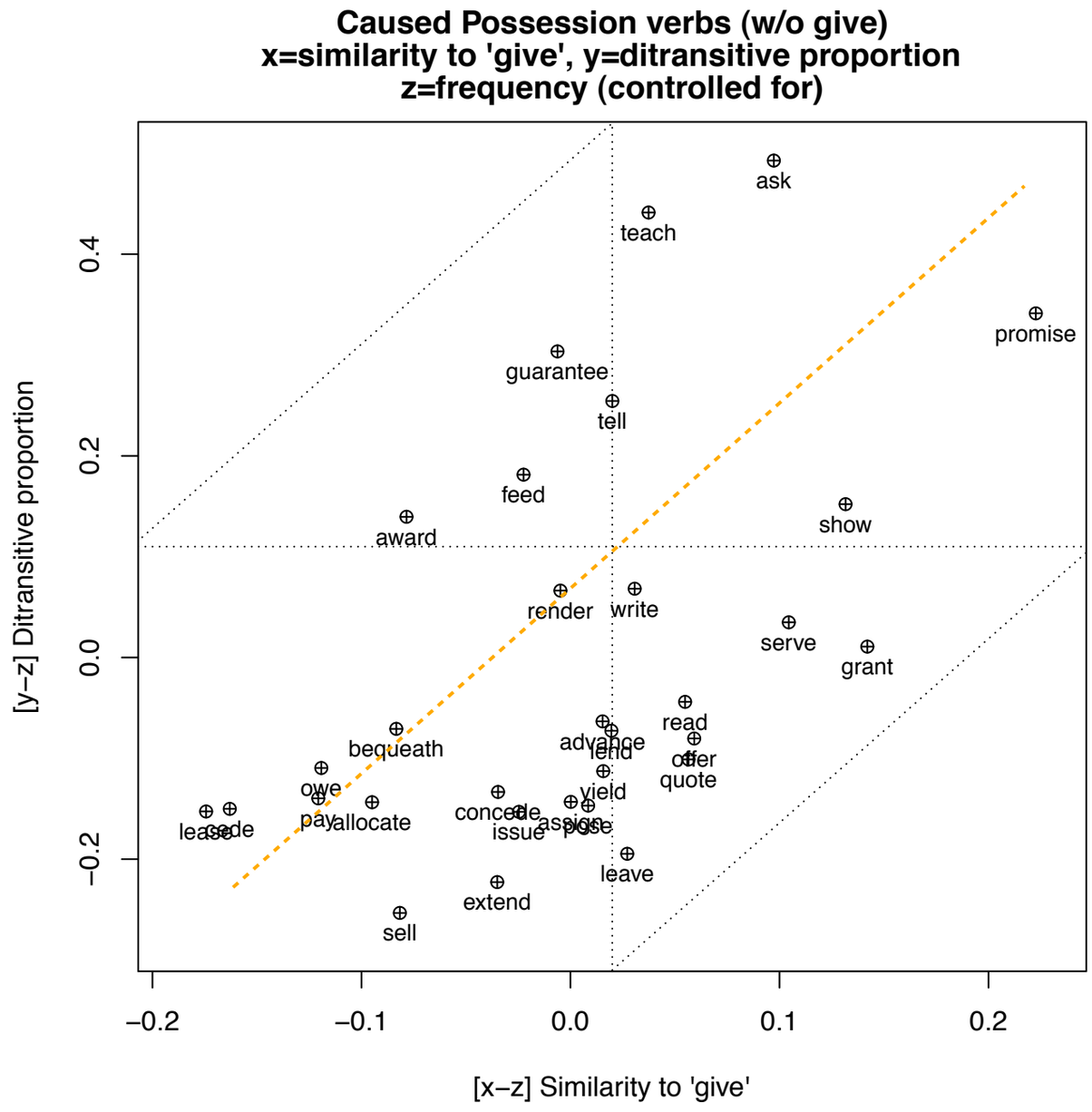
- The syntactic frame of every sentence, either DO (1) or PO (0)

RESULTS

- As predicted, verb semantic similarity to give is a significant predictor of the syntactic frame ($b = 3.77$, $z = 35.41$, $p < .001$)
- As indicated by the positive value of the coefficient (b), higher semantic similarity means higher likelihood of occurring in the DO frame.

SUPPORT FOR MODEL 1 (FOR EXPOSITORY PURPOSES)

- Significant correlation between verbs' similarity to *give* and their proportions of DO sentences
- $r = .507, p < .01$



WHEN WORKING WITH CORPUS DATA, WE MUST STATISTICALLY CONTROL FOR

POSSIBLE CONFOUNDING FACTORS

- Bresnan et al. (2007)
- Syntactic choice in the dative alternation is modulated by many different factors.

SEMANTIC & PRAGMATIC

- Animacy
- Definiteness
- Given information
- Verb class

SYNTACTIC & STRUCTURAL

- Pronominality
- Length difference between recipient and theme (e.g., short-before-long tendency)

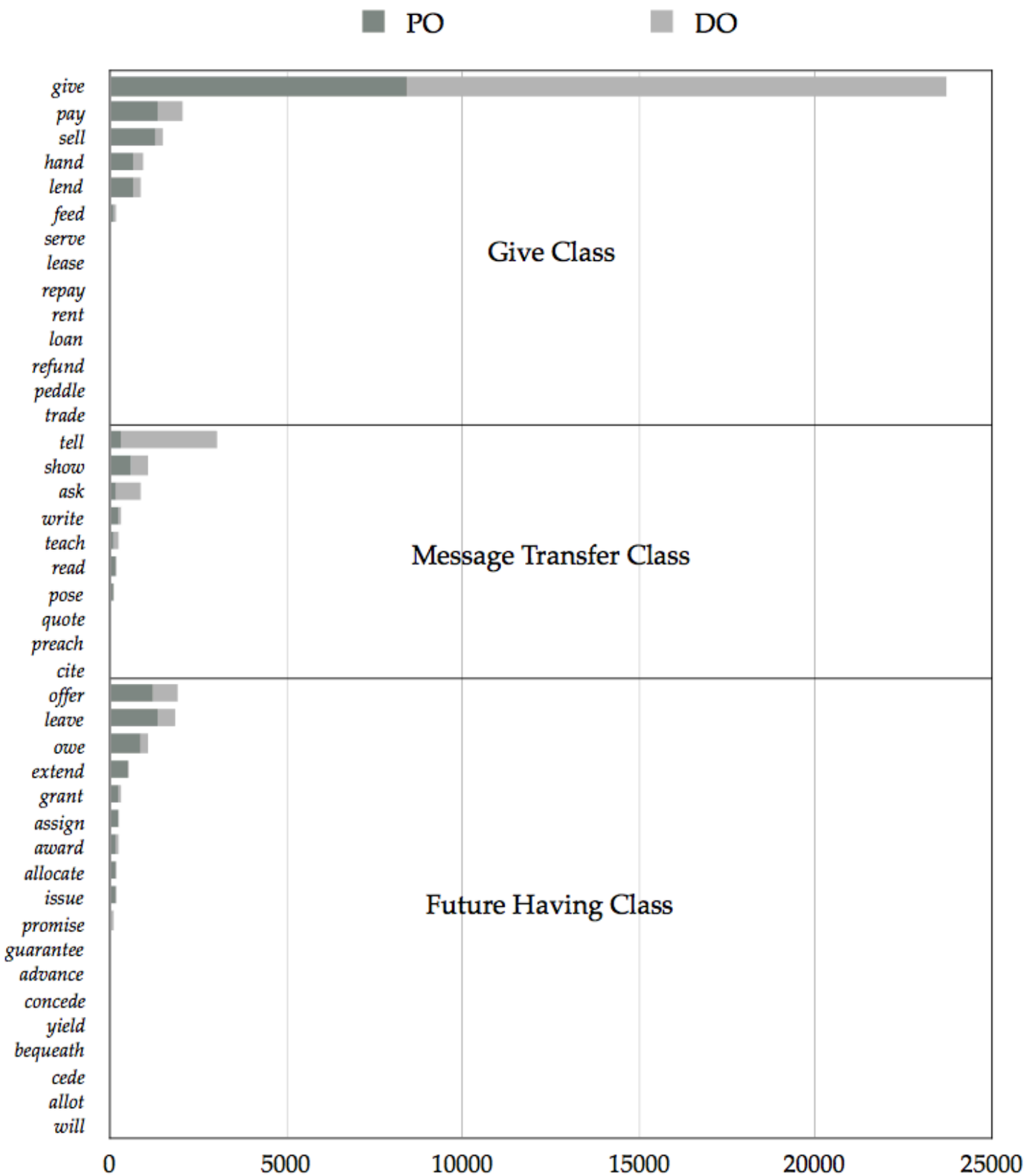
MODEL 2 - *WITH MULTIPLE PREDICTORS (SIMILARITY TO 'GIVE' + BRESNAN'S)*

Predictors	Model *with* similarity to *give*	Model *without* similarity to *give* (Replication of Bresnan et al.'s)
NEW verb similarity to *give* (LSA cosines)	-2.00 **	-
inanimate recipient	3.45 ***	3.59 ***
inanimate theme	-1.38 *	-1.20 *
nonpronominal recipient	1.08 ***	1.21 ***
nonpronominal theme	-0.72 *	-0.70 *
nongiven recipient	1.37 ***	1.38 ***
nongiven theme	-1.21 *	-1.14 ***
indefinite recipient	0.60 *	0.56 *
indefinite theme	-1.22 ***	-1.25 ***
transfer semantic class	-0.08 ns	0.05 ns
communication semantic class	-2.46 ***	-2.62 ***
future having semantic class	-1.49 **	-1.36 **
length difference (log scale)	-0.90 ***	-0.91 ***

DO = 0, PO = 1, Significance: 'ns' $p > .05$, '*' $p < .05$, '**' $p < .01$, '***' $p < .001$

TYPICAL ANCHOR WITHIN NARROW VERB CLASS

- Typical verb anchor can exist in **narrow-range** verb groups
- Natural category analogy
  - e.g., the ‘bird’ category - the ‘eagle’ category
- *‘Tell’* in the message transfer verbs



CONCLUSION

When there is a highly frequent verb that can be typical of a syntactic frame, how similar a verb meaning is the typical anchor modulates its likelihood of occurring in the frame the anchor is associated with.

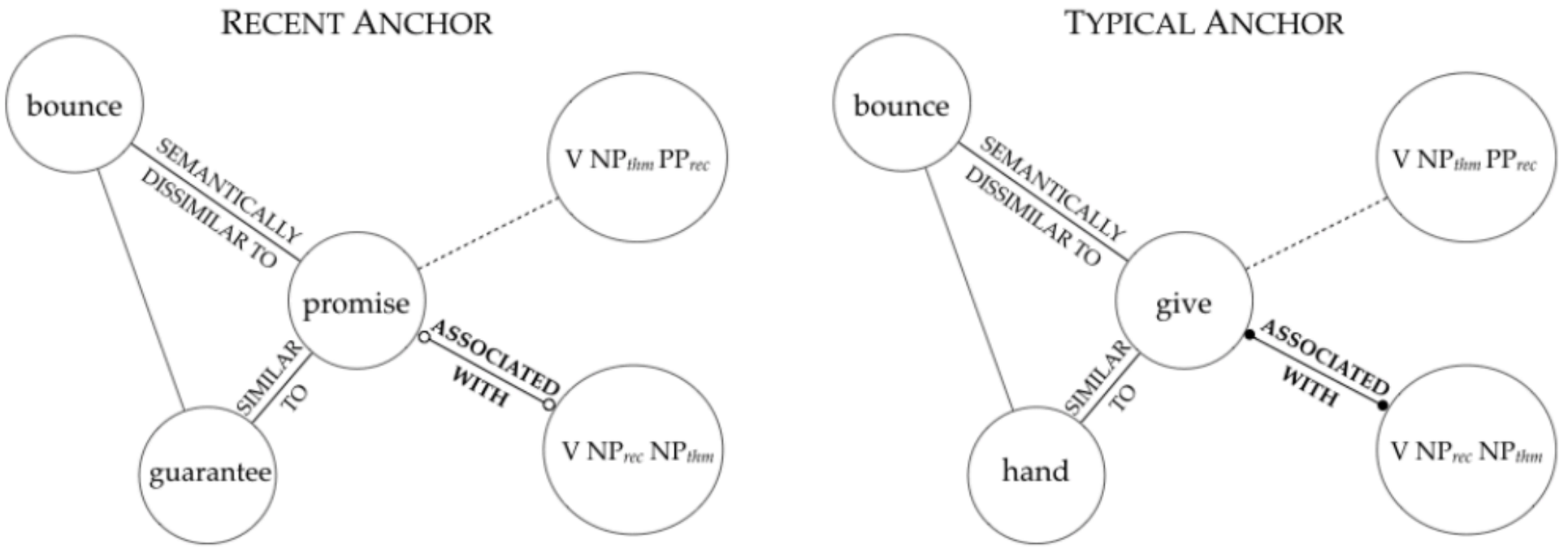
VERB SIMILARITY TO A TYPICAL ANCHOR CAN MODULATE SYNTACTIC FRAME SELECTION.

THE RESULTS CONFIRM THE FREQUENT VERB ANCHOR HYPOTHESIS.

LASTLY,

SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION



- We started out with a question why similar verb meanings occur in similar syntactic contexts (the '**correspodence**' phenomena).

- In the context of sentence production, speakers are sensitive to the **association** between **verb meaning** and **syntactic structure** previously experienced, both ***recently*** and ***repeatedly***.

- The correspondence is not an a priori necessity but **reflects a system that well accords with speakers' cognitive abilities**.

THANK YOU

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