

24.949

Language Acquisition

Class 3
Syntactic
Bootstrapping

Last week

- What can and cannot be learned by observation
 - ▶ may be possible to learn a small set of nouns associated with concrete, mid-sized objects
 - ▶ doesn't seem to work so well for verbs (and potentially many other expressions including several nouns)

Today

- verb learning, argument structure and syntactic bootstrapping

A note on reading empirical papers

- For any experimental enterprise, in addition to the theoretical assumptions, there are often a number of empirical assumptions that are specific to the operationalization at hand
- The validity of the conclusions drawn depend on how good these empirical assumptions are
- A good paper will articulate these assumptions (and spell out counterfactual worlds in which they are false) so that we have a meaningful way to talk about failure reflecting real competence limitation or suboptimal operationalisation

World-to-word mapping

“The cat is **chasing** the mouse”

SITUATION >> OBSERVER >> WORD MEANING

Why word-to-world mapping can't possibly work

- The same situation makes available many meanings
- sometimes necessarily so:
 - ▶ every *give* situation will also be a *receive* situation,
every *kill* situation will also be a *die* situation

Why word-to-world mapping can't possibly work

No one-to-one mapping between scene and verb

► mirror image verbs

(1) The cat is chasing the mouse.

(2) The mouse is fleeing from the cat.

Why word-to-world mapping can't possibly work

No one-to-one mapping between scene and verb

► The granularity problem:

(1) I perceived the fireworks.

(2) I saw the fireworks.

Why word-to-world mapping can't possibly work

No one-to-one mapping between scene and verb

- ▶ Meanings that are closed to observation

(1) I thought that it was snowing.

(2) I hoped that it would snow.

(3) I want it to snow.

Syntactic bootstrapping

- Sentence-to-world mapping

SITUATION >> OBSERVER >> SENTENCE MEANING

How do you get to the verb?

- Children can use the syntactic structure to derive a partial sense of the event being described
 - ▶ E.g. “A gave X to B” involves a transfer event in which A is doing something (as opposed to B doing something)
- This guides the search for an appropriate event construal in the current scene, which in turn constrains hypotheses about the verb's meaning.

How do you get to the verb?

- Grimshaw (1994): identifying a simple transitive structure won't help much at all in narrowing down the meanings

(1) a. She weighed the tomatoes.

b. She weighed 150 lbs.

(2) a. He became a doctor.

b. He hugged a doctor.

(3) Solution: children refine their hypotheses about verb meaning by tracking the *set* of syntactic frames the verb accepts

- Corollary: learning verbs necessarily cross-situational (not tested to my knowledge)

What kinds of regularities are available?

(1) Sue **broke** the vase.
The vase **broke**.
*Sue broke.

Change-of-state

(2) Sue **ate** the apple.
*The apple **ate**.
Sue **ate**.

Incremental theme

What kinds of regularities are available?

(1) I **saw** the fireworks. **Perceptual Experience**

I **saw** that the fireworks are canceled.

I **saw** the man escape.

*I **saw**.

(2) I **looked** at the fireworks. **Perceptual Activity**

*I **looked** (at) that the fireworks are canceled.

*I **looked** (at) the man escape.

?I **looked**.

What kinds of regularities are available?

- (1) I **think** that it is raining.
*I **think** whether it is raining.

Non-factive attitude

- (2) I **know** that it is raining.
I **know** whether it is raining.

Factive attitude

Architectural assumptions

- “Projectionist” framework (Chomsky 1981; Levin and Rappaport Hovav 1995)
 - lexical entry of a verb contains information about its syntactic category, syntactic behavior (subcategorization frames) and the number and type of arguments it requires (θ -grid)

give

phon: give

syn: [____ V NP PP]

sem:

Source/Agent	Theme	Goal
i	j	k

Architectural assumptions

- “Projectionist” framework (Chomsky 1981; Levin and Rappaport Hovav 1995)
 - ▶ **Theta-criterion:** every argument receives one and only one theta-role
 - ▶ **The Projection Principle:** Lexical information (theta roles, etc.) is syntactically represented at all levels

Architectural assumptions

- “Projectionist” framework (Chomsky 1981; Levin and Rappaport Hovav 1995)
 - ▶ Allows for lexical information to directly constrain the validity of syntactic structures
 - ▶ In cases where verbs appear with fewer or more arguments, the theory requires productive lexical operations that can change the θ -grid

Architectural assumptions

- No reason that syntactic bootstrapping and a projectionist framework should align, but most subsequent work since G90 have assumed it (Fisher, 1996; Fisher, Gertner, Scott, & Yuan, 2010; Yuan, Lidz et al., 2004, a.o.)
- On this story, it's *because* the verb meaning limits the set of possible syntactic frames in which it can appear that the child can use the frame to reverse engineer its meaning

Bootstrapping via valency

- Valency: # of arguments that are typically part of the event described by the verbal predicate
 - *kick* usually shows up with 2 arguments, *die* with 1, etc.

Naigles 1990

- Can young children use valency information to deduce verb meanings?
- Starting assumption (taken as by necessity):
 - ▶ intransitives describe events where a single actor does something
 - ▶ transitives describe events where one actor does something to another

Naigles 1990

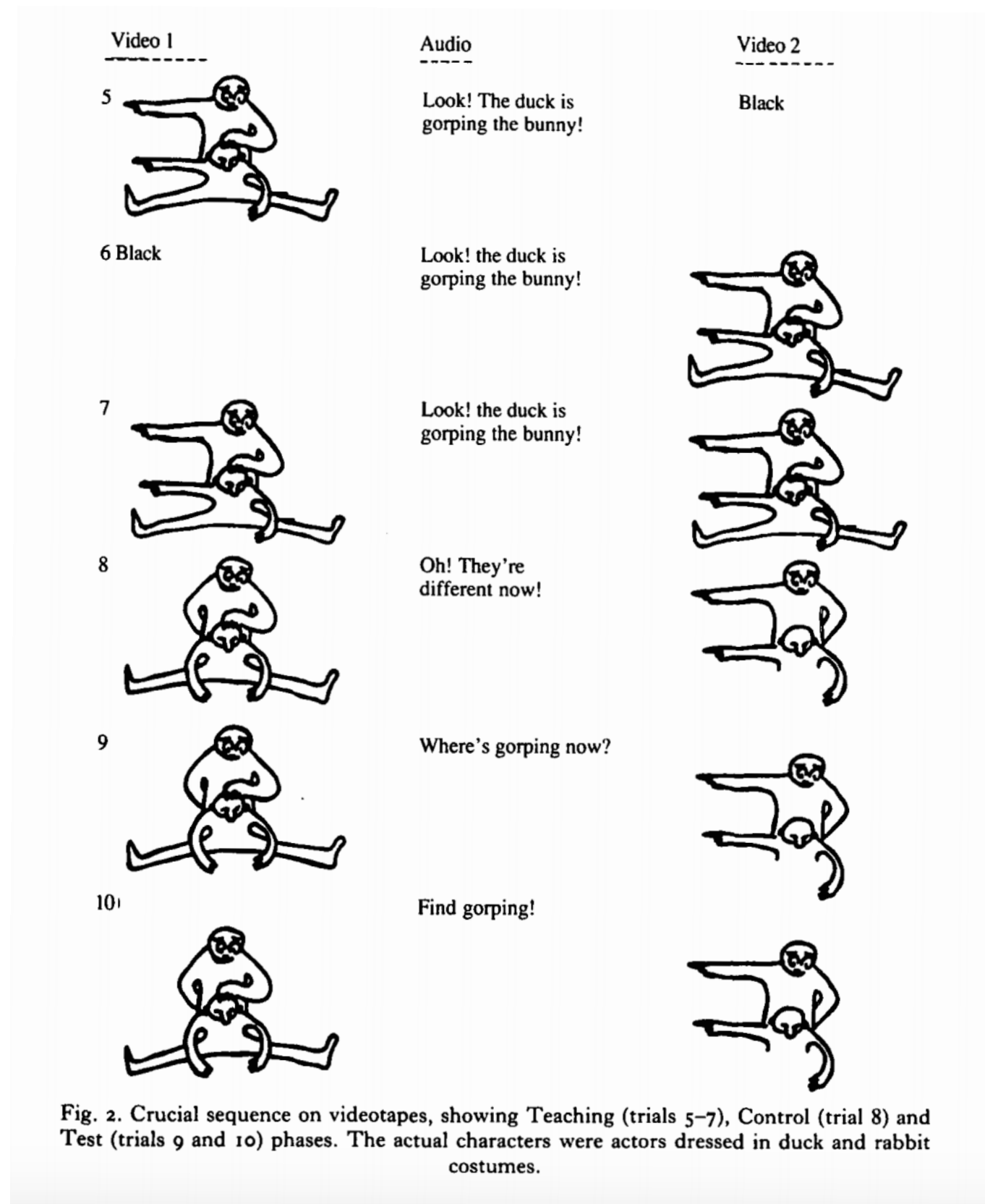
- Participants: 24 2-year-olds (M=25mos)
- Preferential looking paradigm

Naigles 1990

- Familiarization (6s x 3)
 - ▶ scenes in which two actors were simultaneously engaged in two kinds of action
 - ▶ one actor (dressed as a duck) was pushing the other (dressed as a bunny) repeatedly into a squatting position + both actors were waving one of their own hands in circles
 - ▶ Heard one of two frames (between-subjects factor):
 - (1) The duck is gorping the bunny.
 - (2) The duck and the bunny are gorping.

Naigles 1990

- Test (6s x 3):
 - ▶ the two actions were pulled apart on two separate screens
 - ▶ one screen depicted just the duck pushing the bunny into a squatting position
 - ▶ other screen depicted just the duck and bunny waving.
 - ▶ “Where's gorping now? Find gorping!”



Results

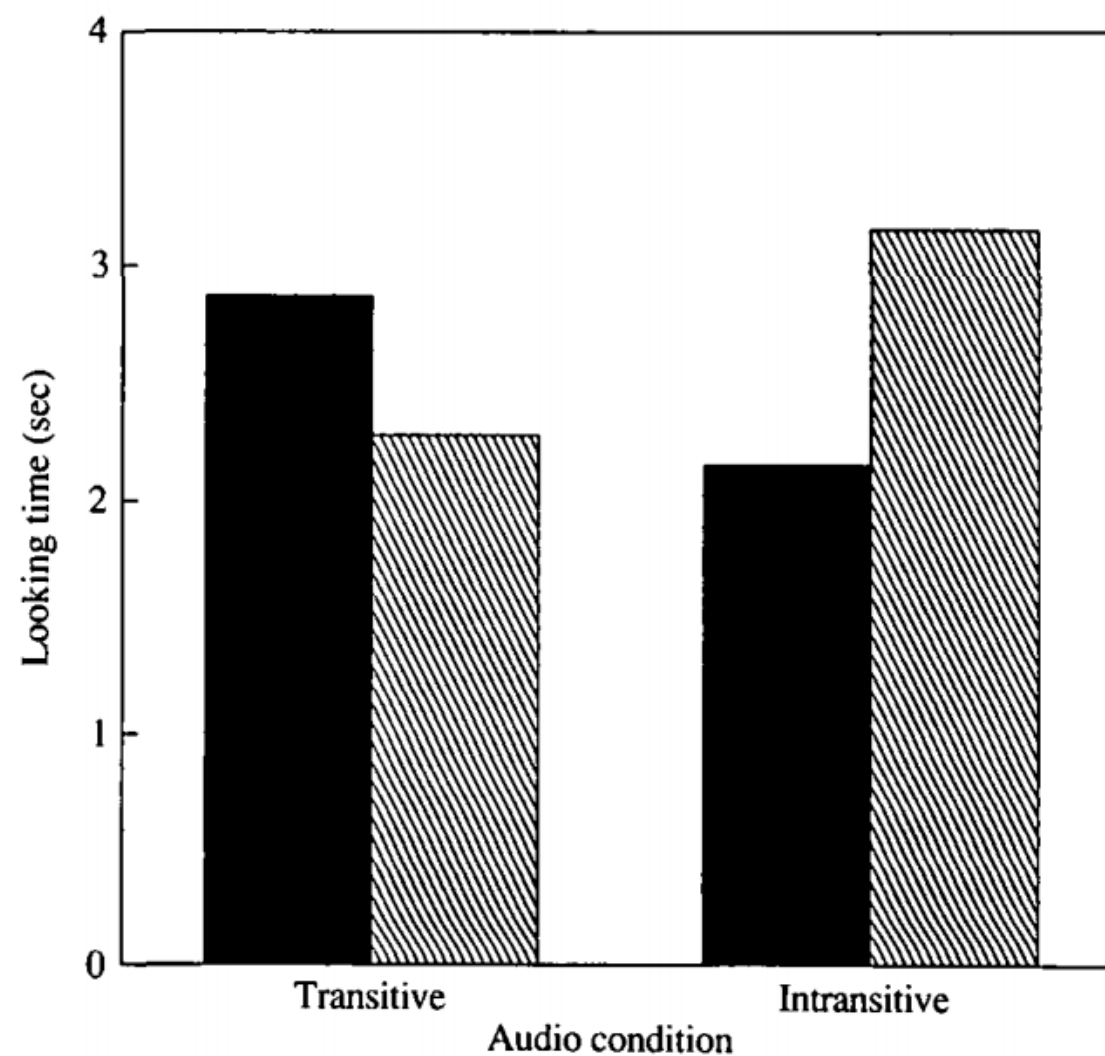


Fig. 3. Mean visual fixation during the test trials to the causative and non-causative actions, for the Transitive and Intransitive Audio conditions. ■, Causative action; ▨, non-causative action.

Implication

- When given a choice between (i) a two-participant causative action and (ii) a single-participant non-causative action, toddlers tend to map a transitive frame to (i) and an intransitive frame to (ii).
- One possibility: systematic links between transitivity, argument structure and causal events
 - A Vs B \rightarrow A=agent/cause, B=patient \rightarrow identify an event in which A does something to B, who undergoes some change as result
- What are others?

Yuan and Fisher 2009

- Can 2-year-olds extract something about a verb's combinatorial privileges (argument structure) from brief dialogues sans situational/referential information?



Yuan and Fisher 2009

Experiment 1

- Participants: 16 2-year-olds; 8 per condition
- Practice trials w/ 2 familiar verbs (clap, tickle), followed by
Test trials w/ novel verb, *black* (either transitive or intransitive frame)

Yuan and Fisher 2009

Dialogue Phase

	<i>Transitive dialogues:</i>	<i>Intransitive dialogues:</i>
	A: Hey...Jim is gonna blick the cat! B: Really? He's gonna blick the cat? A: And Mary was blicking the man. B: Wow, she was blicking the man.	A: Hey...Jim is gonna blick! B: Really? He's gonna blick? A: And Mary was blicking. B: Wow, she was blicking.
	A: Guess what? Jane blicked the baby! B: Hmm, she blicked the baby? A: And Bill was blicking the duck. B: Yeah, he was blicking the duck.	A: Guess what? Jane blicked! B: Hmm, she blicked? A: And Bill was blicking. B: Yeah, he was blicking.


Event Phase 1




"Find blicking! Where's blicking? See? Where's blicking?"

8s

Event Phase 2




"Find blicking! Where's blicking? Find blicking! Find blicking!"

8s

Fig. 1. Dialogue and event phases for the novel verb in Experiment 1. Half the children heard transitive dialogues, and half heard intransitive dialogues. The transitive and intransitive dialogues were identical except for the presence versus absence of the direct-object noun phrase in each sentence. In the event phases, all children watched the same two novel events and heard the verb in syntactically uninformative sentences.

Yuan and Fisher 2009

TABLE 1

Mean Looking and Look-Away Times (in Seconds), Averaged Across the Two Event Phases, in the Test Trial in Experiment 1

Dialogue type	Looking time		Look-away time
	Two-participant event	One-participant event	
Transitive	4.82 (0.43)	2.87 (0.51)	0.31 (0.19)
Intransitive	3.33 (0.24)	4.12 (0.40)	0.54 (0.24)

- reliably longer looks to 2-participant events after hearing transitive frames
- no difference between looks to 2 vs. 1-participant events after intransitives

Yuan and Fisher 2009

Experiment 2

- Eliminated certain potential confounds (e.g. online learning/priming effects from practice)
- Introduced a control (“What’s happening?”)
- Introduced a delay factor (test same day or 1-2 days later)

Yuan and Fisher 2009

Results

TABLE 2

Mean Looking and Look-Away Times (in Seconds), Averaged Across the Three Event Phases, in the Test Trial in Experiment 2

Dialogue type	Same-day condition		Different-day condition		Overall	
	Experimental	Control	Experimental	Control	Experimental	Control
Looking time to the two-participant event						
Transitive	5.41 (0.38)	4.30 (0.41)	5.02 (0.27)	4.82 (0.30)	5.17 (0.22)	4.61 (0.24)
Intransitive	4.11 (0.09)	4.60 (0.45)	3.90 (0.26)	4.57 (0.32)	3.99 (0.16)	4.58 (0.26)
Looking time to the one-participant event						
Transitive	2.28 (0.33)	3.32 (0.44)	2.52 (0.24)	2.80 (0.30)	2.43 (0.19)	3.01 (0.25)
Intransitive	3.09 (0.19)	3.10 (0.45)	3.50 (0.30)	3.00 (0.31)	3.33 (0.20)	3.04 (0.25)
Look-away time						
Transitive	0.30 (0.07)	0.37 (0.12)	0.46 (0.10)	0.38 (0.10)	0.40 (0.07)	0.38 (0.08)
Intransitive	0.80 (0.16)	0.30 (0.05)	0.60 (0.14)	0.43 (0.10)	0.68 (0.10)	0.38 (0.06)

Note. Standard errors are given in parentheses.

Yuan and Fisher 2009

- Having first heard a novel verb in a transitive frame, toddlers find it more likely later to describe a 2-participant causal event as opposed to a 1-participant non-causal event.
- Having first heard a novel verb in an intransitive frame, toddlers find it equally likely to describe a 2-participant causal event or a 1-participant non-causal event.
 - ▶ what's going on here? we'll come back to it.

Counting the nouns

- Syntactic bootstrapping *sans* syntax
- The worry: for syntactic bootstrapping to get going, the child needs to have a rather sophisticated understanding of the syntax of their L1
 - ▶ What do you need to know to make any use of the structures in Y&F2009?
- This is a problem if you need the verbs to learn the syntax of your L1 (e.g. to identify what is the subject)

Counting the nouns

Fisher 1996, Yuan, Fisher & Snedeker 2009, Snedeker 2020, a.o.:

- Claim: children start out with a “simple” algorithm that maps # of noun phrases to # of event participants

Counting the nouns

Assumptions:

- “I assume that **semantic structures of verbs** are **fundamentally of the same kind as the nonlinguistic conceptual structures by which we represent events** (e.g., Grimshaw, 1990; Jackendoff, 1983, 1987, 1990; Pinker, 1989; Rappaport & Levin, 1988). Both verb semantic structures and conceptual representations of events demand a division between predicates and arguments, and thus between relations and the objects they relate (c.f. Bierwisch & Schreuder, 1992; Braine, 1992)”

Counting the nouns

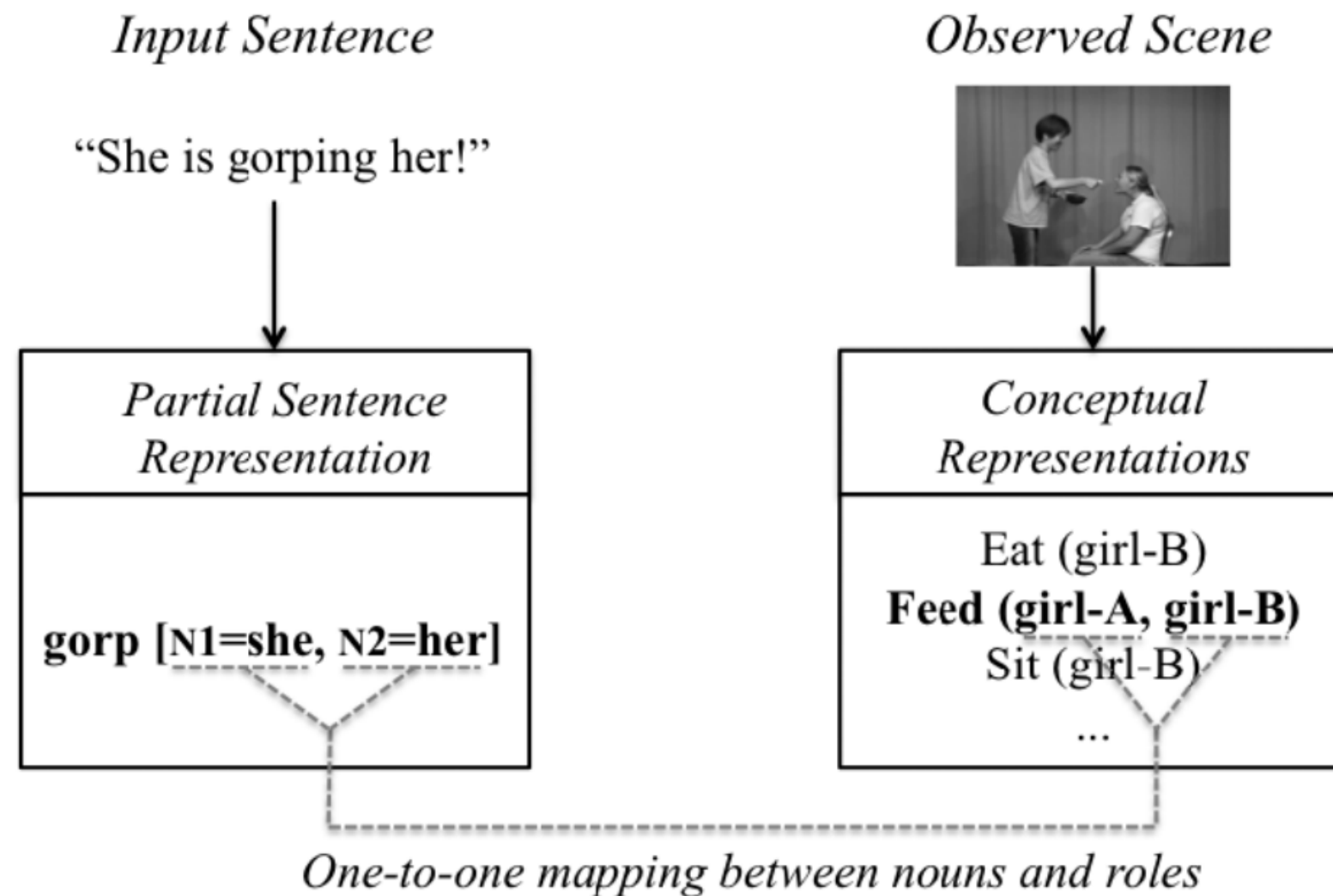
Assumptions:

- Analogic mapping between "conceptual structure" and "syntactic structure"
- “Even before the subject and object of a sentence are identified, **each sentence contains some number of noun phrase arguments**...Once children can identify the nouns in a sentence, they could assign different meanings to transitive and intransitive verbs simply by **aligning a sentence containing two noun phrases with a conceptual relation between the two named participants** and a sentence containing one noun phrase with a conceptual predicate involving the single named participant.”

Counting the nouns

Yuan, Fisher and Snedeker 2012, p. 1384

a) Structure-mapping account



Counting the nouns

- In theory, falsifiable:
 - children should not be able to meaningfully distinguish (1) from any of (2) - (5)

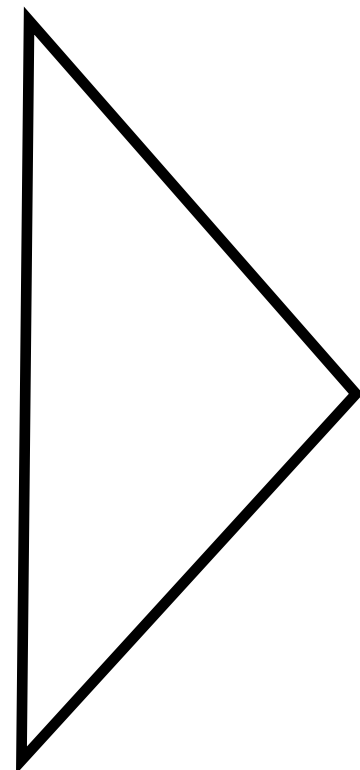
(1) Sue blicked Billy.

(2) Billy blicked Sue

(3) Sue blicked with Billy.

(4) Sue and Bill blicked.

(5) Sue blicked herself.



**some event that relates two
participants**

In practice...

- Yuan, Fisher and Snedeker 2012
 - ▶ “This account makes a strong prediction: The **number of nouns in a sentence** should guide very early verb learning. Via structure mapping, the **semantic significance of transitivity does not depend on prior verb learning or on much prior learning about the native-language syntax**. As soon as children can identify some nouns and represent them as parts of a larger sentence structure, **they should assign different interpretations to transitive and intransitive verbs, essentially by counting the nouns.**”

Yuan, Fisher and Snedeker

- Participants: 21- (Exp 1+2) and 19- month olds (Exp 3)
- 3 Conditions: transitive, intransitive & neutral
- 2 practice trials (clap, tickle) followed by 1 novel verb in one of the 3 conditions

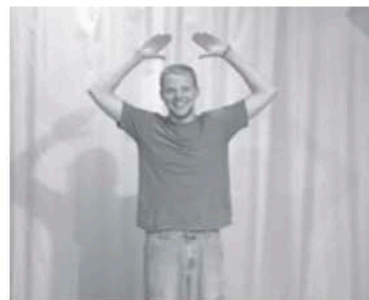
Yuan, Fisher and Snedeker

Experiment 1



Blank-Screen Interval (4s)

Watch!
He's gonna gorp (him)!



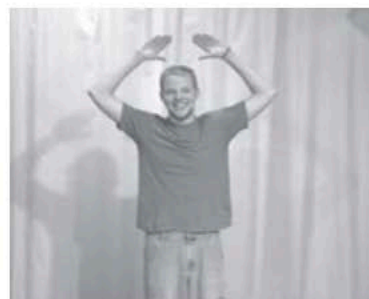
First Test Trial (8s)

He's gorp (him).
He's gorp (him).
See?
He's gorp (him).



Blank-Screen Interval (3s)

Find gorp.



Second Test Trial (8s)

He's gorp (him).
Find gorp.
Find gorp.

Yuan, Fisher and Snedeker

Experiment 1 vs. 2 (bystander)

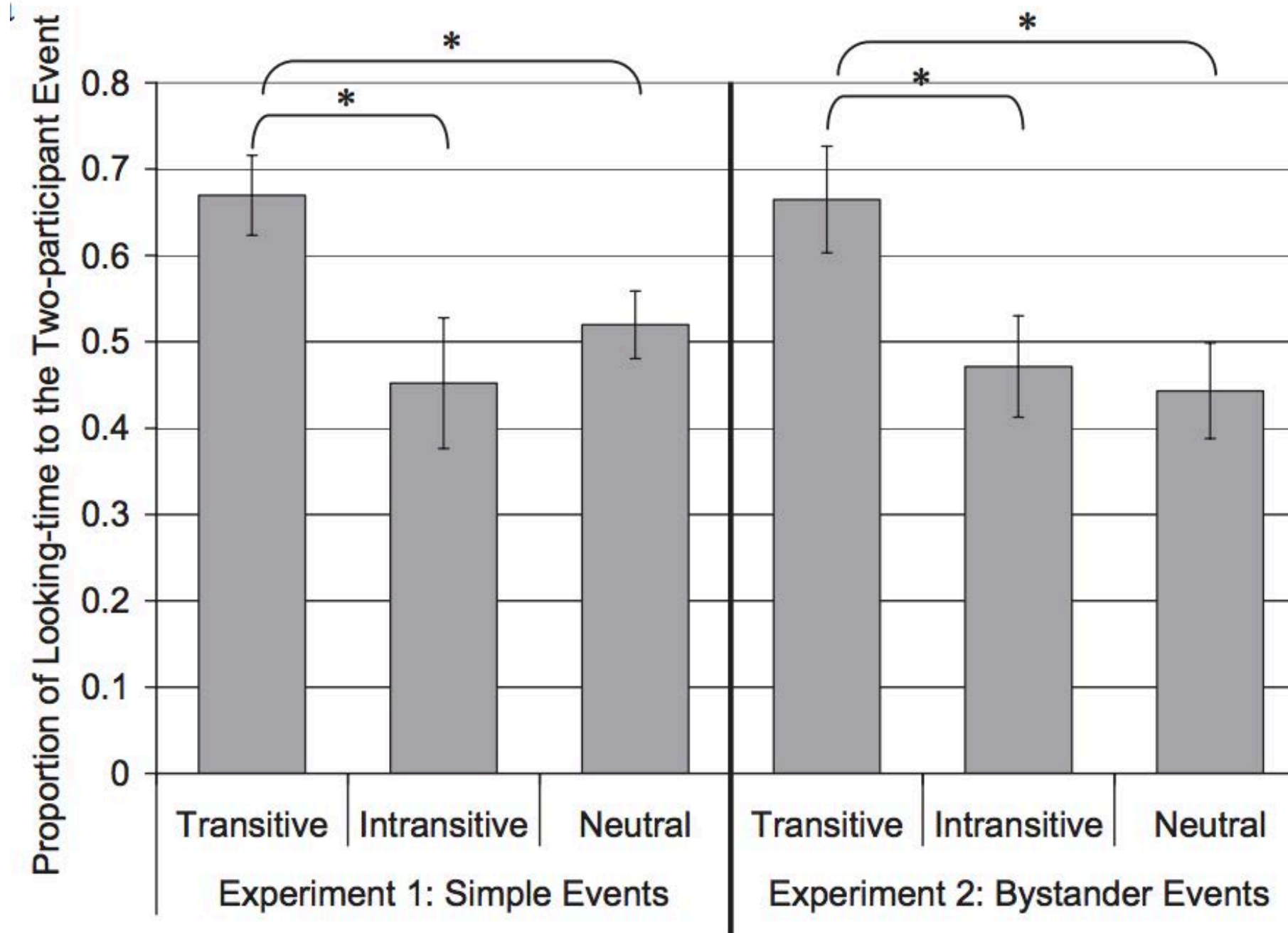
a



b



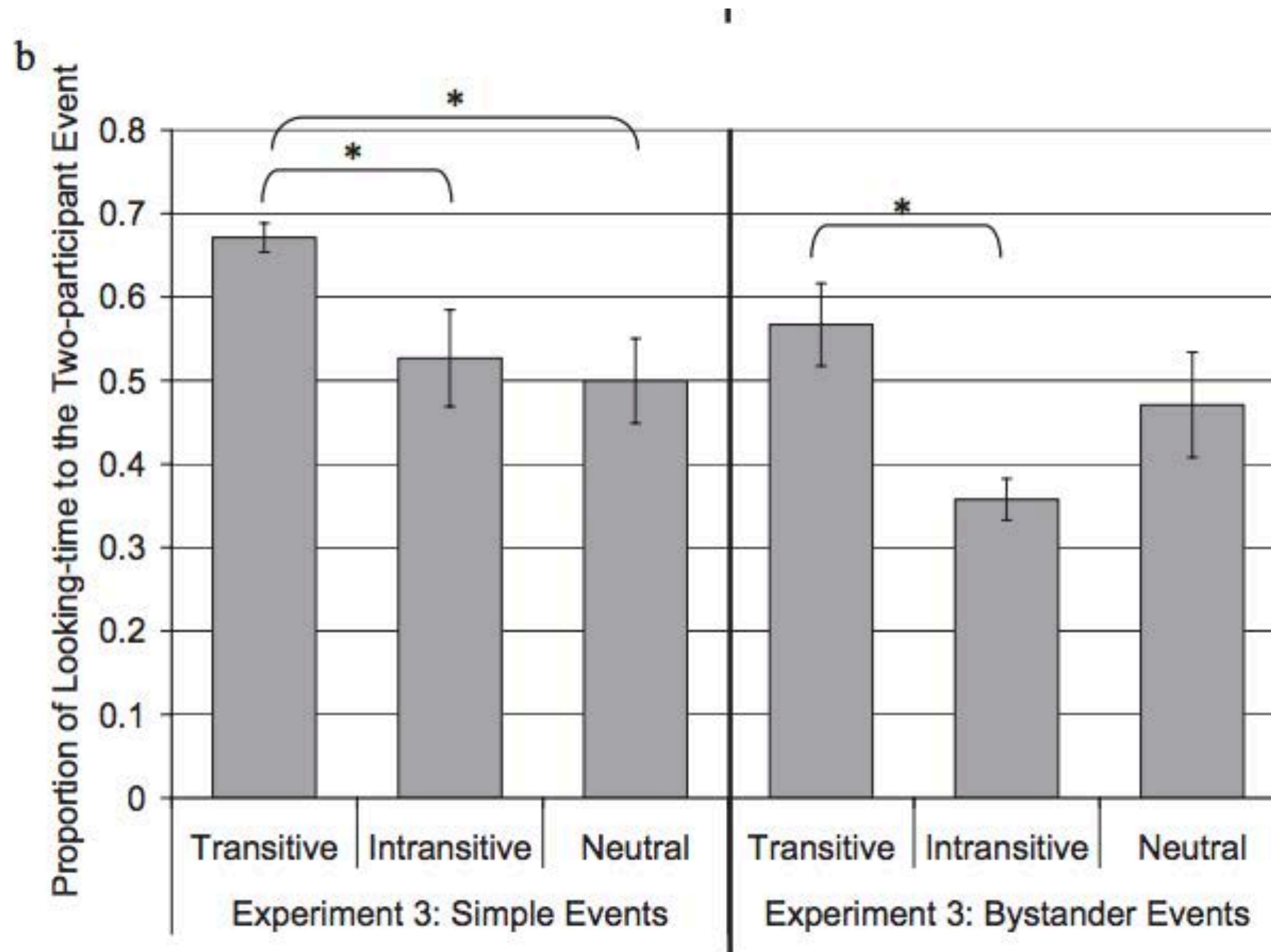
Results



Yuan, Fisher and Snedeker

- Experiment 3
 - ▶ minor modifications to procedure (different practice trials, preceding Y&F-type dialogues)
 - ▶ 72 19-mos split across 6 conditions (valency; +/- bystander)

Yuan, Fisher and Snedeker

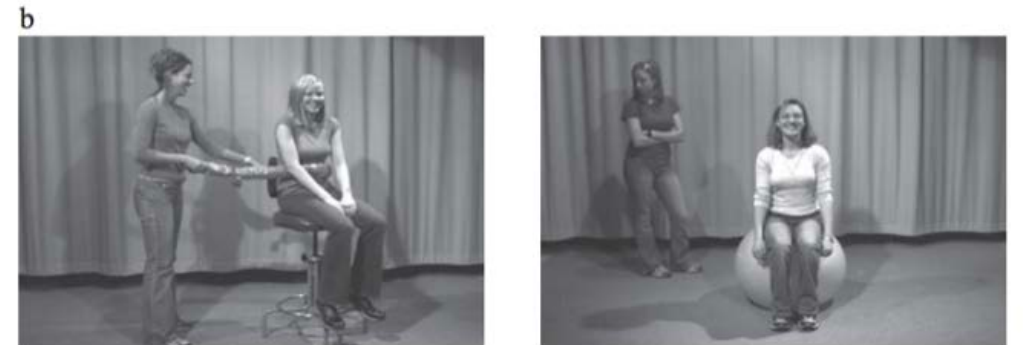


Yuan, Fisher and Snedeker

- Is “noun-counting” the only explanation of these results?
 - ▶ counting the nouns, or any algorithm that entails noun-counting gives a partial explanation to these results (i.e. any other more sophisticated mapping procedure)
- Is “noun-counting” supported by these results?
 - ▶ partially no: intransitives

Implicit auxiliary assumptions

- assumptions that doesn't follow from anything in the theory:
 - ▶ 2 noun phrases: linearly 1st one is the agent
 - ▶ agency translates to active behavior
- empirical assumptions:
 - ▶ chair, ball, rope etc. don't "count"
 - ▶ kids converge on the intended notion of "bystander" (e.g. why doesn't the right image represent "A ignores B"?)



Complicating the picture

- Are the core assumptions of the theory even valid?
 - ▶ In the case of verbs, one key assumption was that verb meanings are event representations and these representations map onto syntactic configurations w/ certain properties
 - ▶ But is this how language works?

Kratzer 1996

- What is the meaning and argument structure of “kill”? (building on arguments in Marantz 1984)

(1) kill a bug = cause the bug to die

kill a conversation = cause the conversation to end

kill an evening = while away the timespan

kill a bottle = empty the bottle

- Why are meaning shifts asymmetrically conditioned by one of the verb's arguments?

(2) John killed a bug.

The flood killed a bug.

The pesticide killed a bug.

Human cruelty killed a bug.

= cause the bug to die

Kratzer 1996

- Kratzer's answer:
 - ▶ The “external” argument (the doer/agent) is not an argument of the verb at all
 - ▶ Rather, it is the argument of a “light verb”, a functional verbalizer element, which combines with the main verb to give it its meaning

Hale & Keyser

- Hale and Keyser 1993, 1998, 2003
 - ▶ Cross-linguistically, the morphological expression of certain intransitive verbs involve what looks like nouns

(1) Jemez

- a. záae-'a “to sing”
song-do
- b. se-'a "speak"
speech-do

(2) Basque

- a. lo egin “to sleep”
sleep do
- b. near egin "to cry"
cry do

Hale & Keyser

- ▶ A systematic correspondence between such verbs and event nouns in English
- ▶ *to laugh, a laugh; to run, a run; to swim, a swim; to sneeze, a sneeze*
- ▶ Proposal: these verbs across languages are syntactically complex, involving a “light” verb + a nominal complement contributing the encyclopedic semantics

What verb? What argument structure?

- Deverbal nouns
 - grow ~ growth
- Argument structure of grow, the verb:
 - (1) a. John grows tomatoes.
b. Tomatoes grow well here.

What verb? What argument structure?

- Prediction if deverbal nouns “inherit” the argument structure of the verb
- (2) a. The growth of tomatoes...
b. *John’s growth of tomatoes...
c. *The growth of tomatoes by John...

What verb? What argument structure?

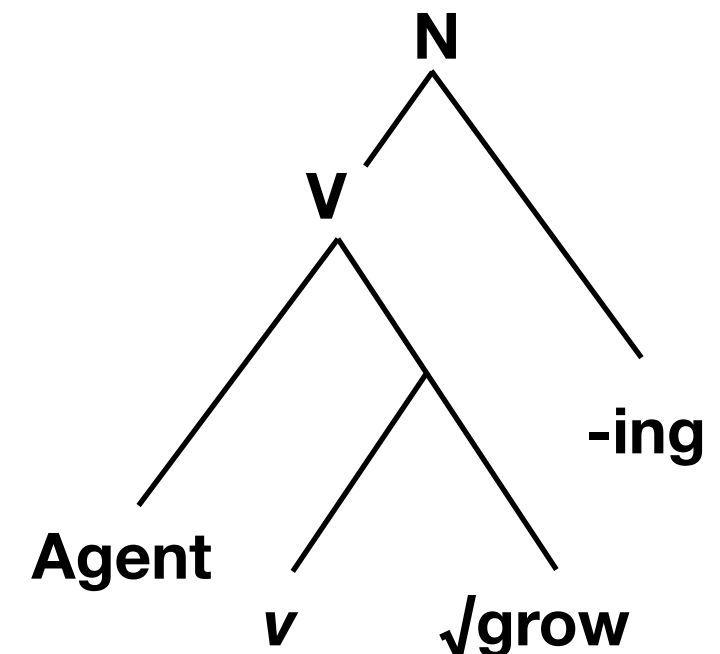
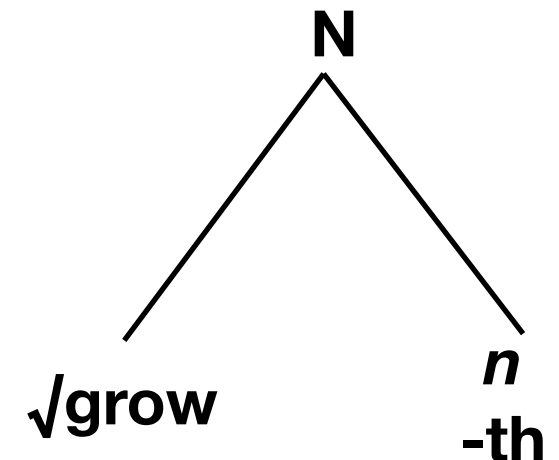
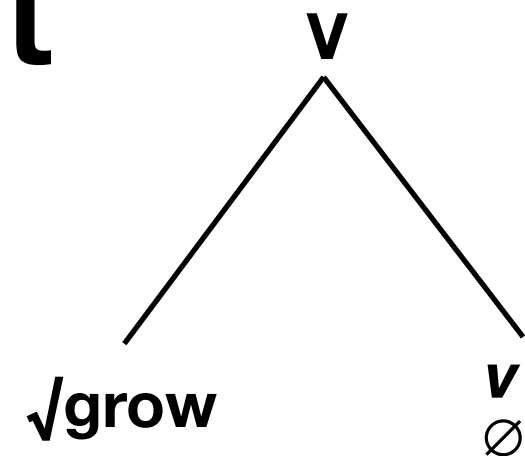
- Prediction if deverbal nouns “inherit” only one of the argument structural variants of the verb...

(2) a. The growing of tomatoes...
 b. John’s growing of tomatoes...
 c. The growing of tomatoes by John...

Paradigm shift

Neo-constructionist/non-projectionist frameworks:

- Abandon the standard picture where words are simplex units that already come with category labels
- All content words are syntactically complex
 - Consist of at least a category-neutral root specifying encyclopedic semantics (e.g. $\sqrt{\text{grow}}$) + some functional element that contributes category information (v , n , adj) and introduces arguments



Syntactic bootstrapping in a non-projectionist framework

- What insights can be maintained?
- What has to be abandoned?

Syntactic bootstrapping in a non-projectionist framework

- The primitives of natural language include a limited inventory of verbalizers with dedicated meanings (e.g. V_{CAUSE}) and which can introduce arguments that relate to them in restricted ways; these are given.
- “verb” learning involves filling a semantic hole (corresponding to root meaning) left in an otherwise fully (or at least sufficiently) interpretable structure.
 - A child hearing “A blicked B” is asking herself, “what flavor of doing is this blicking business that A is doing to B?”
- the formal-semantic interpretations of the functional items in these structures lead to strong conclusions about the possible content of the hole

Syntactic bootstrapping in a non-projectionist framework

- Prediction: argumental value is assigned to NPs according to their syntactic position alone
 - a child who has only encountered *gorp* in an intransitive frame should have no trouble interpreting it in a predictable way in a transitive frame

Children's overgeneralization errors

- Bowerman (1982) for English

- (1) a. He's gonna die you David (4+)
b. Kendall fall that toy (2;3)
c. You ached me (4;1)
d. She came it over there (3;4)

- (2) Berman (1982) reported in Borer (2003) for Hebrew:

- (10) a. Ra'iti.I 'et ha-šiyurim le-'aba. (cf. adult her'eti.V)
saw-I ACC the-paintings to-daddy showed.
'I showed the paintings to Daddy.'
- b. 'Ani roca še-'aba yokal.I 'oti 'akšab. (cf. adult ya'akil.V)
I want that-daddy eat ACC-me now feed
'I want Daddy to feed me now.'
- c. 'Ima zuzi.I li 'et ha-kise. (cf. adult tazizi.V)
mommy move-INTRANS to-me ACC the-chair move.TRANS
'Mommy, move the chair for me.'

Lidz, Gleitman & Gleitman

- "frame compliance" of young children (aged 3; 1–3; 10; N=22) in an act-out task
- The sentences were either grammatical (i.e. canonical frame, e.g., The giraffe falls) or ungrammatical.
 - further divided into "near" and "far," depending on "similarity" to the structure the verb typically appears in.

		NP-expecting Verbs		S-expecting Verbs	
		come/fall	drop/lift	ask/tell	think/know
NP-frames	Intransitive	<i>Grammatical</i>	NEAR	FAR	<i>Grammatical</i>
	Transitive	NEAR	<i>Grammatical</i>	FAR	FAR
S-frames	Infinitival	FAR	FAR	<i>Grammatical</i>	NEAR
	Tensed S	FAR	FAR	NEAR	<i>Grammatical</i>

***The zebra falls the giraffe = NEAR**

***The zebra falls that the giraffe jumps = FAR**

Lidz, Gleitman & Gleitman

- Coding scheme
 - ▶ child's actions were coded as "Frame compliant" if they were similar to one that was typical for a grammatical verb in that frame.
 - “The giraffe falls that the zebra jumps”. Replace *fall* with *thought*. See what adults/children did (make zebra jump). Did kids do the same? Then frame-compliant.
 - ▶ coded as “Verb compliant” if they ignored the frame and relied instead on the meaning of the verb.
 - If they just made the giraffe fall, verb-compliant.

Lidz, Gleitman & Gleitman

Frame	%FC(near)	%FC(far)	Difference Score
Intransitive	85.71	14.29	71.42
Transitive	42.86	7.14	35.72
Infinitival	57.14	30.77	26.37
Tensed S	71.43	50	21.43

Difference score = FC-near minus FC-far

**Positive difference indicates tendency to be frame-compliant in
Near trials more often than Far trials**

Lidz, Gleitman & Gleitman

- Children were able to extend verbs to frames in which they do not normally appear.
 - ▶ Though in a constrained manner
 - ▶ Less willing to be frame compliant for "The giraffe falls that the zebra jumps"

Koring & Thornton 2018

- Two types of intransitive structures
 - ▶ Unergatives: agentive *v*; a no stacking rule can explain why an additional external argument cannot be added to such structures (hence the ungrammaticality of **John laughed the baby*)
 - ▶ Unaccusatives: no agentive *v*, but one can be added (resulting in the inchoative-causative alternation)

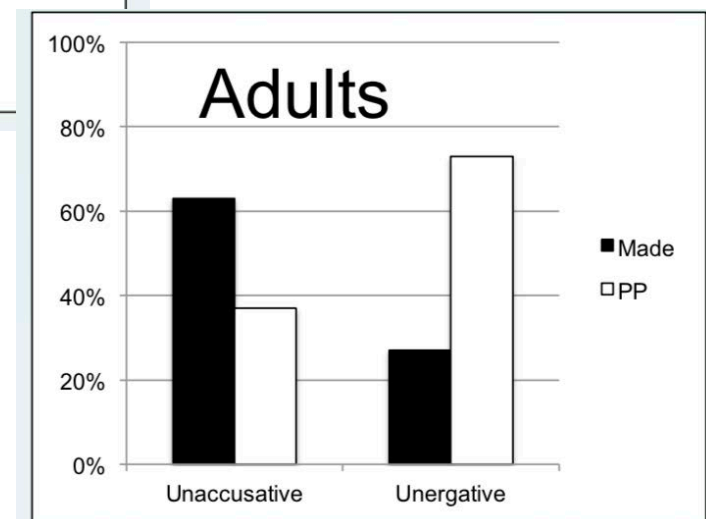
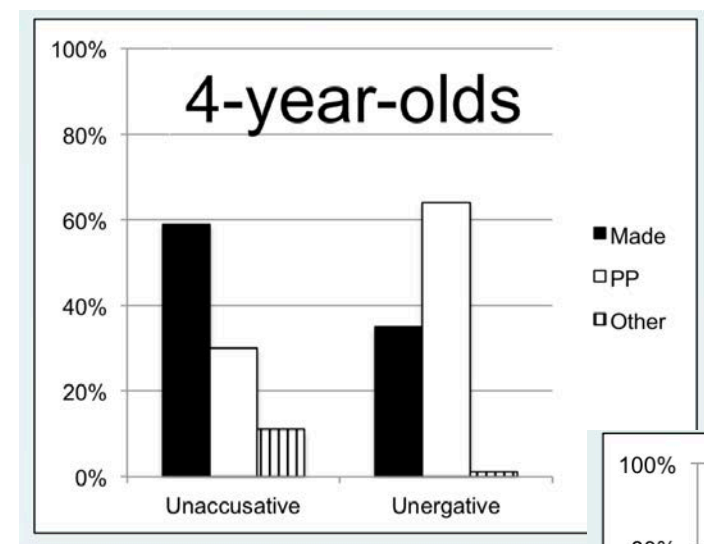
Koring & Thornton 2018

- 4-year-olds' (N=15) extensions of known verbs to novel frames sensitive to this distinction

- "What do you think the silly puppet meant?"
Task

(1) Yesterday, I sneezed a friend.
(i) He made his friend sneeze.
(ii) He sneezed on his friend.

(2) Yesterday, I slipped a friend.
(i) He made his friend slip.
(ii) He slipped on his friend.



Next week

- All read:
 - ▶ Soderstrom et al. 2007
 - ▶ Wexler 1998
 - ▶ Rizzi 1993
- Optional, but recommended:
 - ▶ Shi 2013
 - ▶ Wexler, K. 2011

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