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Does *see that* help children learn *think that*?
The intersection of perception and mental verbs in development

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Introduction

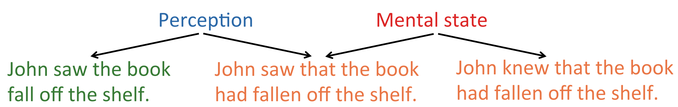
Perception is linked to mental states both conceptually and linguistically.

Conceptual links:

- Infants recognize that seeing leads to knowing[1,2]
- Training preschoolers on (mis)perception improves false-belief performance[3]
- Gopnik et al.[4] proposal: Understanding of perception supports understanding of mental states

Linguistic links:

- Perception verbs and mental verbs share semantics and syntactic structures
- "Experience"[5] perception verbs like *see* can refer to both perception and mental representations resulting from perceptual experience



- Perception verbs with sentential complements express propositional content of mental representations, just like mental verbs
- **Syntax shared by perception and mental verbs could play a role in children's acquisition of these verbs, specifically highlighting mental state meaning, consistent with syntactic bootstrapping[6,7]**

Could acquisition of perception and mental verbs be linked by shared syntax, with one verb class serving as a model for the other?
Two possibilities:

1) **Perception** Syntax **Mental**: Children produce propositional syntax with perception verbs first, supporting acquisition of mental verbs with the same complements
2) **Mental** Syntax **Perception**: Children produce propositional syntax with mental verbs earlier, fostering an understanding that perception verbs can refer to mental states

We evaluated these hypotheses by examining the developmental trajectory of children's production of perception and mental verbs in their syntactic frames.

Methods

Brown corpus[8] of CHILDES

- Adam (2;3 to 4;10), Eve (1;6 to 2;3;), Sarah (2;3 to 5;1), and their parents
- Target verb tokens:
  - Children: 5,727
  - Parents: 5,971
- Analysis:
  - Proportions of verb type (perception and mental) and frames (non-embedded and embedded) produced by children and adults overall and over time
  - Logistic mixed effects models[9] with verb type and age as fixed effects, subject as random effect to analyze frequency of embedded frames

Target verbs[5,10,11,12,13]

Perception	Mental
see	*know*
hear	*think*
feel	*believe*
taste	*understand*
smell	*remember*
look	*forget*
listen	*guess*
watch	*pretend*
sound	*dream*
	mean

Syntactic frames used in coding

Frame	Perception verb examples*	Mental verb examples*
Non-embedded complements		
V	See?	I don't know.
V NP	I heard a motor boat.	I remember him.
V PP	Look in your bags.	I dreamed about Ursula too.
V Adj	He looks funny.	*[not attested]*
V NP VP	Watch me come back.	*[not attested]*
Embedded clause complements		
V CP	I see you carried the book with you.	He thinks the chair moves by itself.
V Q	See what I got in my hand?	I know what is missing.
V VP	*[not attested]*	I forgot to make a sailboat.

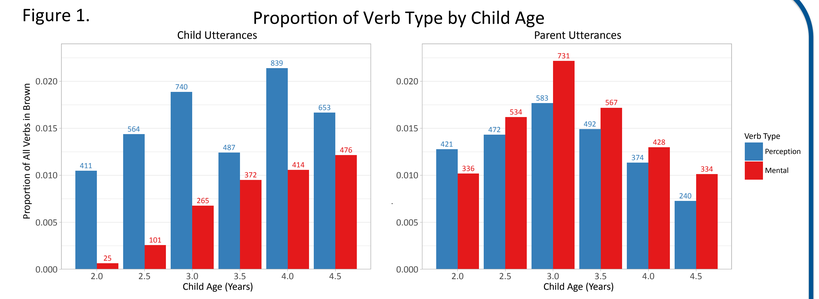
*Utterances produced by Adam

Results

Verbs overall

- Children overall produced more perception verbs than mental verbs ($t(24.572) = -3.03$, $p < 0.05$); parents produced roughly equal numbers of both ($t(27.854) = 0.53$, $p > 0.05$)
- Children's production of mental verbs increased more than their production of perception verbs between ages 2-5 (99% HPD interval for $\beta_{mental*age} - \beta_{perception*age} = [0.54, 0.74]$, M = 0.64); parents' production was stable over time (Figure 1)

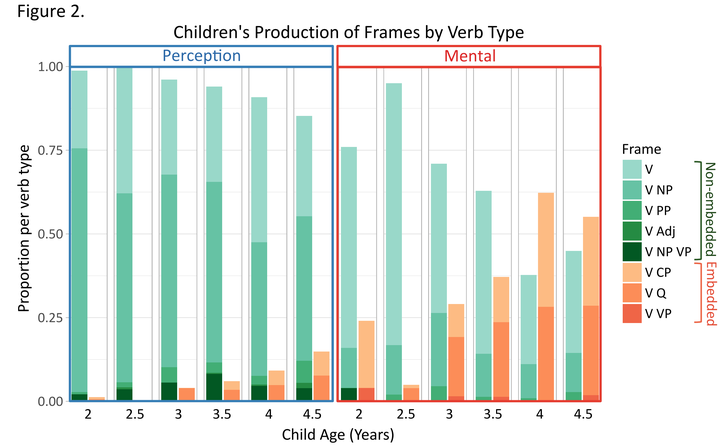
Figure 1.



Verbs in frames:

➢ *Embedded frames predominated with mental verbs from age 2*

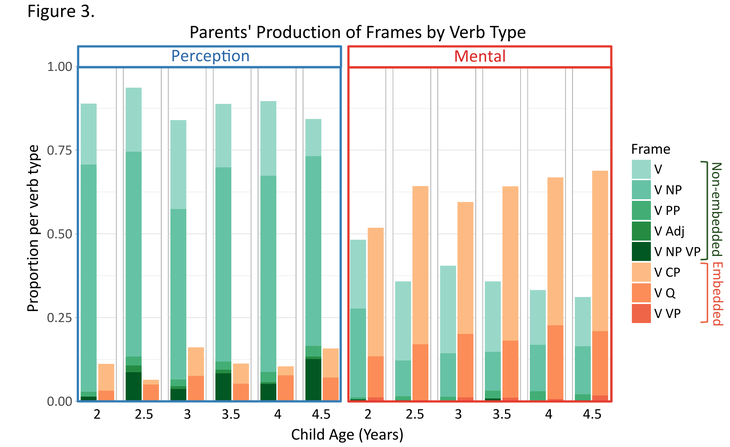
Figure 2.



- Children's use of embedded frames grew over time for both verb types ($\beta = 0.75$, SE = 0.10, $p < 0.05$), but increase was greater for mental verbs than perception verbs* ($\beta = -0.41$, SE = 0.19, $p < 0.05$) (Figure 2)
- Even at age 2, a greater proportion of mental verbs than perception verbs were produced in embedded frames; by age 4, children used mental verbs with embedded frames more than non-embedded frames

➢ *Parents' production of frames was different from children's*

Figure 3.



- Parents overall used embedded frames more often (45% of target verb complements) than children did (23% of target verb complements) ($\beta = -2.01$, SE = 0.51, $p < 0.05$)
- Parents produced perception verbs in embedded frames relatively infrequently (12% of perception verb complements), but still significantly more than children (6% of perception verb complements) ($\beta = -1.47$, SE = 0.33, $p < 0.05$) (Figure 3)

* Frame analysis was done for experience perception verbs only (61% of perception verbs in sample)

Conclusions

✔ **Mental** Syntax **Perception**: Mental verbs appear to lead the way for propositional syntax; children were more likely to produce embedded frames with mental verbs than perception verbs even at age 2

Early knowledge of perception verbs may be incomplete and updated later

- Children's use of perception verbs did not reflect adult input
- Acquisition of propositional syntax expressing mental representations occurs after children have begun to produce perception verbs
- Learning this new syntax with mental verbs may spur a revision of semantic representations for perception verbs to include encoding of mental states

- Ongoing empirical work is further testing this hypothesis; examining comprehension could reveal more about children's semantic and syntactic knowledge of perception verbs

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