3-year-olds' use of situation models in online comprehension varies by language skill

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Adults *generate* causally structured *situation models* during comprehension (Radvansky & Zacks, 2011) and *leverage* this representation to support incremental and inferential language processing (Nieuwland et al., 2007). *When does this ability develop?* 4-5-year-olds generate and leverage situation models to make inferential predictions (Yuile & Fisher, 2021; Yu, Yuile, Ishak, & Fisher, 2024). 3-year-olds *generate* situation models during comprehension (Rall & Harris, 2000; Tillman, Tulagan, & Sullivan, 2020). However, it is unclear if 3-year-olds can *leverage* this representation to make inferential predictions. Recent work shows that 12-month-old infants can use event knowledge to support causal reasoning in non-linguistic domains (Cesana-Arlotti et al., 2018). Yet, these inferences might also emerge from the ability to construct more complex language via morphosyntactic skill (Kaan & Gruter, 2021) and, therefore, may be tied to individual variation in growth of language knowledge. <u>This study asks whether 3-year-olds leverage the situation model for inferential prediction, and if this ability varies with language knowledge.</u>

Methods. English-speaking 36-month-olds (*N* = 98; planned *N* = 120) listened to stories in which the target referent was either ambiguous or unambiguous, while viewing static pictures of story participants (Fig. 1). Each story (modeled after Nieuwland et al., 2007) involved a protagonist (Maisy) and two animal characters (Table 1) and followed a standard structure: (1) **Introduction:** The first sentence introduced the characters and scene. Depending on the condition, there were either two animals of the same species (e.g., two frogs) or two animals of different species (a frog and a butterfly). (2) **Condition:** Next, stories varied whether animals stayed or left. *Ambiguous* trials included two same-species referents (frog with the hat, frog with the scarf) and both stayed. *One-referent Unambiguous* trials introduced one referent (one frog), and another animal (a butterfly) left the scene. *Two-referent Unambiguous* trials introduced two referents (two frogs), but one left the scene. (3) **Critical sentence:** Maisy invited one animal to play. We tracked participants' gaze to the animals during the critical sentence. <u>*Potential Outcomes:*</u> If participants leverage the situation model, they should look to the target animal in Two-ref. Unambiguous trials before hearing the modifier, because only one animal is still present in the story (though both are visible in the display), permitting a pragmatic inference about the intended referent. If participants also use the lexical constraints of the noun to identify the target referent, they should look to the target animal before hearing the modifier more in One-ref. than Two-ref. Unambiguous trials. Each participant heard 8 stories per condition. We measured receptive vocabulary skill using the PPVT-5 (Dunn, 2019) and morphosyntactic skill using the SPELT-P2 (Dawson et al., 2005).

Results & Conclusions. We analyzed fixations (Fig. 2 & Table 2) during the critical sentence from first determiner onset to modifier onset (*"the frog with the"*). Three-year-olds, like adults and older children, used event information in the story to make referential predictions under ambiguity by anticipating the target in both One-ref. and Two-ref. Unambiguous trials, but not in Ambiguous trials (Fig. 2, Table 3). Vocabulary and morphosyntactic abilities also influenced performance: More advanced vocabulary skills were associated with greater target-advantage in One-ref. compared to Two-ref. Unambiguous trials, while more advanced morphosyntactic skills were associated with greater target-advantage generally. In post-hoc analyses, we categorized children as language delayed (LD, *n*=31) or typically developing (TD, *n*=67) based on criteria outlined in Greenslade et al. (2009). Children with TD anticipated the target in both Unambiguous conditions (One-ref.: $t(66)=14.49$, $p<.001$, Two-ref.: $t(66)=2.81$, $p=.007$); children with LD did so only in the One-ref. Unambiguous ($t(30)=6.51$, $p<.001$), but not Two-ref. Unambiguous ($t(30)=0.19$, $p=.85$) trials, suggesting that the LD group experienced difficulties in generating pragmatic, but not lexically-based inferences. These findings provide strong evidence that 3-year-olds leverage the situation model to predict who will be mentioned next based on story events, while our post-hoc analysis hints that the ability to do so may vary as a function of language skill.

Table 1. Example Story

Sentence Phase		Examples
Introduction		Maisy was at the playground with her friends, the frog with the hat and the frog (butterfly) with the scarf.
Condition	**Ambiguous** *same species, both stay*	The frog with the hat was walking. The frog with the scarf was walking too.
	One-referent *diff. species, one leaves*	The frog with the hat was walking. The butterfly with the scarf went home.
	Two-referent *same species, one leaves*	The frog with the hat was walking. The frog with the scarf went home.
Critical		Maisy asked the frog with the hat to play with her.

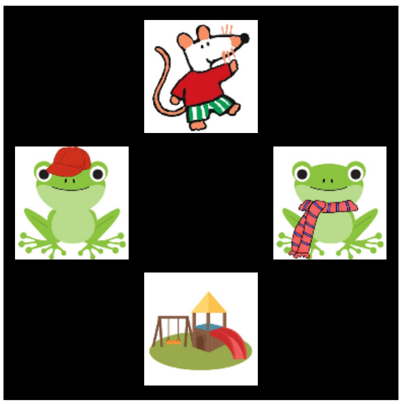

Figure 1. Example trial screen

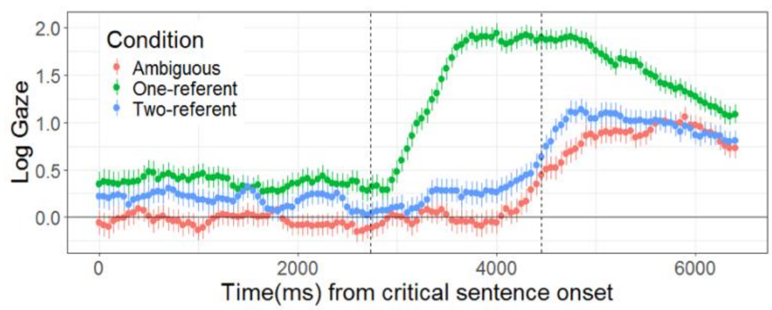

Figure 2. Time-course of log gaze (ln[prop. target/prop. competitor]) during the critical sentence. Vertical lines mark the analysis window. Log gaze values >0 indicate more looking to the target relative to competitor.

Table 2. Mean log gaze in analysis window by condition and lang. skill

	Mean (SD)
LD	
One-referent	1.08 (.93)
Two-referent	.03 (.77)
Ambiguous	-.20 (.94)
TD	
One-referent	1.44 (.82)
Two-referent	.29 (.84)
Ambiguous	.12 (.76)

Table 3. Linear mixed-effects model results

	Estimate	95% C.I.	*p*
Intercept	**.57**	**[.43, .68]**	**<.001*****
Sem-Inf	**1.66**	**[1.40, 1.93]**	**<.001*****
Prag-Inf	**-1.05**	**[-1.32, -.79]**	**<.001*****
PPVT	.01	[-.09, .10]	.90
SPELT	**.08**	**[.01, .18]**	**.08†**
Sem-Inf*PPVT	**.30**	**[.04, .57]**	**.03***
Prag-Inf*PPVT	-.17	[-.43, .10]	.21
Sem-Inf*SPELT	.10	[-.18, .38]	.48
Prag-Inf*SPELT	-.09	[-.35, .18]	.53

Note. †*p*<.10, *p<.05, ***p<.001. Continuous variables were centered and scaled. Condition was effects coded. Sem-Inf: Ambiguous=0, One-ref.=.5, Two-ref.=-.5; Prag-Inf: Ambiguous=.5, One-ref.=0, Two-ref.=-.5

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