Reasoning about perspectives

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We propose a Rational Speech Acts (RSA) model of how perspectival expressions are interpreted and provide experimental support for its core assumption, that listeners consider multiple perspectives simultaneously. Perspectival expressions like English *come*, which describes motion towards a perspective-holder, pose an interpretative problem because there are multiple possible perspective-holders: the speaker, listener, or attitude-holder (Fillmore 1997; Nakazawa 2007). Consequently, (1) can mean that Thelma is traveling to either Seattle or London.

1. *Context: Sam, in Seattle, is talking to Lucy, in London.*

   Thelma is coming.

Because the listener must reason both about the perspective adopted by the speaker and their intended message, the interpretation of perspectival items can be described as a joint reasoning process.

We propose an RSA model of perspectival reasoning, a framework in which listeners use Bayesian inference to calculate a probability distribution over a set of worlds representing possible meanings (Bergen et al., 2012; Frank and Goodman, 2012). In our perspectival version (Fig. 1), the listener jointly infers the probability of a world and perspective according to their mental model of how the speaker selects an utterance-perspective pair (the Literal Speaker).

Figure 1: Perspectival Rational Speech Acts model

Literal Listener

$P(w|m,a) \propto [[m]]^{a,w} \, p(w)$

Literal Speaker

$P(m,a|w) \propto \text{softmax} \left(p(w|m,a) \sum_w [[m]]^{a,w} p(a) - \text{Cost}_m(m) - \text{Cost}_a(a) \right)$

Pragmatic Listener

$P(w,a|m) \propto p(m,a \mid w) \, p(w)$

where a is a perspective, w is a world, and m is an utterance

A critical component of the model is that listeners consult multiple perspectives simultaneously, in contrast with prior work positing a speaker-default strategy (Harris 2012, Barlew 2017). Our **multiple perspectives** approach predicts that given a sentence like *Thelma is coming to Northampton*, the marginal posterior probability should be highest for the world where both the speaker and listener are at the destination.

We tested this prediction in a comprehension task. Participants read a sentence with a perspectival verb (*Thelma is coming to the zoo*) or manner-of-motion verb (*Thelma is walking to the zoo*) and then saw a scene depicting both the speaker and listener at the destination of motion; just the speaker; just the listener; or neither (Fig. 2). Participants indicated whether the scene and sentence matched; accuracy and reaction times were measured.

Figure 2: Comprehension study example stimulus, speaker-only condition
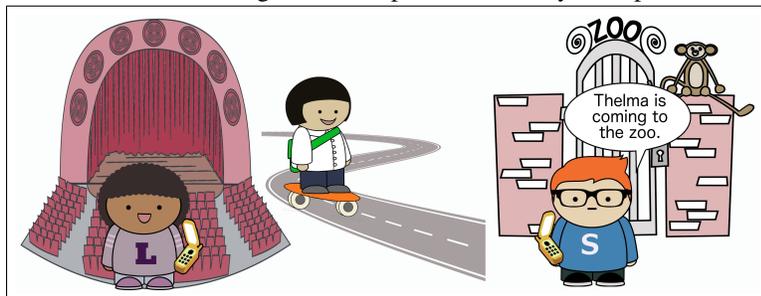
Reaction times decreased in the *come* condition relative to *walk* for the scenes with both perspective-holders at the destination (Table 1). For all other scenes, reaction times were slower in the *come* condition.

Table 1: Comprehension study reaction times (ms) of accepted items

Condition	*walk* Cosineau-corrected mean (95% CI)	*come* Cosineau-corrected mean (95% CI)	Difference
item-both	2385 (+/- 87.5)	2366 (+/- 87.0)	19
item-listener	2261 (+/- 85.0)	2627 (+/- 105.2)	-336
item-none	2129 (+/- 79.5)	2537 (+/- 102.9)	-408
item-speaker	2331 (+/- 92.5)	2469 (+/- 91.3)	-138

Table 2: Comprehension study mixed effects regression analysis (N=3630)

	$\hat{\beta}$	z	p
(Intercept)	7.65(+/-0.04)	179.5	**<0.0001**
come	0.06(+/-0.02)	3.16	0.0016
both	0.029(0.02)	1.43	0.15
listener	-0.03(0.02)	-1.28	0.20
none	-0.08(+/-0.02)	-4.14	**<0.0001**
come:speaker	-0.06(+/- 0.03)	-2.22	**0.027**
come:listener	0.03(+/-0.03)	1.05	0.30
come:none	0.05(+/-0.03)	1.65	0.10

A mixed-effects regression model reveals a significant interaction between the both-scene and *come* condition (Fig. 2). Participants are faster to recognize the both-scene for perspectival expressions, in support of the multiple-perspectives account.

Although motion verbs are our case study, we expect the model to generalize to other perspectival expressions, like epithets.

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