Pitjantjatjara children's comprehension and problem-solving in a spatial cognition task

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in collaboration with Areyonga School and community

Introduction

- Much research on spatial reference in Australian languages (Palmer et al., 2022), often using the Man and Tree elicitation tool (Terrill & Burenhult 2008).

- Typically this research has descriptive and typological aims: What strategies/frames of references are dominant in this language?

- However, this is a very rich **interactional problem-solving** task

Research questions:

1. What frames of reference and linguistic strategies do Pitjantjatjara speakers use when talking about space, and how do they use them?

2. How do children comprehend and make use of spatial descriptions in a problem-solving task?
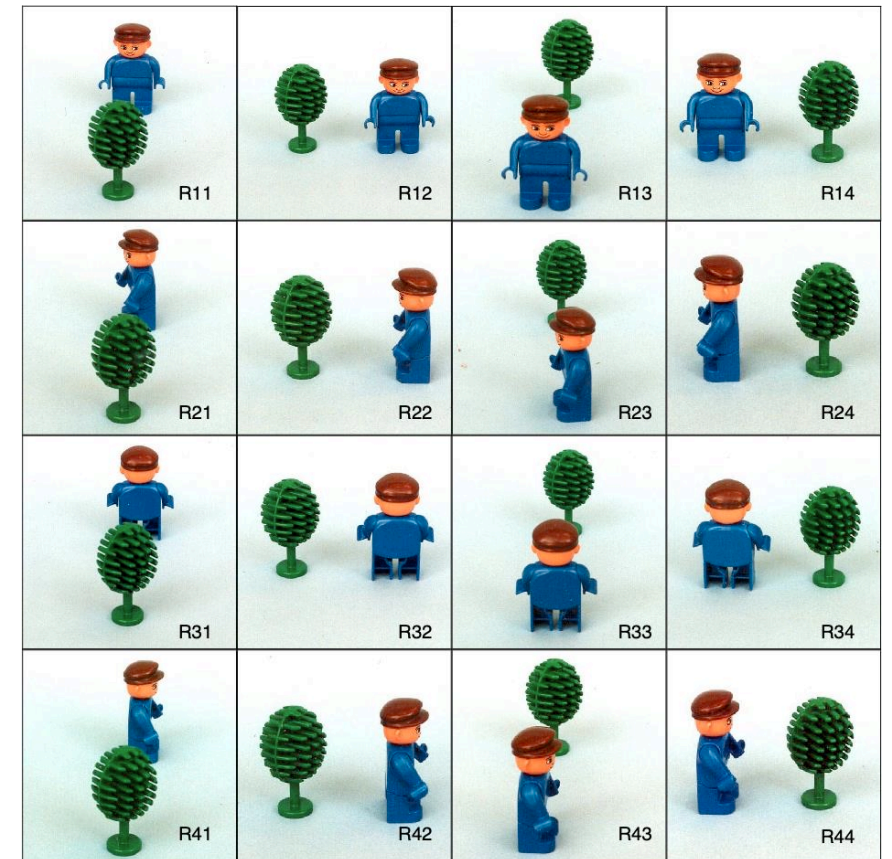
The Mathematics in Indigenous Languages project

- Identifying mathematical expression for teaching and learning mathematics in diverse Australian Indigenous languages
  - Funded by Charles Darwin University CSFP 2021, Sasha's work funded by Schools Plus Smart Giving grant
  - CDU Human Research Ethics Committee clearance number H22078

- Typological approach to mathematical language with focus on space

- Working with three communities to develop early primary mathematics teaching sequences in language
  - Anindilyakwa (with James Bednall)
  - Tiwi (with Kate Charlwood)

west

Australia
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Pitjantjatjara

- Western Desert, Pama-Nyungan
- Central Australia (SA/NT/WA)
- 3000+ speakers
- Learned by children as first language

Utju/Areyonga

- ~250 people
- Small bilingual primary school

Utju Kuula/Areyonga School, including:
Tarna Andrews, Leanne Goldsworthy, Toby Brown, Claire Smith

Uṯuḻu Kutju Nintiringanyi (UKN), including:
Daphne Puntjina, Lydia Angus, Tjirpowa Meneri, Renita Anawari, Margaret Poulson, Hilda Amuna Nampitjinpa Bert

Kids and families

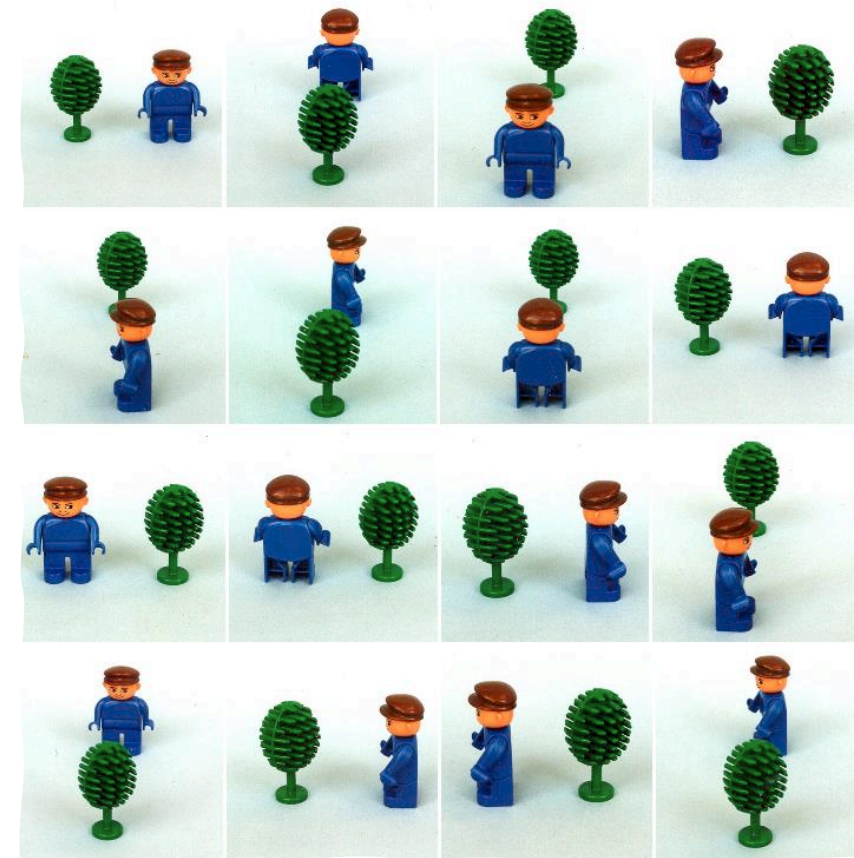Assistant teachers Christine Bennett and Lucinda Nipper

How to talk about space in Pitjantjatjara

Morphosyntactic type	Form	Meaning	Frame of reference
Verbal prefix	*ngalya-, ma-, wati-*	towards speaker, away, across	egocentric
	para-	around	intrinsic
Locational	*alinytjara, ulpaṟira, kakaṟara, wiluṟara*	cardinals	geocentric
	tjangaṯi, munkara	nearside, farside	egocentric
	kuranyu, maḻa	in front, behind	egocentric or intrinsic
	tjaiti	next to (from English 'side')	egocentric or intrinsic
	tjampu, waku	left, right	egocentric or intrinsic
	various	near, far, between, high, low, etc…	Egocentric, intrinsic or NA
Suffix (/postposition)	*-kutu, -nguṟu*	allative, ablative	NA
	-wanu	perlative	NA
	-ngka, -tjaiti	locative, 'side'	NA

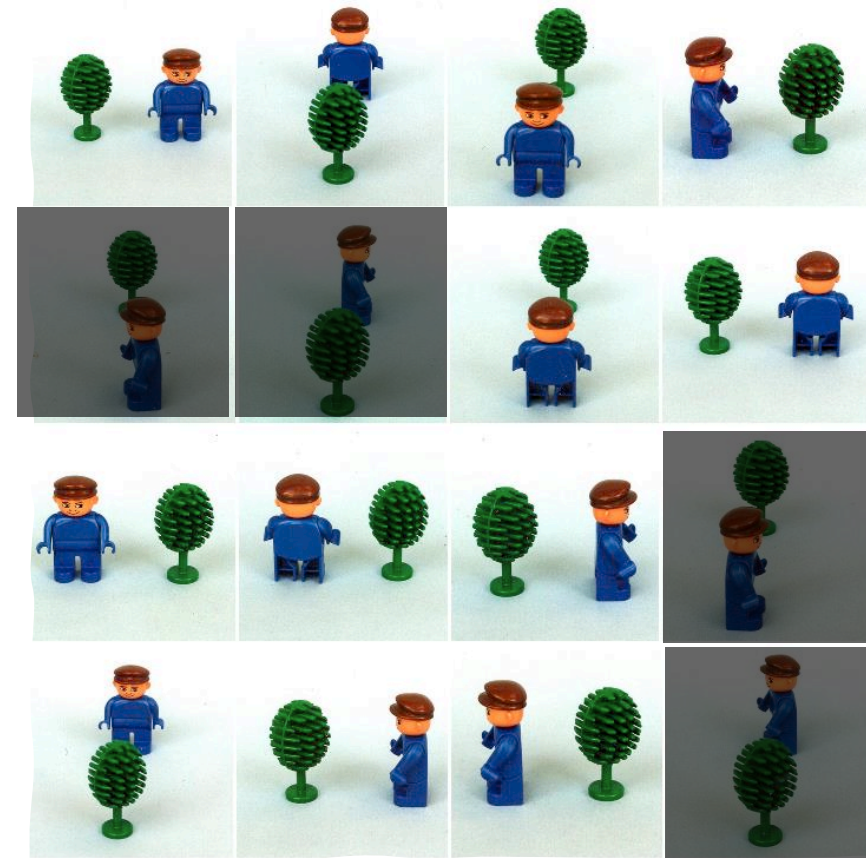(Goddard 1985, Langlois 2004)

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Methodology

- Man and Tree task (Terrill & Burenhult, 2008)
- Modified OzSpace protocol (Ennever et al., forthcoming)
  - Fixed layout and order of cards
  - Matcher and director facing west
- Adapted for children
  - Three difficulty levels:
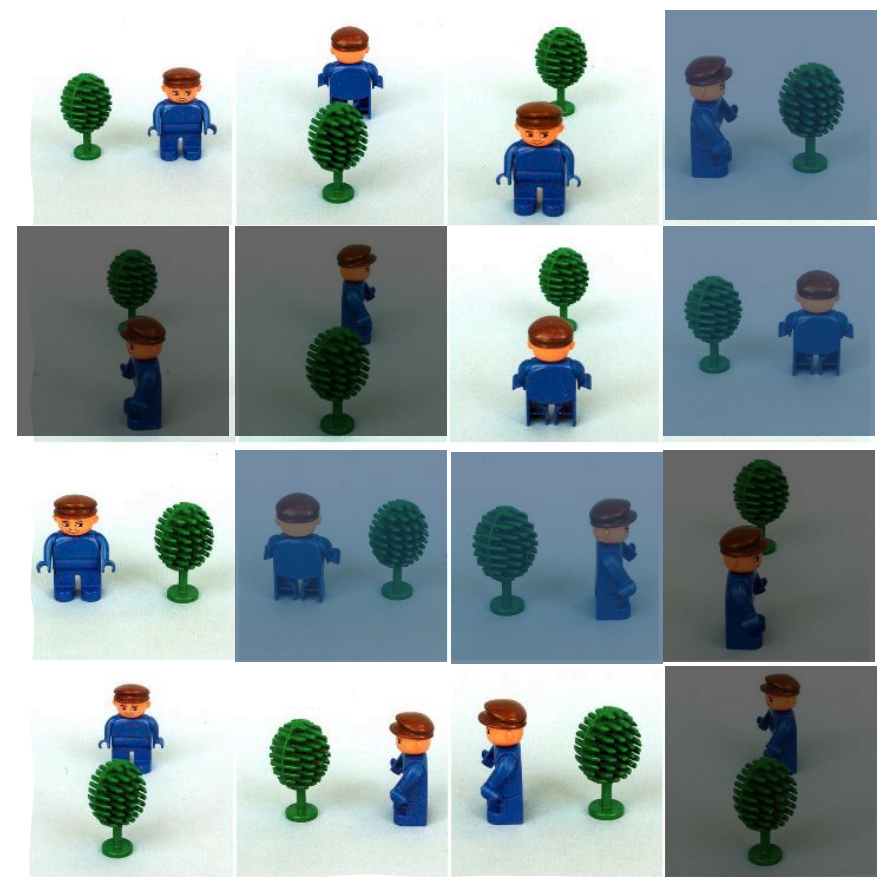 - Hard (full set of 16 cards)

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  - Hard (full set of 16 cards)
  - Medium (12 cards)

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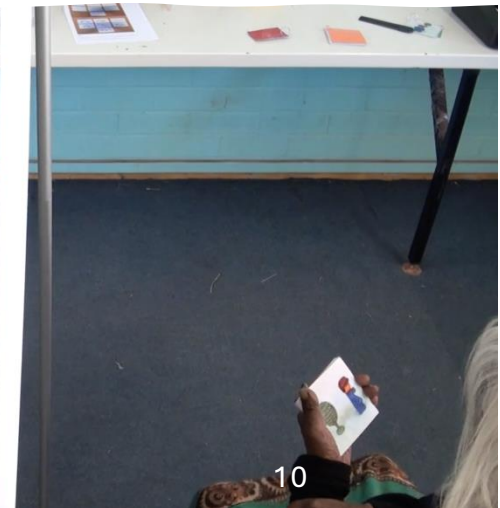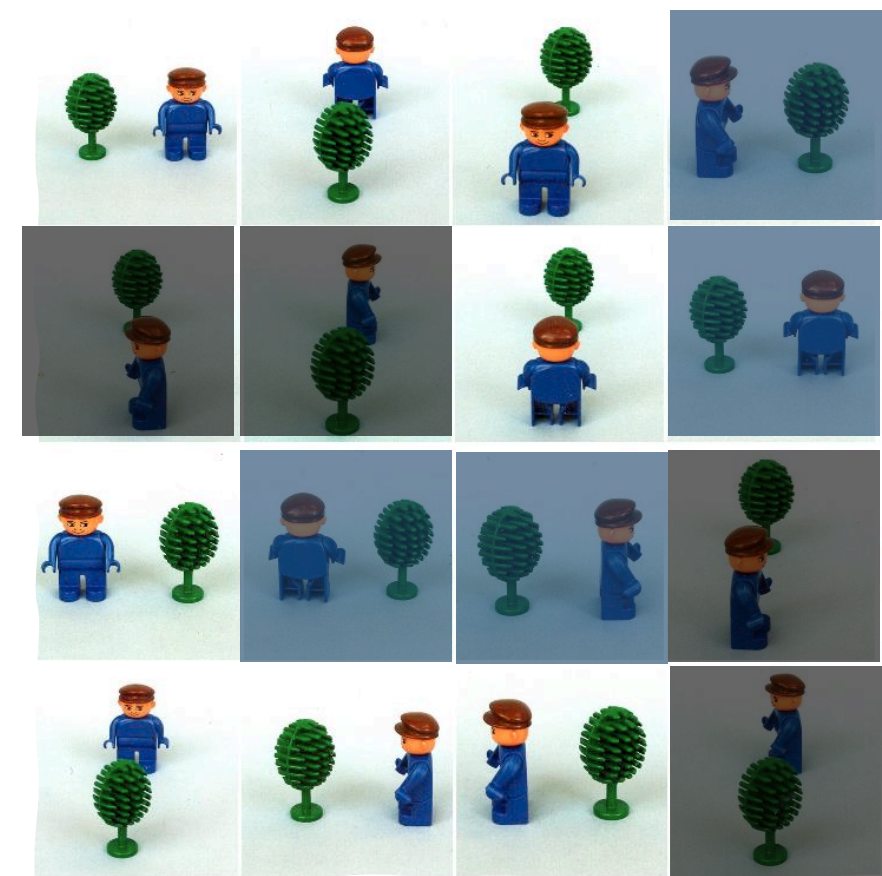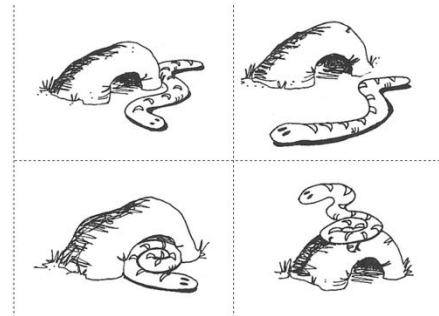 - Easy (8 cards)

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Methodology

- Man and Tree task (Terrill & Burenhult, 2008)
- Modified OzSpace protocol (Ennever et al., forthcoming)
  - Fixed layout and order of cards
  - Matcher and director facing west
- Adapted for children
  - Three difficulty levels:
  - Hard (full set of 16 cards)
  - Medium (12 cards)
  - Easy (8 cards)
  - Warm up round with topological relations pictures

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Participants

- Task was not successful with children as directors
- No notable differences between strategies used in adult-adult vs adult-child pairs

- We recorded 11 pairs of adult directors and child matchers
  - 11 children: age 8;1 – 12;5 (mean = 10;7). 4 M, 7 F
  - 7 Adults: 30s-70+, all F

What are the adults doing?

Coding

- Each utterance had between 1-3 spatial expressions, each of which was coded for:
    - Linguistic form (word, prefix, suffix, etc)
    - Strategy
    - Frame of reference
    - Location and/or orientation

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Coding

- Strategies
  - Cardinal
  - Front/back
  - Directional prefix
  - Nearside/farside
  - Left/right
  - Transverse (*tjaiti*)

  - Gesture
  - Local ('He's looking at the guitars')
  - Other array ('He's giving his back to the tree')
 - Sun ('He's watching the sunset')

- Location and/or orientation

1. The man is standing on the east side. (LOC)
2. The man is facing this way. (ORI)
3. The man is standing 'to the east' (LOC+ORI)

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Results

- 148 successful trials ✅

- 667 director utterances, 893 spatial expressions
  - Very few errors (8 errors in 4 trials)

- Our counts are <u>not tokens</u>. We exclude within-trial repetitions, i.e. giving same information with same strategy and frame of reference.
  - E.g.   *The tree is on the south side.*
    The man is on the north side.
  - = 1 use of cardinal/geocentric to describe location.

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What frames of reference/strategies do the adults use?
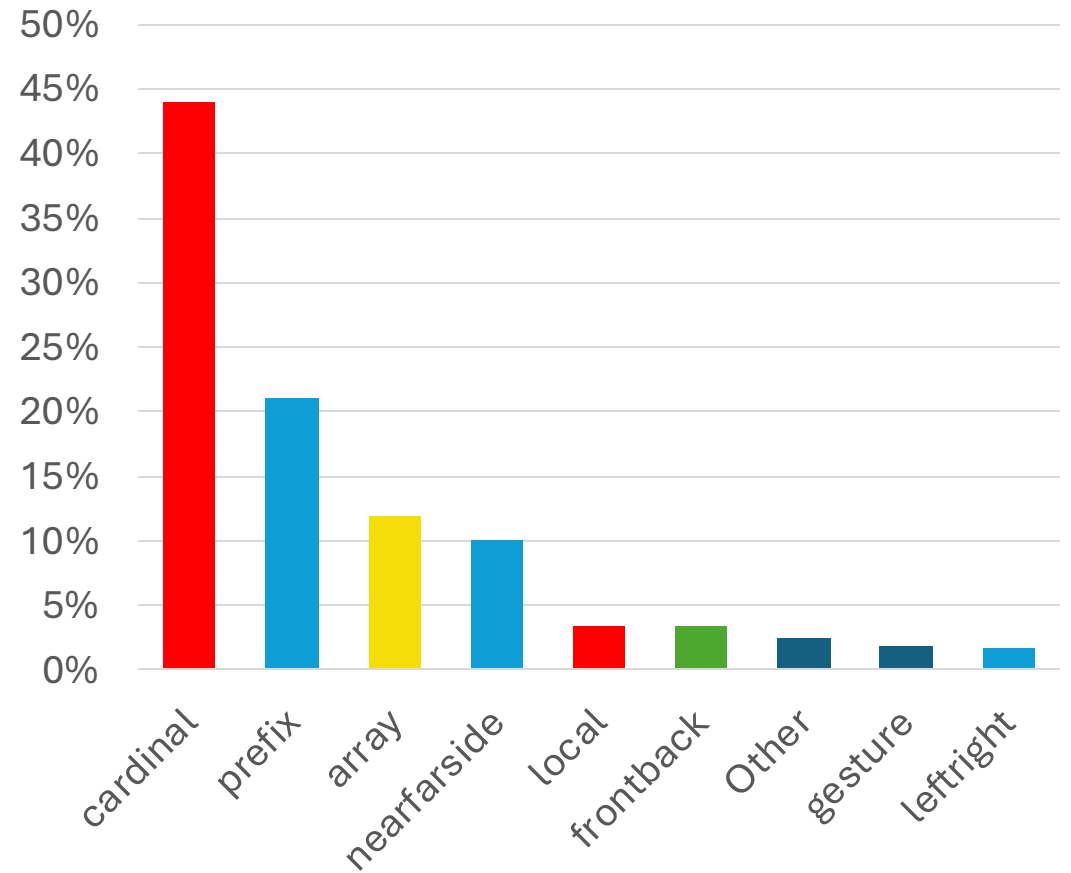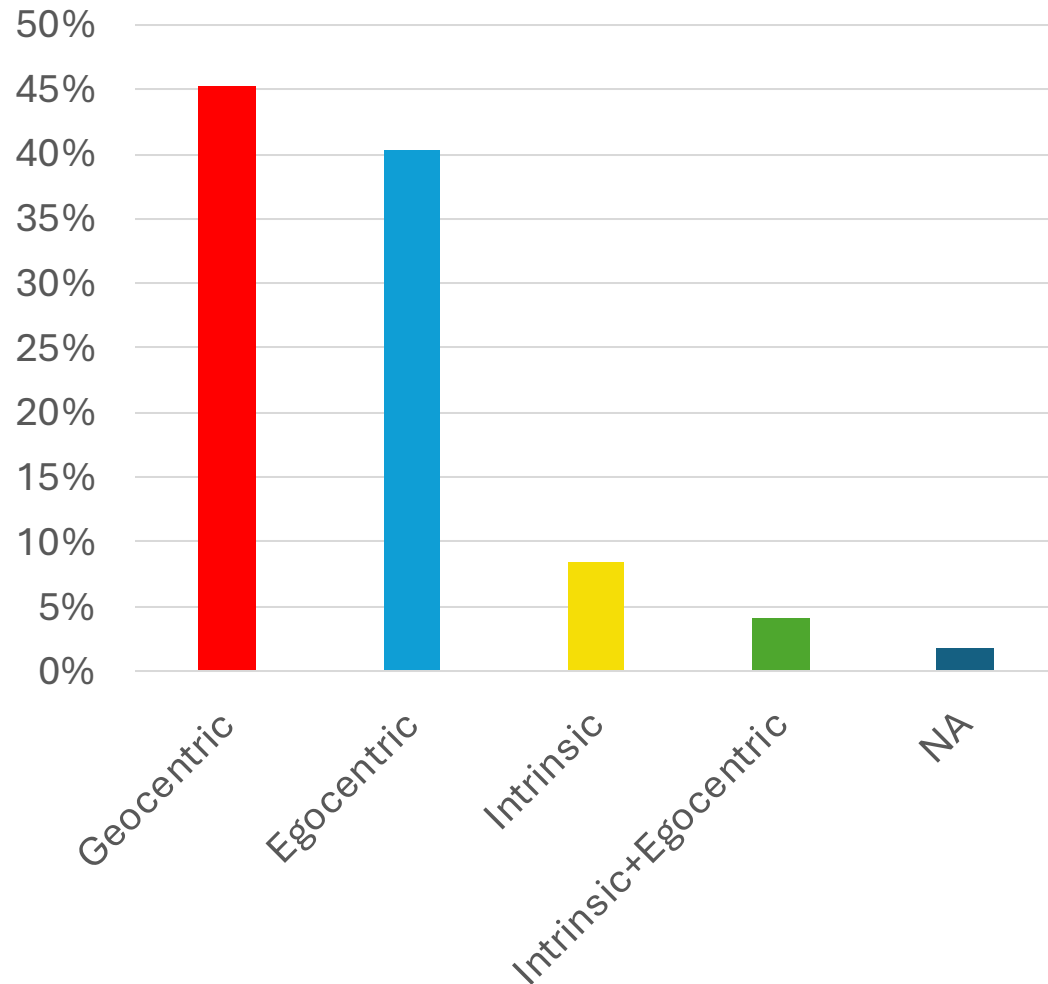
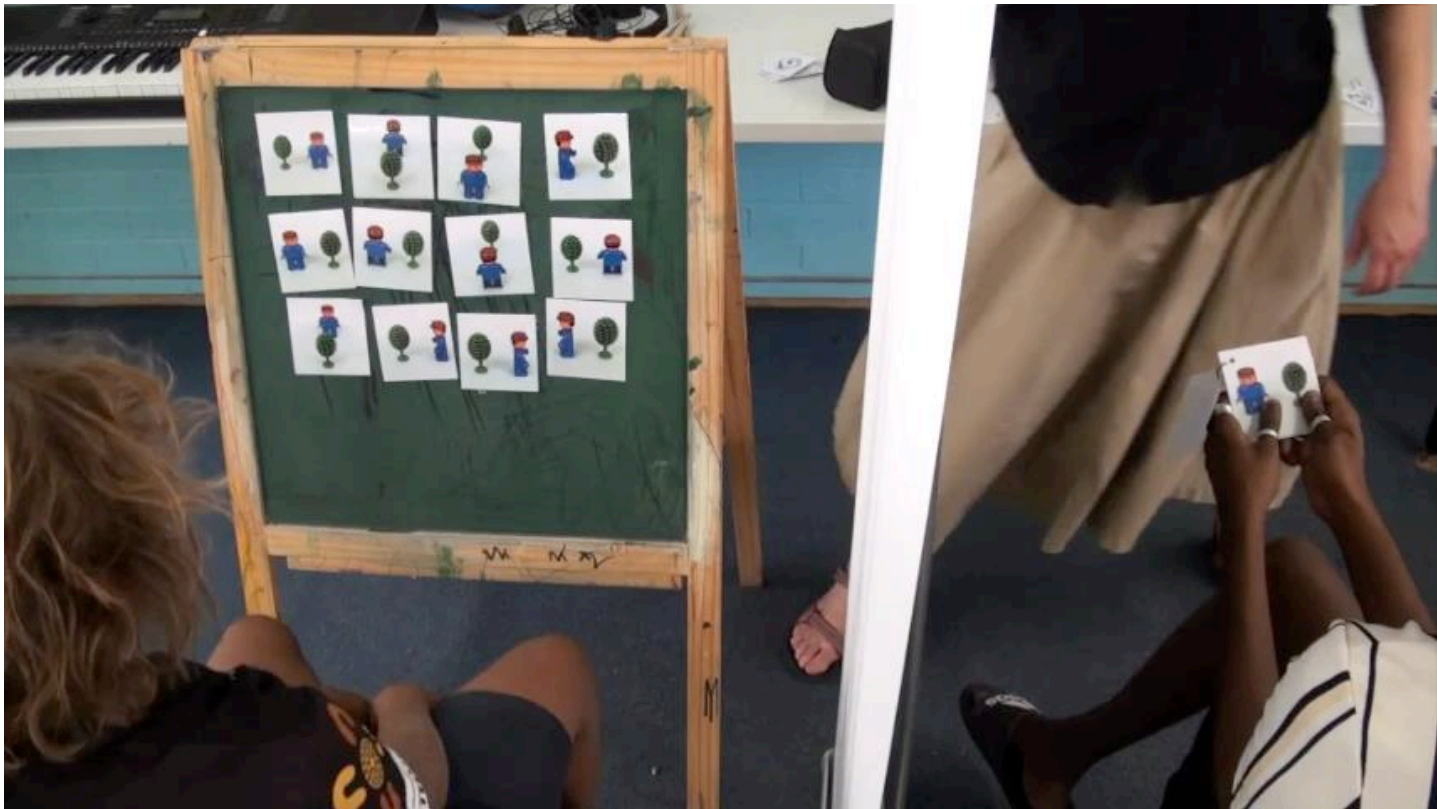# What are the kids doing?

What are the kids doing?

The man is on the south side, towards the east.
The tree is on the north side.

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Target:

Touch:

	LOC	ORI
	✅	✅
	Axis	✅
	❌	✅
	✅	❌

Select:

	✅	✅

Coding

- We coded the matcher's speech/actions:
  - 157 touches
  - 302 selections
  - 30 questions
  - 24 instances of self-talk
- Touches and selections: do they match target card's location and orientation? Y/N/Axis
- We also need to know what information is available to matchers
  - Are there potential ambiguities?
  - Is there enough information to get the right card?

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Coding

- Based on information provided so far, can the matcher deduce that this expression refers to location and/or orientation? Y/N/Potentially

- E.g. allative *-kutu* can refer to either LOC or ORI

Utterance
Alinytjarakutu *ngaranyi,* (He's) standing **to the north**,
ulparirakutu *ngaranyi,* (he's) standing **to the south**,

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Coding

- Based on information provided so far, can the matcher deduce that this expression refers to location and/or orientation? Y/N/Potentially

- E.g. allative *-kutu* can refer to either LOC or ORI

Utterance	Speaker's intention	
	ORI	LOC
Alinytjarakutu ngaṟanyi, (He's) standing **to the north**,	Y	N
ulpaṟirakutu ngaṟanyi, (he's) standing **to the south**,	N	Y

(20240207_01)

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Coding

- Based on information provided so far, can the matcher deduce that this expression refers to location and/or orientation? Y/N/Potentially

- E.g. allative *-kutu* can refer to either LOC or ORI

Utterance	Speaker's intention		Available interpretation	
	ORI	LOC	ORI	LOC
Alinytjarakutu nga<u>r</u>anyi, (He's) standing **to the north**,	Y	N	Pot.	Pot.
u<u>lp</u>a<u>r</u>irakutu nga<u>r</u>anyi, (he's) standing **to the south**,	N	Y	Pot.	Pot.

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Coding

- Cumulative 'completeness' at each utterance: based on the information provided so far, can the matcher deduce the correct location and/or orientation? Y/N/Potentially/Internal

Utterance			Completeness	
			ORI	LOC
Wati ***ngalya**-nga<u>r</u>anyi* *kaka<u>r</u>ara-**kutu**,* man hither-standing east-ALL 'The man is standing **this way to the east**'			Y	Pot.

R12

Coding

- Cumulative 'completeness' at each utterance: based on the information provided so far, can the matcher deduce the correct location and/or orientation? Y/N/Potentially/Internal

| Utterance	Completeness	
	ORI	LOC
Wati **ngalya**-*ngaṟanyi* *kakaṟara*-**kutu,** man hither-standing east-ALL 'The man is standing **this way to the east**'	Y	Pot.
puṉu *ngaṟanyi* *uḻpaṟira-kutu* tree standing south-ALL 'the tree is standing **to the south**'	Y	Y

R12

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Information states

- We can track how speakers combine strategies to provide different types of information, and how information states are updated interactionally
  - Logical impossibility (i.e. error)
  - Absence of information
  - Ambiguity
  - Complete description
    - In some cases, utterance may lead to updated interpretation of previously ambiguous utterance

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What do the kids do?

- Kids usually get it right on the second try
  - Average 1.04 incorrect guesses per card, no correlation with age
  - Complete errors very rare (4% of selections, 6% of touches)
  - Either LOC or ORI correct in 70% of selections, 74% of touches

- 25% of trials completed with incomplete/ambiguous descriptions
  - If description is incomplete:
    - Pause
    - Question
    - Attempt (random guess or guess least 'marked'?)
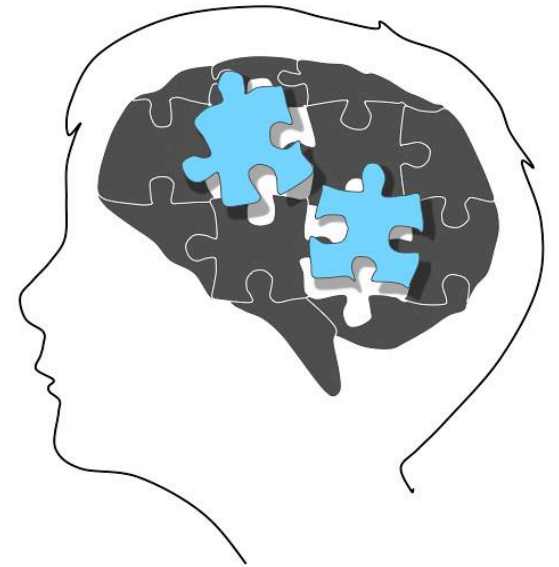
Ambiguity and deductive reasoning

- **Logical** inferences (combinatorics/set theory problem)

  - The person is standing to the south (south-ALL)
  - He's standing on the north side
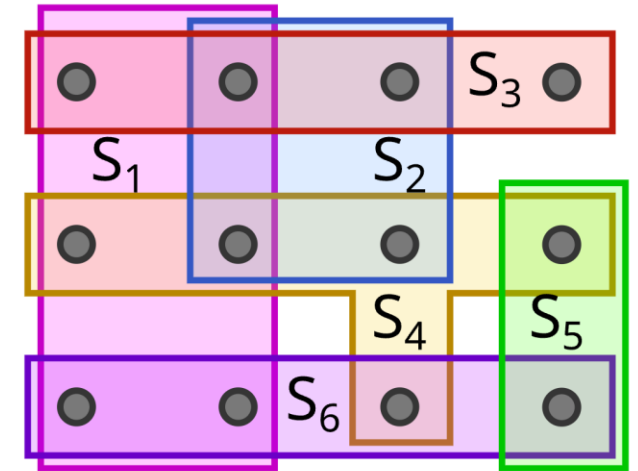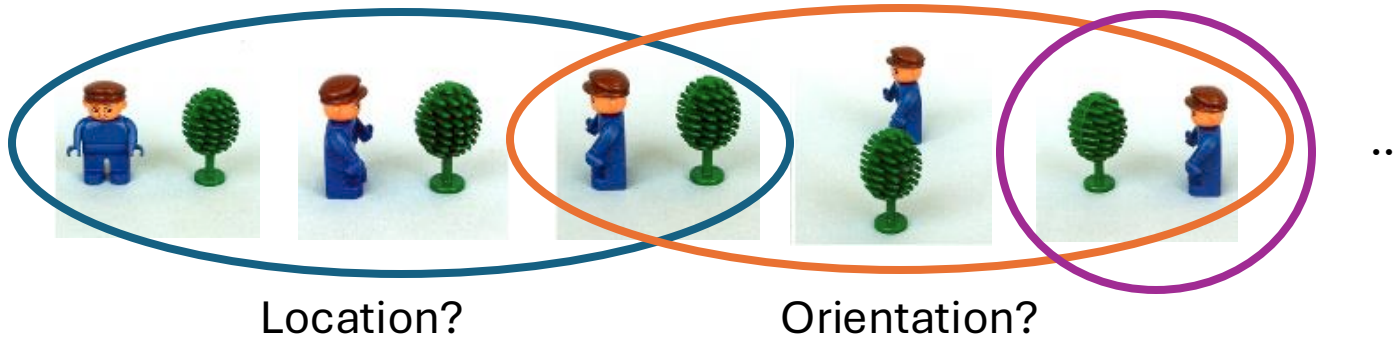
Location?   Orientation?

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Ambiguity and deductive reasoning

wati *ulparira-kutu* *ma-ngaranyi* *wilurara-kutu*
man south-ALL away-standing west-ALL
'The man is standing away to the south to the west'
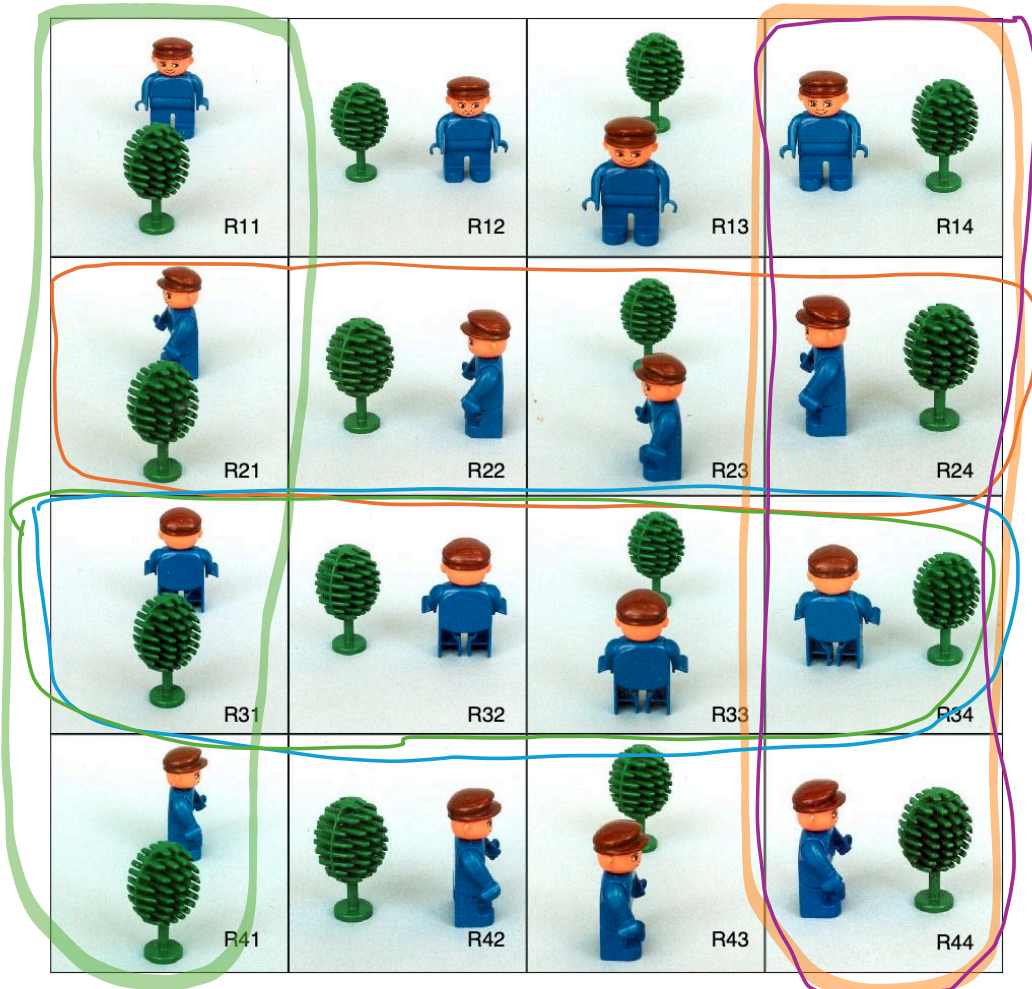
Matcher touches:

punu *alinytjara-tjaiti* *ngaranyi*
tree north-side standing
'The tree is on the north side'

Matcher selects:

Ambiguity and deductive reasoning

wati *u̱lpa̱rira-kutu* *ma-nga̱ranyi* *wilu̱rara-kutu*
man south-ALL away-standing west-ALL
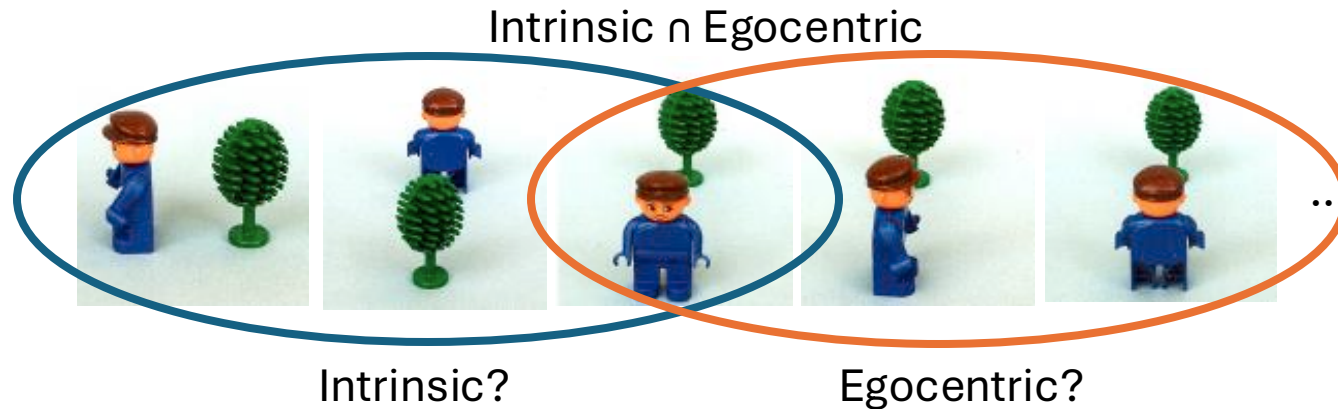'The man is standing away to the south to the west'

Matcher touches:

pu̱nu *alinytjara-tjaiti* *nga̱ranyi*
tree north-side standing
'The tree is on the north side'

Matcher selects:

Ambiguity and pragmatic inferences

- **Pragmatic** inferences

- The tree is behind the man

Intrinsic ∩ Egocentric

Intrinsic?   Egocentric?

- Game-theoretic pragmatics (Benz et al 2005): assume speaker is rational agent, will minimise costs while maximising probability of understanding

- Ad hoc conversational quantity implicature

- Impressionistically, younger kids struggled with this

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Ambiguity and pragmatic inferences

DIR: *Puṉungka maḻa ngaṟanyi aṉangu*
The person is standing behind the tree

MAT: *Yaaltjikutu kunyun wangkanyi?*
Towards where, did you say?

DIR: *Puṉungka maḻa ngaṟanyi*
Standing behind the tree

MAT: *Yaaltjikutu face-amani?*
Towards where is he facing?

DIR: *Nyuntunya nyanganyi*
Looking at you

MAT: *Nyangatjanku*
This is the one!

Final thoughts

Conclusion

- Man and Tree is a pragmatically complex task
  - How are linguistic expressions combined to create a complete (or incomplete) description?
  - How does the matcher use the available information to solve this task?
  - How can we code/analyse this?

- Pitjantjatjara-speaking children use information in reasoned ways
  - Errors are not random – usually within correct contrastive class
  - They make logical and pragmatic inferences to resolve ambiguity
  - Engaging in mathematical reasoning at their capacity in their own language!

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