



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

The spontaneous eMERGEncE of recursion in child language

Iain Giblin, Stephen Crain, Cory Bill

Macquarie University

Jiawei Shi, Peng Zhou

Tsinghua University

Recursion: the basic property of human language



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

- The generative approach to language has converged on the view that human syntax has at least three key properties:
 1. Human language is hierarchical
 2. The hierarchical structures associated with sentences affect their interpretation
 3. There is no upper bound on the depth of hierarchical structure building
- Our ability to create and interpret a discrete infinity of hierarchically structured expressions entails that there is some recursive procedure that generates these structured expressions. Thus, recursion is the fundamental property of human language (Hauser et al., 2002; Yang et al., 2017).



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Recursion: the basic property of human language

- Syntactic recursion is an operation in which a syntactic object of category XP can dominate another instance of itself (Berwick and Chomsky, 2017). That is, recursion enables identity of categories across hierarchical levels and there is no grammatical constraint on the number of embedding levels.
 - $NP \rightarrow N PP$
 - $PP \rightarrow P NP$
1. the book in the box
 - $[NP \text{ the book } [PP \text{ in } [NP \text{ the box }]]]$
 2. the book in the box on the table
 - $[NP \text{ the book } [PP \text{ in } [NP \text{ the box } [PP \text{ on } [NP \text{ the table }]]]]]$



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Recursion: the basic property of human language

- According to the Strong Minimalist Thesis (Berwick and Chomsky, 2016), recursion should (optimally) reduce to the operation MERGE.
- In its simplest terms MERGE is set formation. Given a syntactic object X and another syntactic object Y, MERGE creates a new hierarchically structured object {X, Y}. This new syntactic object is also assigned a label {X, {X, Y}}
- If recursion is a basic and innate property, it should emerge early and universally, in the absence of decisive linguistic input (Crain, 1991 ; Crain et al., 2017), and its emergence should vastly exceed the evidence that is available to the child.



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Recursion: the basic property of human language

- The goal of the present study is to test children's ability to produce recursive structures within nominal phrases.
 - Nominal recursion is a useful domain to study recursion because it is a manifestation of a crucial linguistic property within a limited syntactic domain and it is an instance of recursion where the category XP immediately dominates another instance of itself.
3. Mary's house [DP [DP Mary] 's [NP house]]
 4. Mary's brother's house [DP [DP [DP Mary] 's [NP brother]] 's [NP house]]
- For this talk I will refer to structures such as (3) as Level 1 Genitives and structures such as (4) as Level 2 Genitives.

Recursion: the basic property of human language



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

- Both Roeper (2011) and Roeper and Pérez-Leroux (2011) argue that only Level 2 embedding constitutes true recursion because it is only with Level 2 embedding that children create a representation beyond a simple lexical template.
- Clearly, Level 2 embedding within nominal phrases is a crucial domain to examine for the emergence of recursion in child language.
- We conducted a production experiment in English and Mandarin to elicit Level 2 genitives from 3-, 4-, and 5-year-old children.

Corpora



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

- A survey of parent-child interactions in CHILDES revealed 107 recursive possessive phrases by caretakers; 75 of these phrases (70%) conformed to a simple format: <proper name>'s + <common noun>'s + *name* (e.g., *Sue's baby's name*).
- A previous survey of CHILDES reported that children younger than 6 do not produce or comprehend possessive genitives (Roeper and Snyder, 2005).
- A survey of three Mandarin corpora revealed no examples of nominal recursion in children's input.
- Despite the poverty of the stimulus, every English- and Mandarin-speaking child in the present study evinced understanding of sentences with nominal recursion, and over three-quarters of the child participants produced them.



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Previous Work

- Previous studies have argued that children have substantial difficulty linking DPs recursively.
 - Roeper and Snyder (2005) argue that young children do not produce recursive genitives and do not comprehend them when such phrases are used by adults.
5. Mother: huh? what's your.... what's.... what's your cousin
 Arthur's Mummy's name
- Sarah: I don't. your cousin?

(Gu 2008; cited in Roeper 2011)

Previous Work

- In Gentile (2003; cited in Roper 2011) children were shown two pictures:



A: Cookie Monster's Sister



B: Cookie Monster and his Sister

6. "Can you show me Cookie Monster's sister's picture?"
 - One third of children preferred picture B
 - The suggestion is that children interpret recursive structures as coordinations ('Cookie Monster and his sister').

Previous Work

- In Limbach and Adone (2010) children and adults were asked to choose the correct picture when presented with a Level 2 Genitive, as in (7):
 7. Jane's father's bike
 - a) A picture of Jane's bike (single DP reading)
 - b) A picture of the father's bike (single DP reading)
 - c) A picture of Jane's father's bike (recursive reading)
 - d) A picture of Jane and her father's bike (coordinated reading)
- Limbach and Adone report that on average correct responses formed a majority (60%). However, 4- and 5-year olds chose a coordinated interpretation for approximately 20% of their responses.



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Previous Work

- Pérez-Leroux et al. (2012) constructed a production task designed to elicit Level 2 Genitives.
 - Pérez-Leroux et al.'s data indicate that children have difficulties with nominal recursion and significant difficulty with Level 2 Genitives.
 - Children heard 11 constructions: 2 training; 3 Genitive Recursion (Level 2); 3 PP Recursion; 3 Coordination Control.
8. Here is Elmo. This is his sister. And here is Bart and that's his sister. They each have a ball. Their sisters are carrying balls too. They are all going together to the basketball court. But look! Oh, oh.

Prompt: What is broken and flat?

Target: Elmo's sister's ball

Previous Work



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Table 1

Number of responses per group (adults and children) for Level 1 and Level 2 Genitives

	Level 1 Genitive	Level 2 Genitive
All children ($n = 46$)	28	1
Adults ($n = 11$)	12	7

Pérez-Leroux et al. (p. 309, 2012)

Previous Work



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Table 2

Number of Individual Participants per Age Group According to Their Overall Production of Embedded Genitives per Level

	Only Level 1 Genitive	At Least Level 2 Genitive
3-year-olds ($n = 16$)	3	1
4-year-olds ($n = 16$)	1	0
5-year-olds ($n = 16$)	1	0
All children ($n = 46$)	5	1

Pérez-Leroux et al. (p. 309, 2012)



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Our experiment

- A Truth Value Judgment task with an elicitation component was designed to maximize the felicitous use of nominal recursion.
- Whenever children rejected a puppet's false statement about events that had taken place in a story, they were asked to justify their rejections by telling the puppet "What really happened?"
- 4 false test trials were designed so a felicitous justification could be formed by embedding an additional possessive phrase inside the possessive phrase produced by the puppet:
 - Puppet: *Big Bird's blanket got dirty*
 - Child: *No, Big Bird's cats' blanket got dirty*

English



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

- English recursive genitives allow unbounded embedding:

Level 1:

Mary's house [DP [DP Mary] 's [NP house]]

Level 2:

Mary's brother's house [DP [DP [DP Mary] 's [NP brother]] 's [NP house]]

...



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

English - participants

- A total of 26 English-speaking children (15 male, 11 female; age ranged from 3;3 to 5;10, with a mean age of 4;7) participated in the current study. They were all recruited from Banksia kindergarten, Gumnut kindergarten, and Macquarie University child language lab. They had no reported history of speech or hearing disorders.

English - materials



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

- **Target construction:**
Big Bird's cats' blanket (Level 2 Genitive)
- **Control construction:**
Elephant's horse (Level 1 Genitive)
- **Filler construction:**
True response
- 10 stories in total (4 true filler trials, 2 false control – Level 1 Genitives, 4 false test trials – Level 2 Genitives).
- The stories were arranged in a pseudo-random order.



ccd

ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

English - story

Experimenter: This is Gecko and these are his pet koalas. This is Catboy and these are his pet koalas.

Gekko: It's dinner time, today we're having hotdogs for dinner with our pet koalas.

Catboy: Let's eat our hotdogs by the side of the road.

Experimenter: Oh no, here comes a motorbike and he's in a hurry. He nearly knocks over Gecko's hotdog, and then he swerves and knocks over this hotdog and it falls out of the bun and is ruined!



English - story

First question to puppet:

Whose hotdog got knocked over?

Blindfolded puppet: I can't see but let me guess. Gecko's hotdog got knocked over.

Target utterance for child:

No, Gecko's koalas' hotdog got knocked over!



English - story

Question for puppet: Whose blanket got dirty?

Puppet: I can't see but let me take a guess! Big Bird's blanket got dirty

Target Response: No, Big Bird's cats' blanket got dirty!

Child 4;3



English - results



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Table 3
Number of responses with Level 2 Genitives

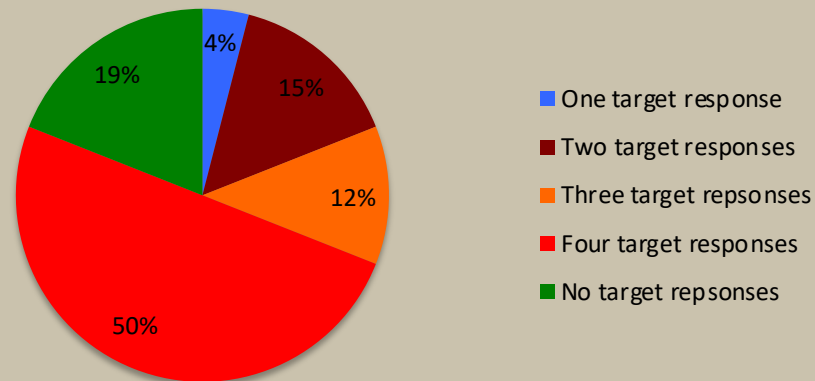
	Level 2 Genitives	% of trials
All children ($n = 26$)	70	67% (70/104)

English - results



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Percentage of Target Responses



English - results



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Table 5
Number of Level 2 Genitives per Age Group

	Level 2 Genitives	% of potential targets
3-year-olds ($n = 1$)	1	25% (1/4)
4-year-olds ($n = 17$)	40	59% (40/68)
5-year-olds ($n = 8$)	29	90% (29/32)
All children ($n = 26$)	70	67% (70/104)

English - conclusion

- 3-, 4-, and 5-year-old English speaking children are capable of producing Level 2 genitives.



ccd

ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Mandarin



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

- Possessive “DE” construction:

9. Jiawei de lao shi DP1 + de + DP2
 Jiawei GEN teacher
 “Jerry’s teacher”

- Children at age of 4 generally acquire Possessive “DE” construction in both production and comprehension, while 3-year-olds are in a transitional stage where they develop from noun-noun compounds to “DE” construction. (Shi & Zhou, in press)



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Mandarin - participants

- A total of thirty 4-year-old monolingual Mandarin-speaking children (18 male, 12 female; age ranged from 4;0 to 4;11, with a mean age of 4;5) participated in the current study. They were all recruited from Taolifangyuan Kindergarten, Beijing, and they had no reported history of speech or hearing disorders.



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Mandarin - materials

- **Target construction:**

haidao DE qingwa DE binggan

Pirate DE frog DE biscuit

“The pirate’s frog’s biscuit”

- **Control construction:**

xiaoxiongweini DE huasheng

Winnie the Pooh DE peanut

“Weenie the Pooh’s Peanut”

- **Filler construction:**

tuzi DE beike

rabbit DE shell

“The rabbit’s shell”



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

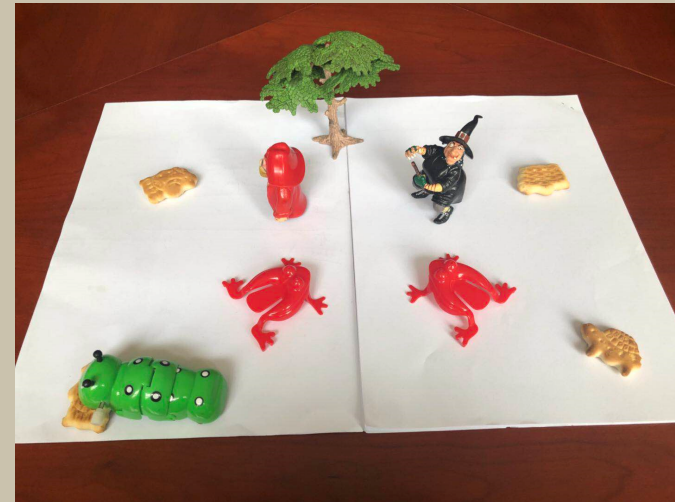
Mandarin - design

- 10 stories in total (4 target, 4 filler, 2 control). In half of the stories, the puppet produced a true response. In the remaining half, the puppet produced a false response.
- For all target constructions (Level 2 Genitives), the puppet produced an incorrect response, so that the children had to correct the puppet by producing the recursive possessive construction.
- The stories were arranged in a pseudo-random order.

Mandarin story



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS



Experimenter: Now it is your turn, catty. Do you know, which biscuit was stolen?

Catty: I can't see. Let's me guess... The pirate's biscuit was stolen

Target response: No! The pirate's frog's biscuit was stolen.

Mandarin - results



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Table 6
Number of responses with Level 2 Genitives

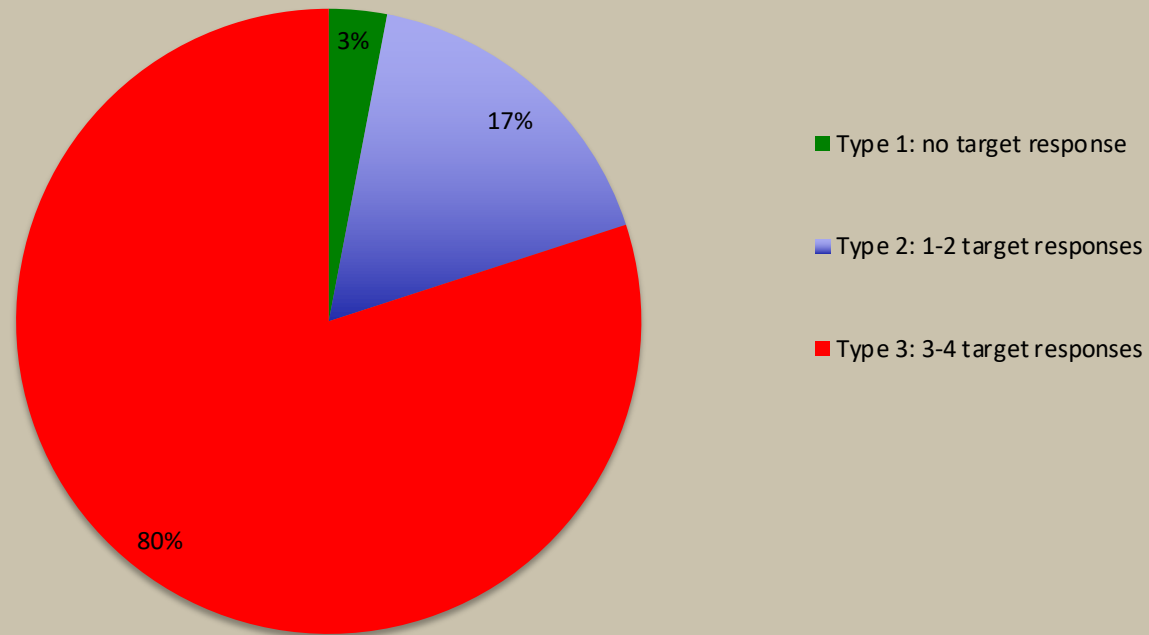
	Level 2 Genitives	% of trials
All children ($n = 30$)	95	79% (95/120)

Mandarin - results



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Percentage of Target Responses





ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Mandarin - conclusion

- Four-year-old Mandarin-speaking children are generally capable of producing the Level 2 Genitive constructions, as soon as they can be tested for possessive “DE” construction.



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

General conclusion

- The child participants consistently rejected the puppet's false statements on the test trials (Mandarin 98%; English 97%).
- Twenty-nine of the 30 Mandarin-speaking child participants (average 4;5) produced at least 1 sentence with recursion, and 24 produced 3 or 4. Twenty-one of the 26 English-speaking children (average 4;7) produced at least 1 sentence with nominal recursion, and 16 produced 3 or 4.
- In total, 95 sentences with nominal recursion were elicited from Mandarin-speaking children (79% of trials) and 70 were elicited from English-speaking children (67% of trials).



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

General conclusion

- Our experiments show that both English and Mandarin speaking children show evidence for recursive computation within nominal phrases despite the problems raised by the poverty of the stimulus.
- These experimental findings are just what the generative approach to language predicts. Namely, if recursion is a basic and innate property, it should emerge early and universally and its emergence should vastly exceed the evidence that is available to the child.
- Mandarin construction and Piraha...



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

References

- Berwick, R. C., & Chomsky, N. (2016). *Why only us: language and evolution*. Cambridge, MA: MIT Press
- Crain, S., & Thornton, R. (1998). *Investigations in universal grammar: a guide to research on the acquisition of syntax and semantics*. Cambridge, MA: MIT Press.
- Gentile, S. (2003). *On the acquisition of left-branching recursive possessives*. MA thesis, University of Massachusetts, Amherst.
- Gordon, P. (1985). Level-ordering in lexical development. *Cognition*, 21. 73-93
- Luo, Y. (2013). Possessive constructions in Mandarin Chinese. In A. Y. Aikhenvald & R. M. W. Dixon (Eds.), *Possession and ownership: a cross-linguistic typology* (pp.186-207). Oxford, England: Oxford University Press.
- Pérez-Leroux, A.T., Castilla-Earls, A. P. , Bejar, S. & Massam, D. (2012) . Elmo's Sister's Ball: The Problem of Acquiring Nominal Recursion, *Language Acquisition*, 19, 301-311.
- Roeper, T. (2007). *The Prism of Grammar: How Child Language Illuminates Humanism*. Cambridge, MA: MIT Press.
- Shi, J., & Zhou, P. (In Press). How possessive relations are mapped onto child language: A view from Mandarin Chinese. *Journal of Psycholinguistic Research*.



ARC CENTRE OF EXCELLENCE IN
COGNITION AND ITS DISORDERS

Addendum

- It might be objected that the examples we used as Level 2 Genitives are not true Level 2 Genitives:
 - Big Bird's cats' blanket
 - Kwazii's dolphins' robot
 - Gecko's koalas' hotdog
 - Xuli's turtles' towel
- Specifically it might be objected that DP_2 and DP_3 form a compound [cats-blanket] rather than a recursive construction.
- However, results from several studies indicate that children almost never allow regular plurals inside compounds: *rats-eater (Gordon, 1985).