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Introduction

• Adults in the Pirahã tribe lack exact number words, but show evidence of small-number exact representations (1-to-3) and approximation for larger quantities (Gordon, 2004; Frank et al., 2008; Everett & Madora, 2012) reflecting a distinction between small number and large number numerical representations that is common across multiple populations and situations where counting or exact verbal encoding is not possible.

• Children in counting cultures can typically recite extensive rote count number sequences before the number words map onto actual numerosities (Gelman & Gallistel, 1978). In learning to count, they go through number-knower stages reflecting knowledge of small number semantics before incrementally developing fuller numerical competence and knowledge of the incremental mapping properties (Wynn, 1990; 1992).

Research Questions and Methods

• The present study begins to ask questions about how young children with limited knowledge of small numbers are similar or different to adult Pirahã, who are cognitively mature, but lack exact numerical representations because they lack exact number words in their language and do not engage in counting in their culture. Using this comparative methodology allows us to address questions about the role of age, experience, cultural and language in numerical cognition.

• In this study, we used standard tests of numerical knowledge in young children including **GIVE A NUMBER** tasks to assess their number-knower level, and also tested them on **ROTE COUNTING** (Wynn, 1990).

• We tested children on tasks that had been used in Gordon (2004) to test numerical cognition in the Pirahã. Results from the full battery for the Pirahã are shown in Fig. 1, with the averaged data in Fig 2. From this battery, we tested children on the **1-1 LINE MATCH** task (A), the **ORTHOGONAL LINE MATCH** task (C), and the "**NUTS-IN-A-CAN**" task (G).

• In addition, we tested children on the **ascending versus descending quantity-naming procedure** developed by Frank et al. (2008). In their adult Pirahã data, they tested participants with an incremental ascending count (1→10), followed by a decremental descending count (10 → 1) asking them to name the quantity on each change in quantity.

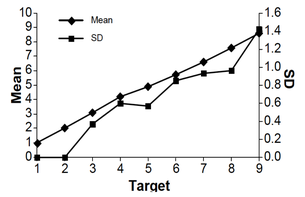
• In the *ascending* object count, Pirahã adults used the term *hói* (falling tone = ~1/small amount) for singular quantities only. Across Pirahã adults, *hoí* (rising tone = ~2 /*hói* +1) was used to name quantities from 2 to 10 (frequencies ramping down), and *ba'agiso* (= many) named quantities 3 through 10 (frequencies ramping up).

• On the *descending* count, across individuals, *ba'agiso* was used to denote quantities of 10 through 5 (ramping down), *hoí* (~2) was used for quantities 8 through 2, and *hói* (~1) for 4 through 1 (SEE FIG 3). These results show that *hói* and *hoí* represent quantities inconsistently, in a way that is relative to the preceding context of numerical presentation. In other informal observations, *hói* (~1) is often used to denote a group of objects (up to say 6), and then *hoí* (~2) is used when one is added to that group. Thus, *hoí* appears to denote something like "*hói plus one*" In the descending count, reference for both terms becomes unstable in the absence of an incremental sequencing of quantities.

• We were interested in whether children who exhibit limited number-knower status show similar or distinct patterns of responding to these tasks compared to adult Pirahã, whose limitations in numerical cognition are linguistic, experiential and cultural rather than developmental in nature.

Data from the Pirahã

Fig 2. Numerical estimation from Pirahã Data



Data from children in contemporary settings

Fig. 3: Ascending vs. Descending Task from Frank et al. (2008) on the Pirahã

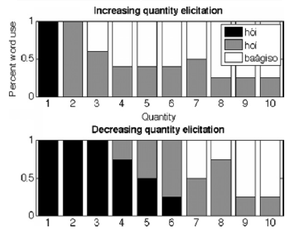


Fig. 1. Proportion of Pirahã speakers using each of the three proposed quantity words in Pirahã. Sets with different quantities were presented in increasing order and participants were asked to describe their quantity.

Fig. 4: Child Data on the Ascending vs. Descending Task (2018):

			Ascending Task										Descending Task								
Age (mts)	# Knower	Rote Count	1	2	3	4	5	6	7	8	9	10	10	9	8	7	6	5	4	3	2	1
25	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	2	10	1	2	3	3	2	1	1	1	1	1	-	-	2	2	2	2	2	2	2	1
31	2	-	2	2	2	2	2	3	3	1	-	-	2	-	-	-	-	-	-	-	-	-
39	2	10	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
36	3	5	1	2	5	9	9	9	9	9	5	-	10	10	9	5	7	6	5	4	2	1
39*	3	13	1	2	1	4	5	7	5	4	7	1	6	5	6	4	7	6	6	6	-	1
41	3	14	1	2	3	2	1	2	3	7	11	-	10	5	10	4	3	3	3	2	3	3
39*	4	10	1	2	3	5	7	13	9	7	8	5	13	11	9	8	8	7	4	4	13	1
31	4	13	1	2	3	4	5	6	7	4	5	6	-	-	-	-	-	-	-	-	-	-
45	5	5	1	2	3	4	5	10	7	8	0	4	11	8	8	8	7	5	4	3	2	1
42	5+	10	1	2	3	4	5	6	7	8	9	10	12	15	10	10	7	5	6	3	2	1

= Data from twins = Correct response

- Performance on the Ascending task is predicted by number-knower level.
- For 5-knowers, accuracy begins at 5 on the Descending task.

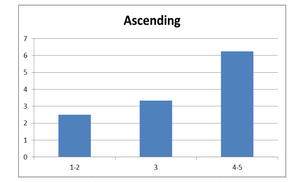


Fig. 1. Pirahã Numerical Cognition Battery from Gordon (2004)

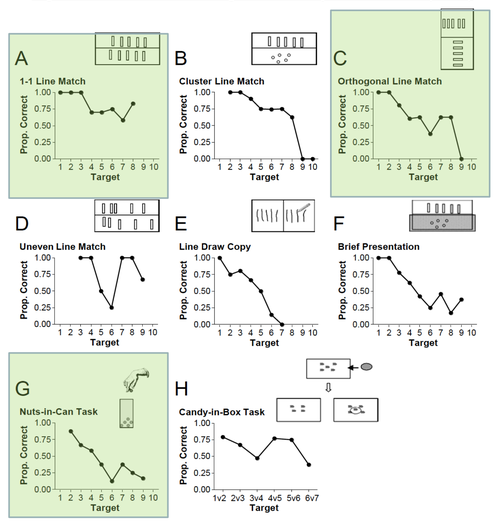


Fig. 5: Child Data (2018) on Numerical Cognition Tasks from Gordon (2004)
For a visual representation of the following tasks, please see Figure 1 (A, C, G).

			1-1 match (Parallel)				1-1 match (Orthogonal)				Nuts-in-can			
Age (mts)	# Knower	Rote Count	2	4	6	8	2	4	6	8	1	2	3	4
25	1	10	-	-	-	-	-	-	-	-	-	-	-	-
38	2	10	3	4	9	6	-	-	-	-	1	2	3	3
31	2	-	-	-	-	-	-	-	-	-	-	-	-	-
39	2	10	2	4	6	8	2	4	8	9	1	2	>3	>4
36	3	5	-	-	-	-	-	-	-	-	>1	>2	>3	>4
39*	3	13	2	4	6	8	2	4	7	8	1	>2	3	4
41	3	14	4	11	11	3	2	3	16	3	-	-	-	-
39*	4	10	2	4	6	9		6	12	12	1	1	3	3
31	4	13	2	4	4	6	2	4	-	-	-	-	-	-
45	5	5	2	4	6	8	2	-	10	10	1	2	3	4
42	5+	10	2	4	6	8	2	4	11	9	1	2	3	4

= Data from twins = Correct response

Results:
- Performance on the 1-1 match (parallel) task is mixed, and not predicted by number knower level.
- Performance on the 1-1 match (orthogonal) task is predicted by performance in the parallel task, with 50% decrement.

Participants
12 children aged 25 – 45 months. Two were dropped due to lack of useable data.

Specific Methods
- **Give a number**: Children were asked to give Cookie Monster X number of cookies (1-5). There are three trials per number. Needed 66% criterion for number knower status.
- **Rote counting**: Children were asked to count as high as they could without referents.
- **Ascending**: Blocks were laid out one at a time (1 → 10) and the child was asked to say how many there were. About 2/3 of children counted during this task. The **descending task** was the same procedure, but starting with 10 blocks and removing one at a time until there was one.
- **1-1 match: Parallel:** involved the child laying out the same number of blocks (n= 2,4,6,8) on their side of a divider to that modeled by the Experimenter. **Orthogonal** involved the same matching process except the modeled set was laid out orthogonal to the divider
- **Nuts in a can**: Experimenter showed child a set of blocks (n= 1,2,3,4) and put them in a container. Blocks were removed one at a time and the child was asked if there are any more left inside the container.

Preliminary Observations:
The present dataset is too small to warrant strong conclusions. However, the following observations appear to be emerging:
1. Children in this study differ from Pirahã adults in that the former are taught to count and engage in counting in everyday activities, whereas this is absent in Pirahã culture. We do not see, for example, the 2-knowers looking like the Pirahã, if we consider the *hói - hoí* system of quantification to be a roughly 1-2 counting system. Children do not use "many" to refer to larger quantities but, instead, appear to show chaotic use of number words, which appears to be their diffuse way of denoting larger numerical sets. However, like the Pirahã, the descending number naming task disrupts the order found in the ascending task. For the 5-knowers, children do well on the ascending task either up to their knower level (5) or their rote counting level (10). On the descending count, they appear to engage in correct counting when quantities reach to within their number-knower level.
2. Performance on 1-1 matching tasks appears to be less constrained by Number-knower level, but spatial reconfiguration shows detrimental effects for small (2-3) and large (4-5) number knowers alike.
3. Performance on the nuts-in-a-can task was only mastered by 5-knowers, suggesting that performance is contingent on their ability to represent quantities.