Acquiring the successor function of symbolic numbers: longitudinal comparison of verbal number words and cardinal number gestures

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Introduction

Children would achieve a complete understanding of the cardinal principle through the discovery of, a conceptual rule, the successor function, which is that every number word n in the verbal number sequence has a strict predecessor/successor with a cardinal meaning of n -1/n + 1, respectively (Carey, 2004, 2009; Sarnecka & Carey, 2008). It has been suggested that counting would implement the successor function in two stages. Children would first work out the direction of the numerical change the child before the unit of the change. These conceptual progess were found to be accessible only to cardinal principle knowers (Give-a-number task).

Counting activities and basic "+1" small calculation were found to be important sources of knowledge for the acquisition of the successor function (Schneider et al., 2020, 2021ab) but they might not be the only ones. Converging lines of evidence suggest that children's ability to use their fingers in numerical contexts contributes to their understanding of numerical concepts (Roesch & Moeller, 2015) but there is no consensus at present on the role of fingers in cardinal knowledge development. Some authors found no advantage of cardinal number gestures compared to number words in 2-to 5-year-olds (Nicoladis et al., 2010) while others showed that children who do not master the cardinal principle were more accurate at estimating numbers with cardinal finger gestures than with number words (Gunderson et al., 2015).

Aims

Tracking the two stages of development the successor function in a longitudinal study using the Direction and the Unit task

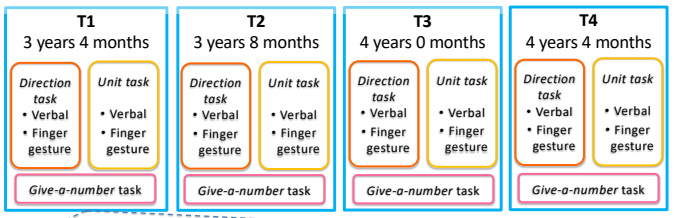
Examining how finger might contribute to the discovery of the successor function

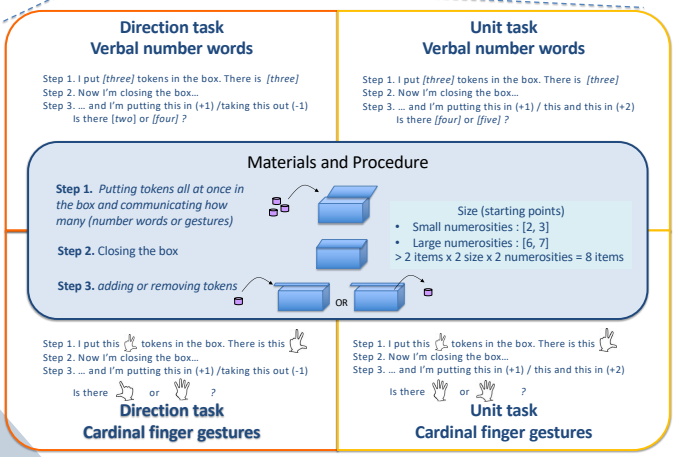
Exploring the relationship with cardinal knowledge development (*Give-a-number* task)

Methodology

48 prescholers tested 4 times every 4 months from the age of 40 months

TIME LINE



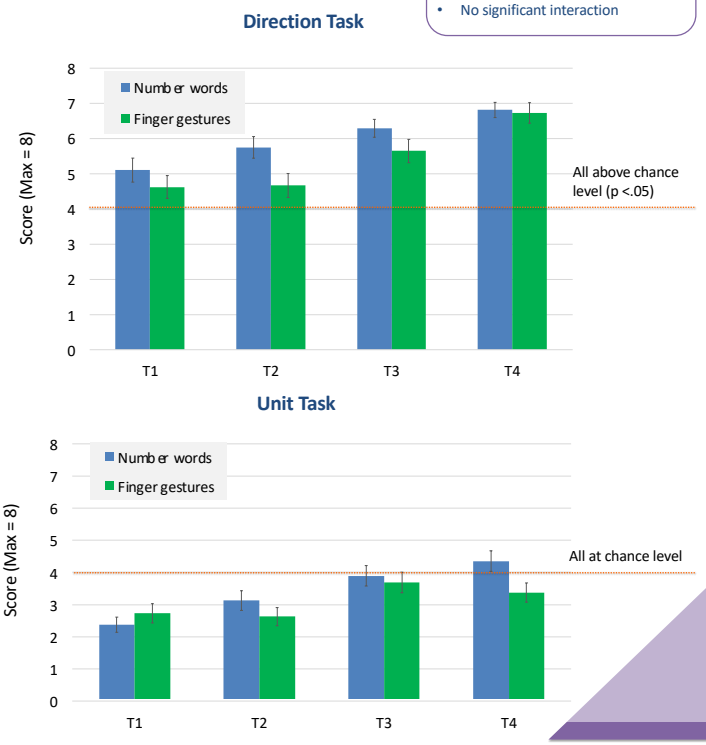


Give-a-number task

- The child received 10 tokens : Can you give me [three] tokens? »
- Cardinal development level = the largest numerosity accurately identified by the child two out of three times

Results

Repeated Measures ANOVA :
- Task : F(1, 47) = 220.9, p < .001
- Modality : F(1, 47) = 7.8, p < .01
- Time : F(3, 141) = 22.3, p < .001
- No significant interaction



Distribution of children as a function fo their verbal cardinal knowledge level across time

		Give-N	T1 Frequency	T1 %	T2 Frequency	T2 %	T3 Frequency	T3 %	T4 Frequency	T4 %
Subset-knowers	Pre-numeral knowers	0	2	4.2	3	6.3	0	0	0	0
	One-knowers	1	5	10.4	4	8.3	0	0	0	0
	Two-knowers	2	26	54.2	10	20.8	14	29.2	6	12.5
	Three-knowers	3	11	22.9	14	29.2	8	16.7	8	16.7
CP-knowers	Four-knowers	4	3	6.3	5	10.4	11	22.9	3	6.3
	Five-knowers	5	0	0	5	10.4	1	2.1	6	12.5
	Six-knowers	6	0	0	0	0	2	4.2	3	6.3
	Seven-knowers (max)	7	1	2.1	7	14.6	11	22.9	21	43.8
		Total	48	100	48	100	48	100	48	100

Mean performance in each task in subset- and CP-knowers (Give-N task)

		Subset-knowers				CP-knowers			
		T1	T2	T3	T4	T1	T2	T3	T4
Task	N	44	31	23	15	4	17	25	33
Direction	Number words	5.05*	5.42*	5.65*	5.8*	/	6.35*	6.88*	7.27*
	Finger gestures	4.57	4.23	5.39*	5.47*	/	5.47*	5.88*	7.3*
Unit	Number words	2.27	2.74	3.22	3	/	3.82	4.52	4.97
	Finger gestures	2.7	2.45	3.91	2.13	/	2.94	3.48	3.94

* above chance level (p <.05)

Conclusion

The development of the successor function is a long-lasting process which extend over a protracted period beyond the age of 4 years and 4 months.

Children first figure out the direction of the numerical change the child before the unit of the change.

Cardinal finger gestures provided no advantage in the discovery of the successor function

Subset-knowers performed above chance level in the Direction task, suggesting that they are able to understand the direction of the numerical changes. This result contradicts the idea that this important conceptual progess would only be accessible to cardinal principle-knowers

Any question ? laurence.rousselle@uliege.be

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