Cross-situational learning of word-pseudosign pairs in children and adults: a behavioral and event-related potential study

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BACKGROUND

- In human communication, both auditory and visual inputs are essential[1]
- In child and adult communication, gestures often persist to accompany, emphasize, and complement speech[2,3].
- In conjunction with speech, gestures can be used to support word learning with pre-verbal children (*baby signing*[4]) and clinical populations[5].
- Word learning can occur implicitly through the recognition of patterns in language input (*statistical learning*[6]).
- The *cross-situational learning*[7] paradigm is used to replicate statistical learning mechanisms, mostly using pseudowords as referents for novel objects to investigate noun learning.
- *Cross-situational learning* consists of ambiguous learning trials, useful to mimic real-life learning scenarios in experimental settings.
- Despite the role of gestures in language and communication, there is a lack of research on cross-situational learning of visual language and speech.

RESEARCH QUESTIONS

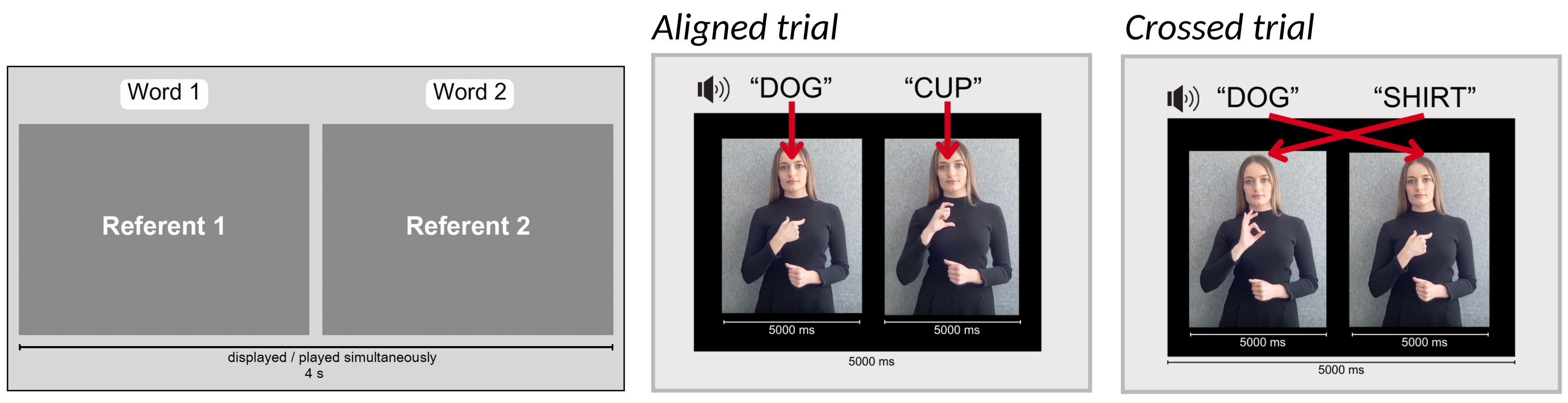
- Is it possible to map familiar spoken words to novel pseudosigns?
- Is this possible to do this mapping rapidly through statistical learning?
- Is it possible to build semantic categories of novel pseudosigns?
- In case of category violation, do pseudosigns elicit electrophysiological responses similar to spoken words (e.g., N400 response)?

MATERIALS AND METHODS

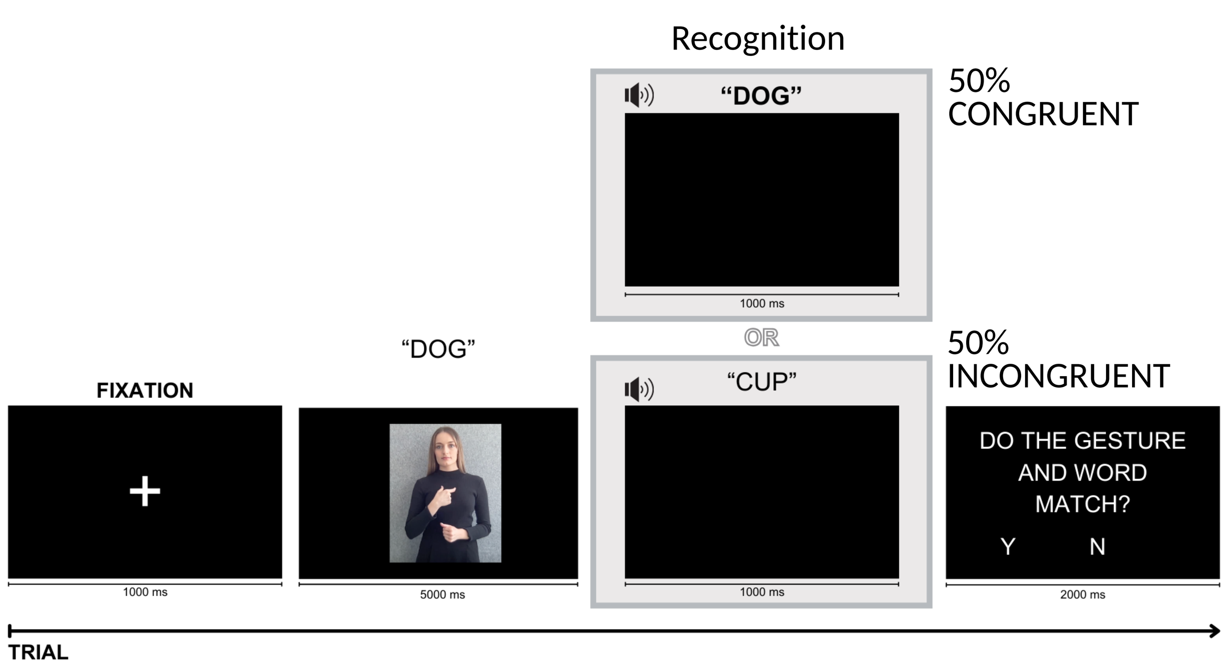
- participants: 25 children (*M* = 9.11 years, *SD* = 14.8) and 19 adults (*M* = 27 years, *SD* = 4.9)
- stimuli: 8 words (8 semantic categories) matched with 8 pseudosigns (non-iconic, phonotactically legal)
- dependent variables: response accuracy (%), d-prime, mean N400 amplitude (μV)
- data analysis: signal detection theory[8], cluster-based permutation analysis, linear mixed models

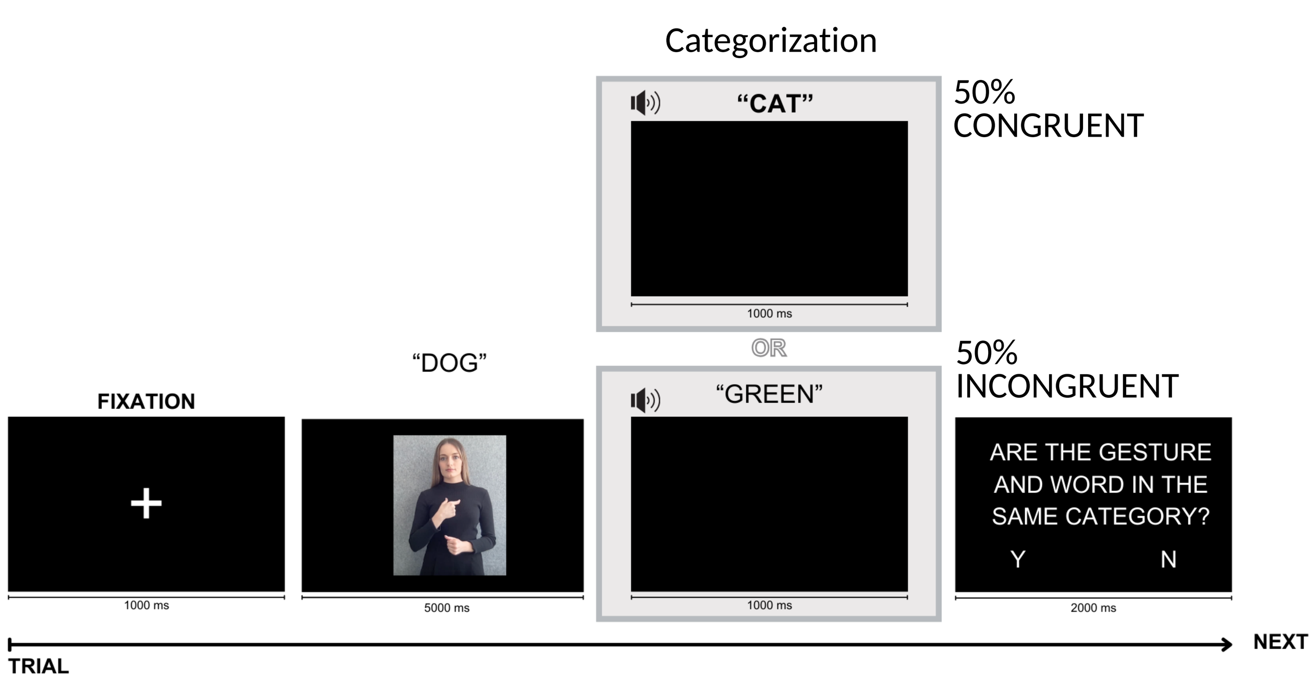
PROCEDURE

- Familiarization phase: cross-situational learning paradigm



- Recognition and categorization tasks: yes/no task (response button press)





BEHAVIORAL RESULTS

- Both groups performed above chance (accuracy and *d*-prime scores)
- Adults performed significantly better than children in both tasks (*d-prime ~ (Task * Group)*)
- No significant effect of tasks

		Accuracy (%)			*d*-prime		
Group	Task	M	SD	Wilcoxon W	M	SD	t-statistics
Adults (N = 19)	Recognition	87.5	13.6	190, *p* < .001	2.76	1.27	9.47, *p* < .001
	Categorisation	83.8	16.6	170, *p* < .001	2.48	1.34	8.04, *p* < .001
Children (N = 25)	Recognition	72.0	17.5	314, *p* < .001	1.47	1.33	5.52, *p* < .001
	Categorisation	69.0	18.2	295, *p* < .001	1.29	1.34	4.79, *p* < .001

Table 1: Behavioral performance of the two groups in recognition and categorization tasks.

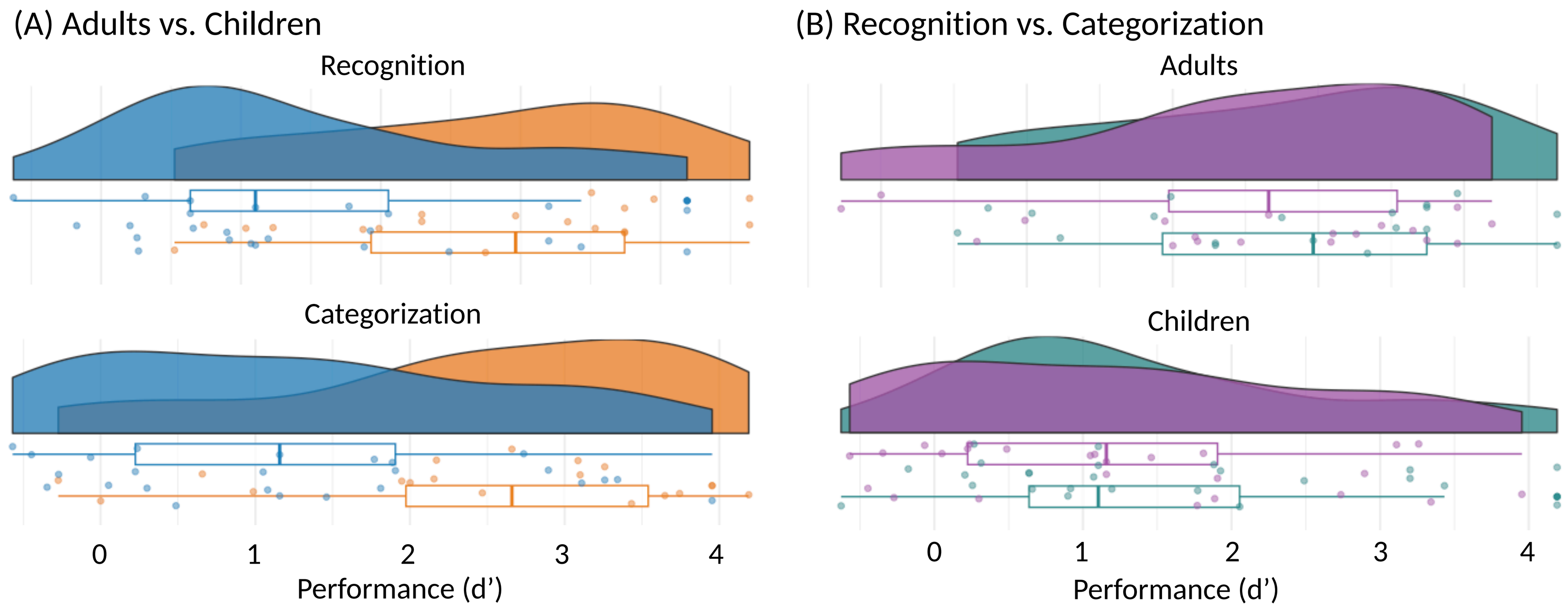


Fig. 1: Comparisons of performance scores expressed as sensitivity scores (*d*-prime). (A) Yellow = Adults, Blue = Children; (B) Green = Recognition task, Purple = Categorization task

ERP RESULTS

- Adults: N400 in recognition and categorization
- Children: N400 in recognition; in categorization, after additional analysis
- For both groups, LPC in recognition but not in categorization

Group	Task	Cluster type	Latency	p	Cohen's d
Adults (N=19)	Recognition	Negative	285-497	.001	-1.77
		Positive	625-997	.001	1.62
	Categorization	Negative	513-673	.005	-1.44
Children (N=24)	Recognition	Negative	156-464	.001	-1.39
		Positive	572-896	.002	1.23
	Categorization†	*Negative*	*760-876*	*.043*	*-1.44*

Table 2: Cluster-based permutation test results with effect sizes of the ERPs of the two groups in *recognition* and *categorization* tasks. † Results of the additional analysis on ERPs from correctly identified trials only.

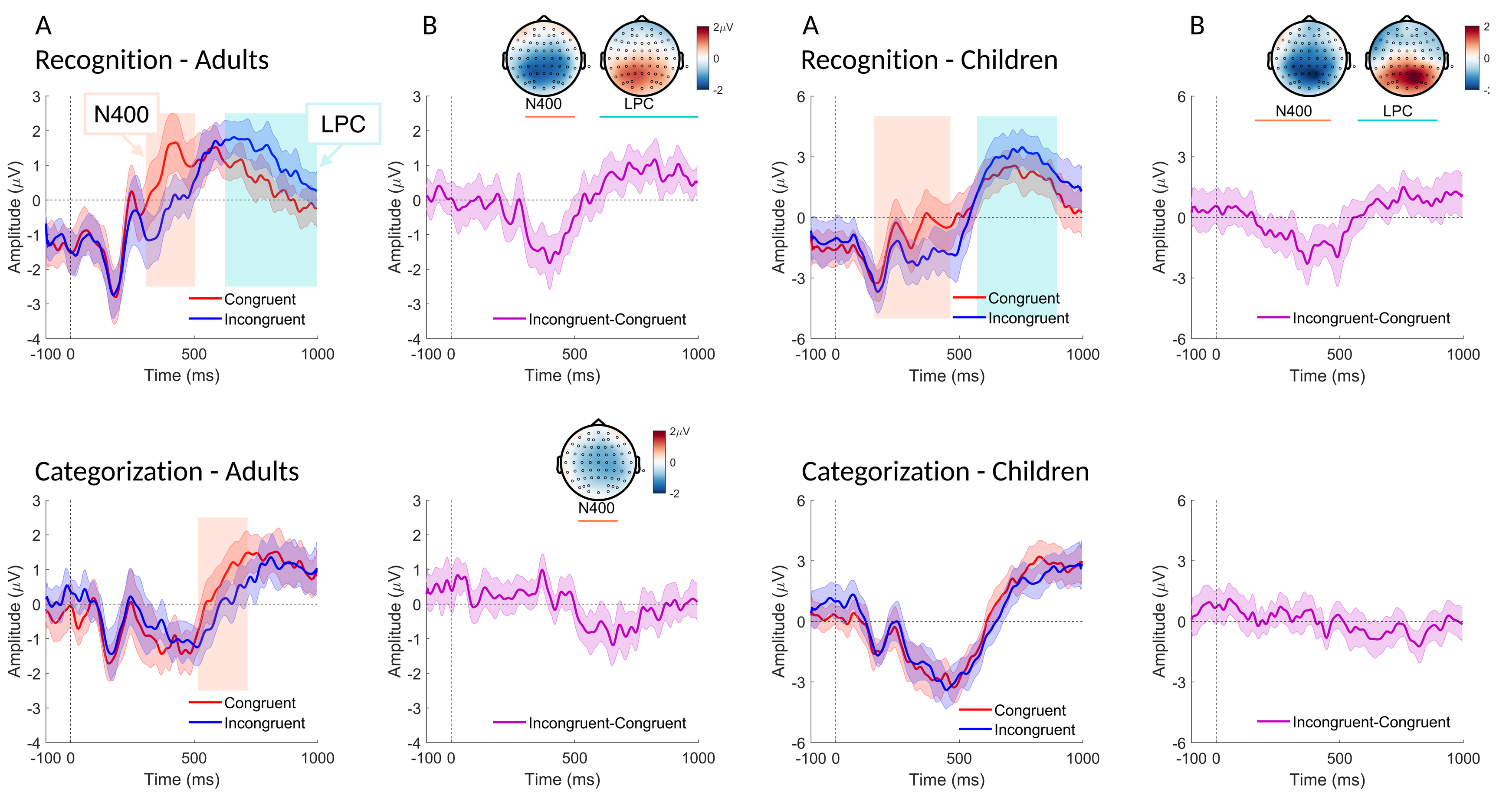


Fig. 2: Grand averaged ERPs of the adult group divided by task (*recognition task*, upper row; *categorization task*, bottom row). (A) The N400 and LPC time windows are highlighted in red and blue, respectively (B) The shading of the difference waveform encompasses 95% confidence intervals.

SUMMARY

Spoken words can be rapidly mapped onto novel pseudosigns via cross-situational learning. Pseudosigns can be rapidly associated with meaning and, in case of semantic violation, elicit brain responses (N400) similar to spoken words.

These findings suggest that spoken words + pseudosigns can constitute an ecologic language input. Future research should further explore how younger populations respond to this form of language input, to check for developmental differences in this process.

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