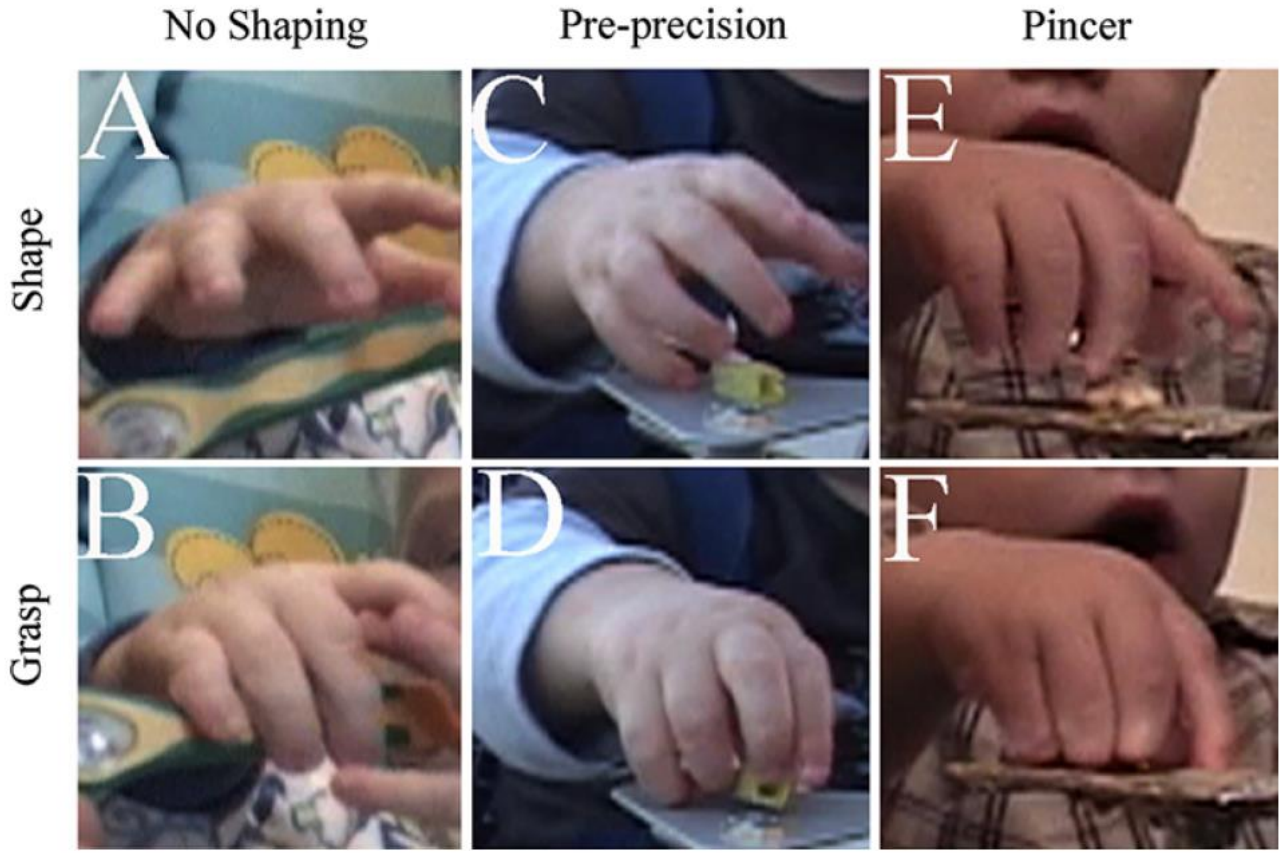
Early grasping trajectories and later neural representations of infant fingers

Melissa N. Horger, Kaitlyn Campbell, Peter J. Marshall, Valentina Parma

Hand movements as an experimental window on motor development

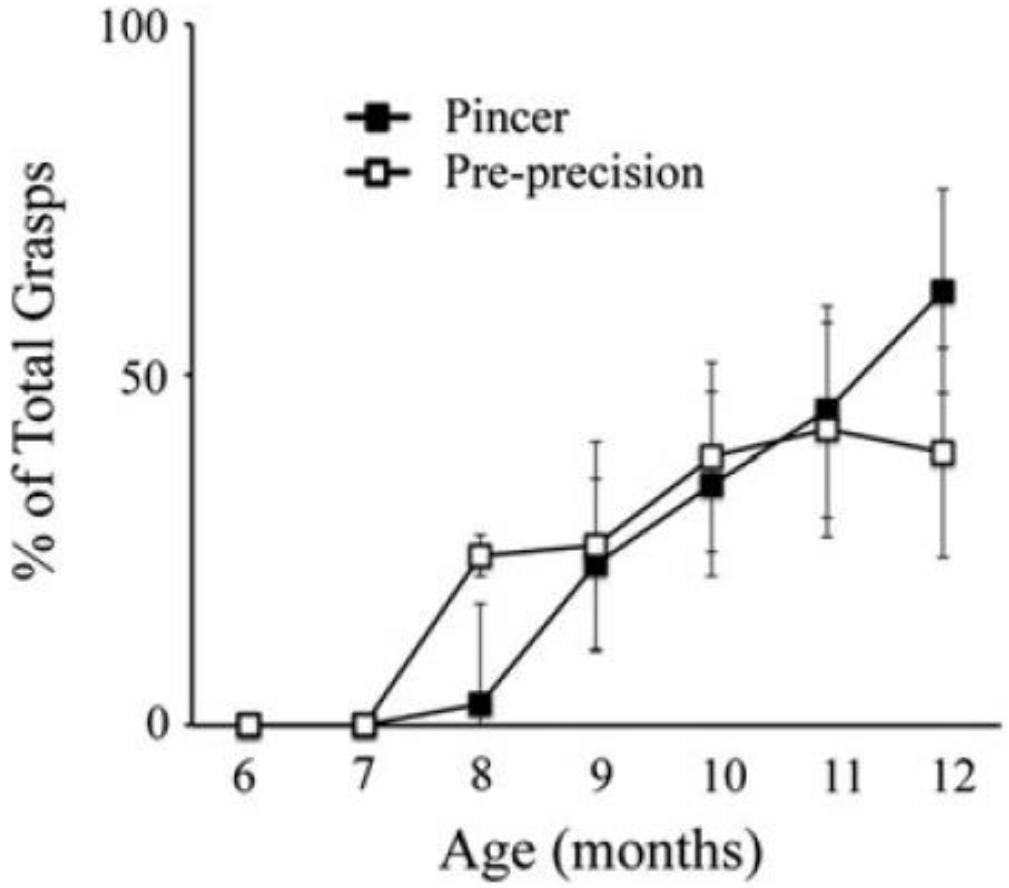
- Ecologically valid
- Well practiced

Finger position as an indicator of grasp maturity



Sacrey, Karl, & Whishaw, 2012

Grasping precision improves from 9 months



Sacrey, Karl, & Whishaw, 2012

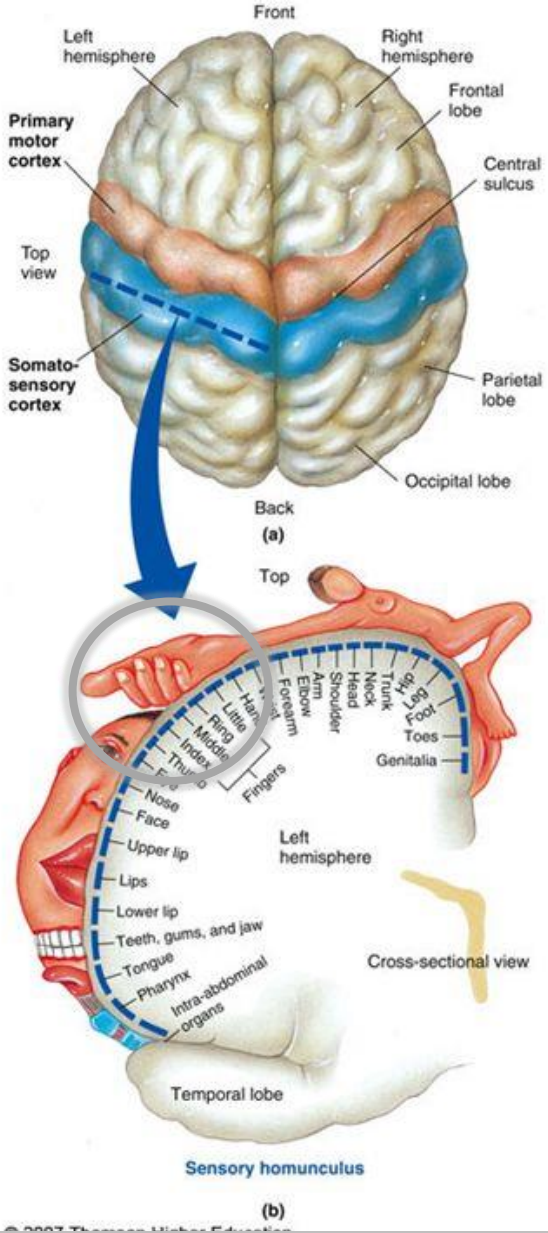
For review, see von Hofsten & Rosander, 2018)

The pincer grasp evolves with finger independence

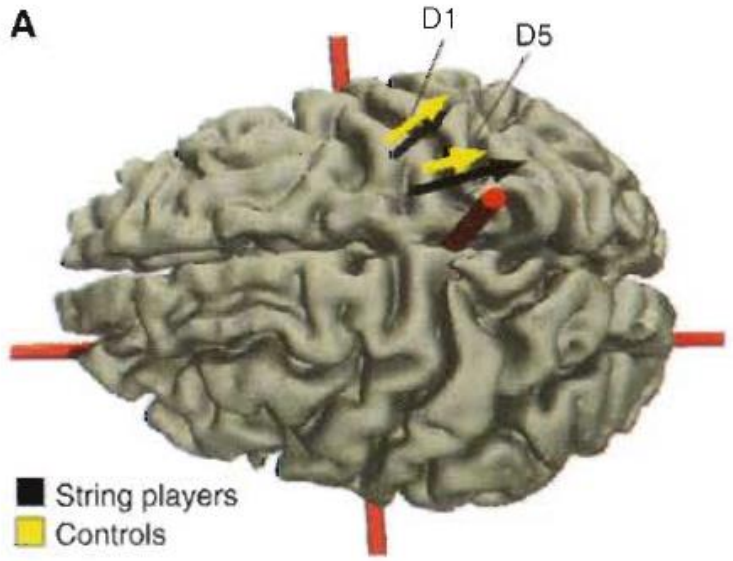
Sacrey, Karl, & Whishaw, 2012

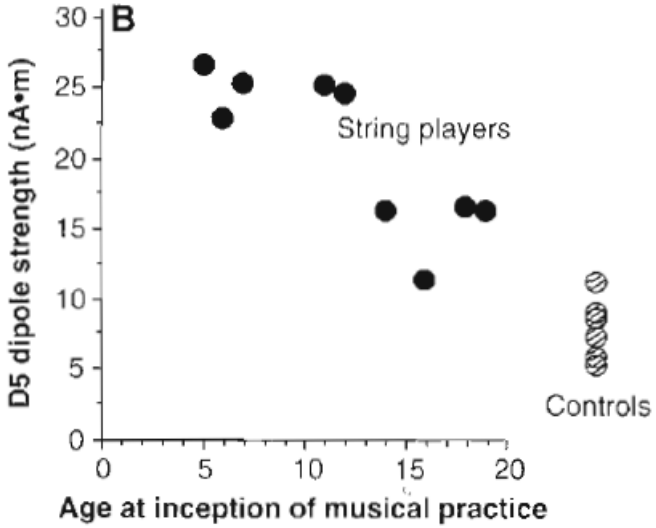
Finger independence and neural representations in somatosensory cortex

- Large relative to anatomical size
- Neuroplasticity
  - Marshall & Meltzoff, 2015
  - Dall'Orso et al., 2018



Tactile experience affects the neural representation of digits

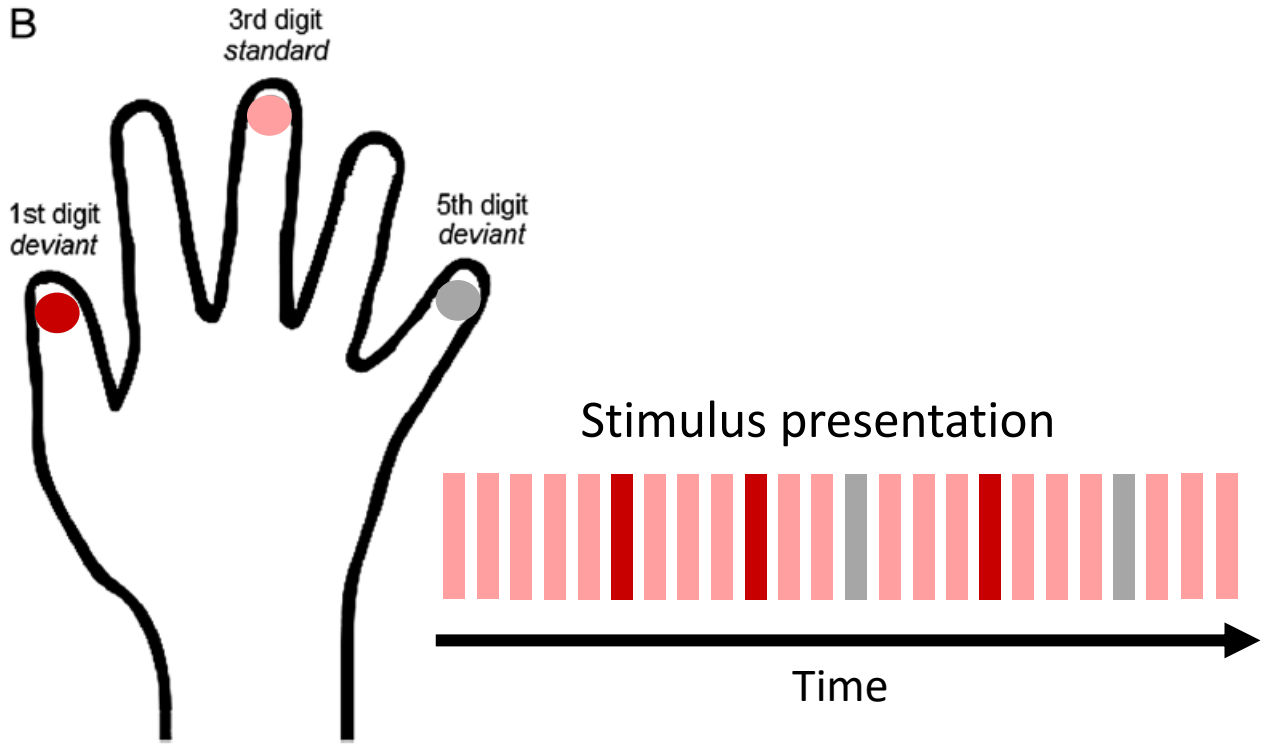




For a more recent review, see Olszewska et al., 2021

Elbert et al., 1995

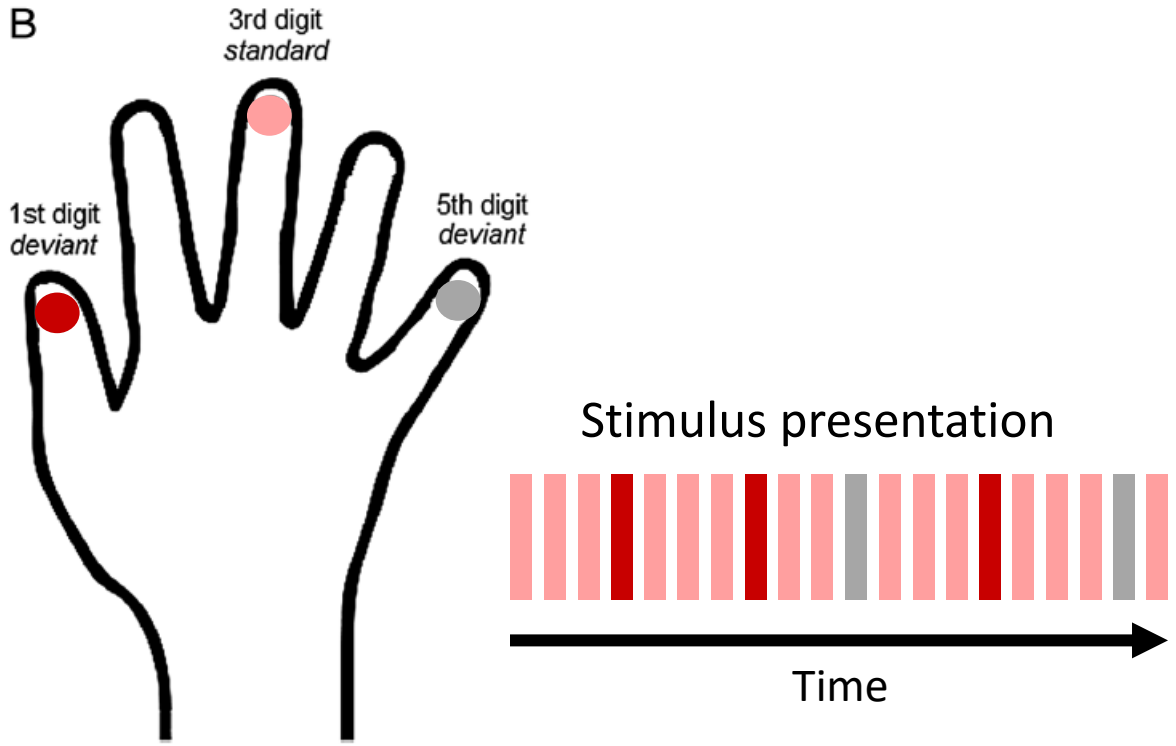
sMMN as a neural window into relations between fingers

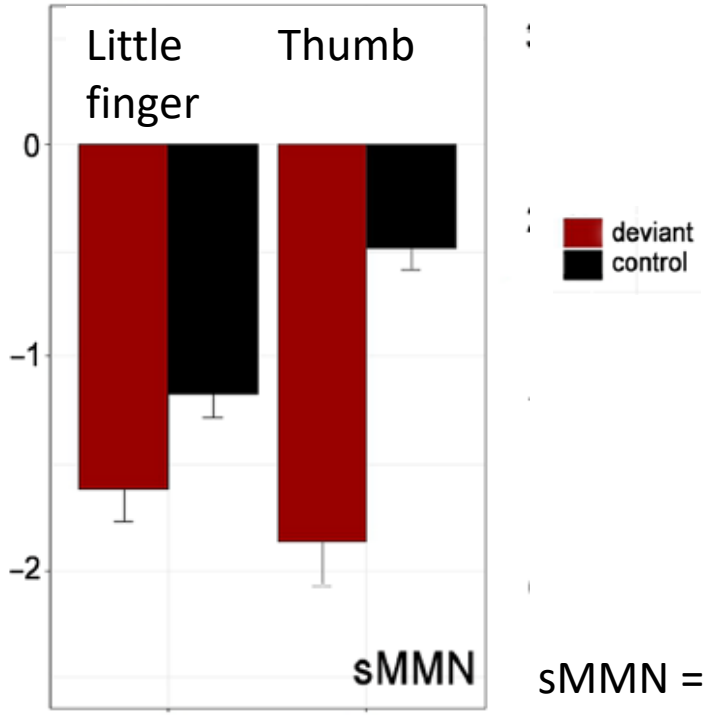


sMMN = somatosensory mismatch negativity

Shen et al., 2018

sMMN as a neural window into relations between fingers





sMMN = somatosensory mismatch negativity

Shen et al., 2018

Does grasp maturity at 9 months have an impact on the neural representation of infant fingers at 14 months?

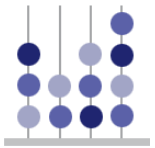
Participants

- N = 10 (80% Female)

Age M(SD)	**Household income**	**Race**	**Ethnicity**
At in-home grasp task 290.78 (6.86) days At lab visit 440.7 (9.7) days	20% <$50,000 20% $50-99,000 60% >$100,000	70% White 10% Black 20% multiracial	20% of Hispanic origin

In-home grasping task

Kinematic coding



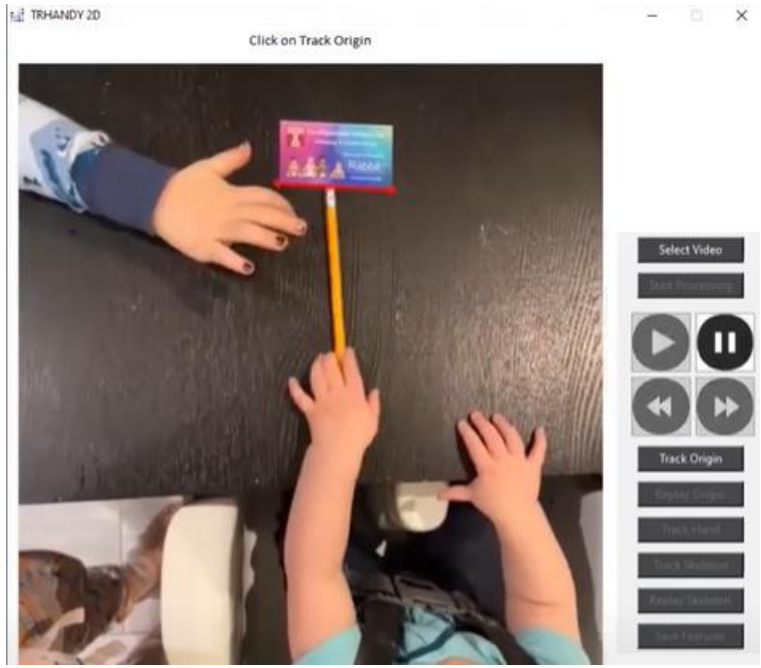
Steps:

1. Define frame of start, first contact, and end

Kinematic coding

Steps:

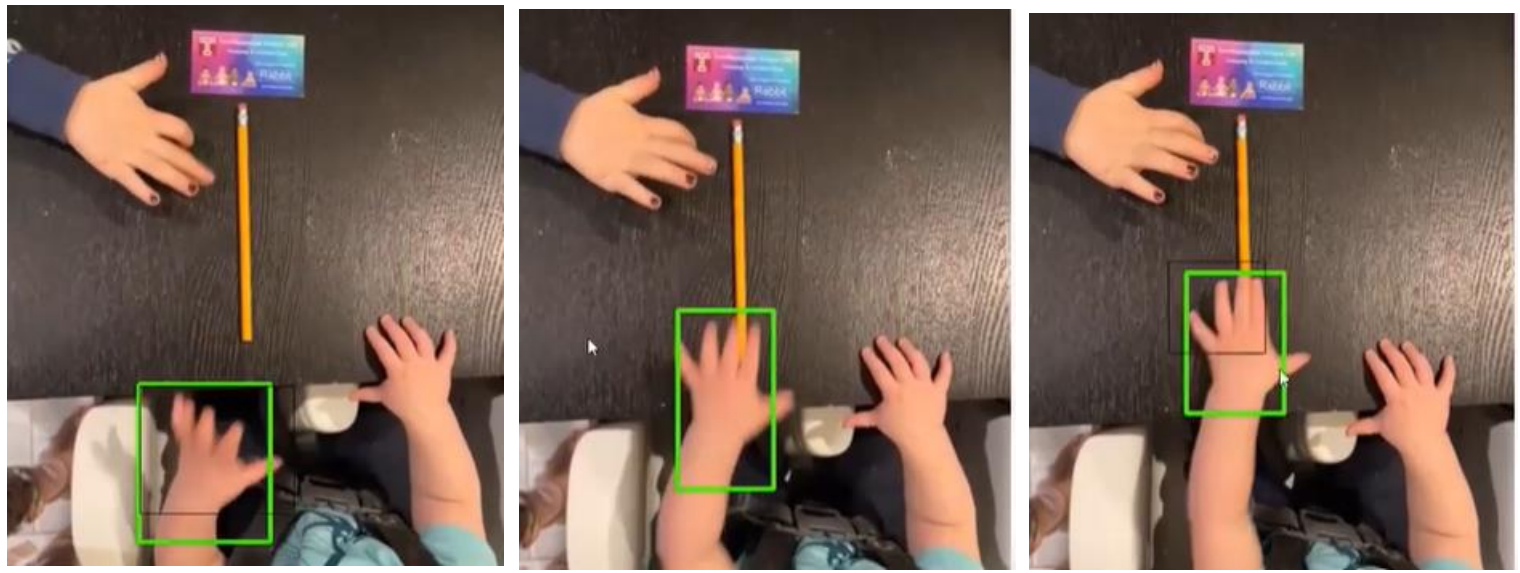
1. Define frame of start, first contact, and end
2. Define length of card



Kinematic coding

Steps:

1. Define frame of start, first contact, and end
2. Define length of card
3. Track the hand



Kinematic coding

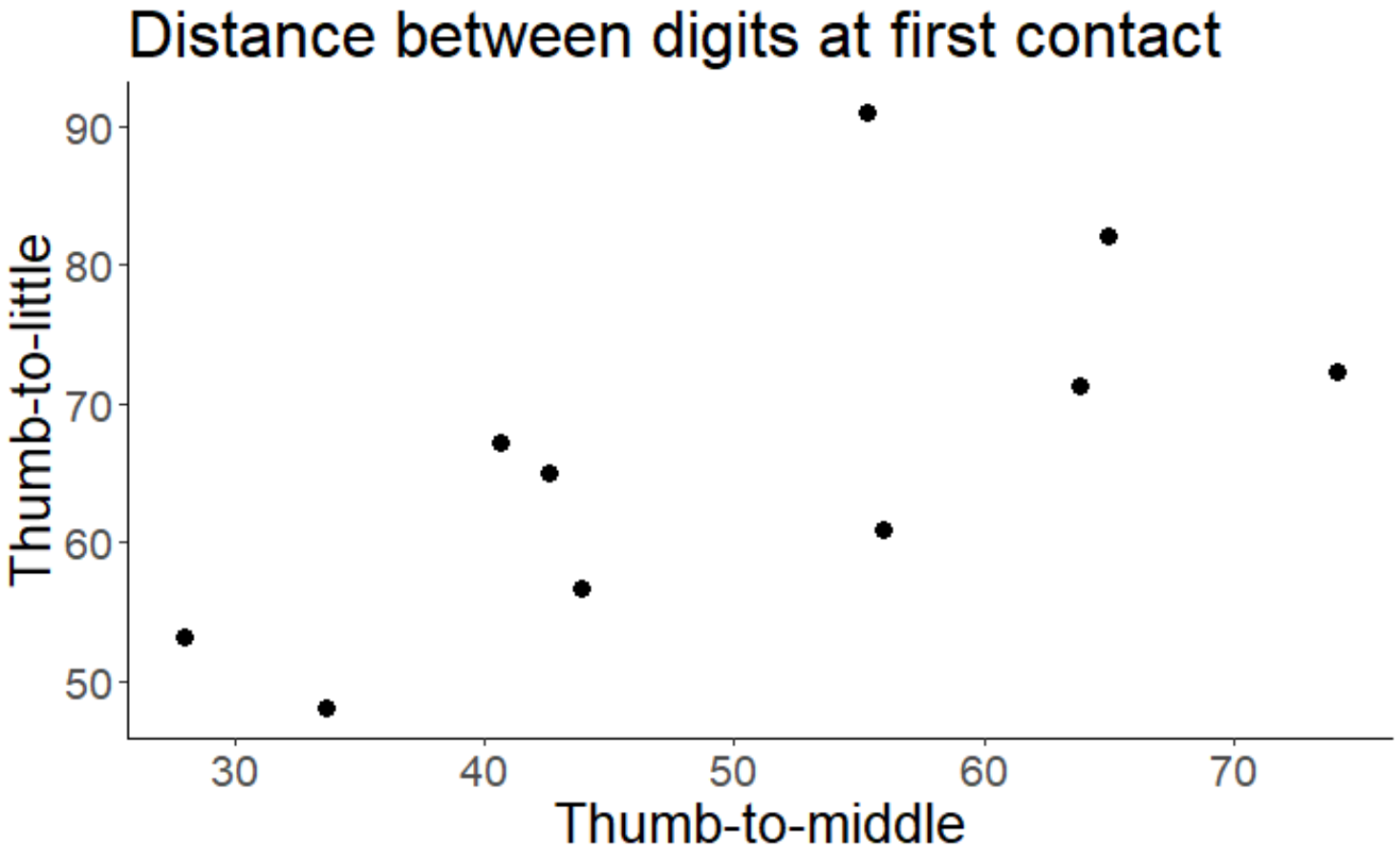
Steps:

1. Define frame of start, first contact, and end
2. Define length of card
3. Track the hand
4. Track the skeleton

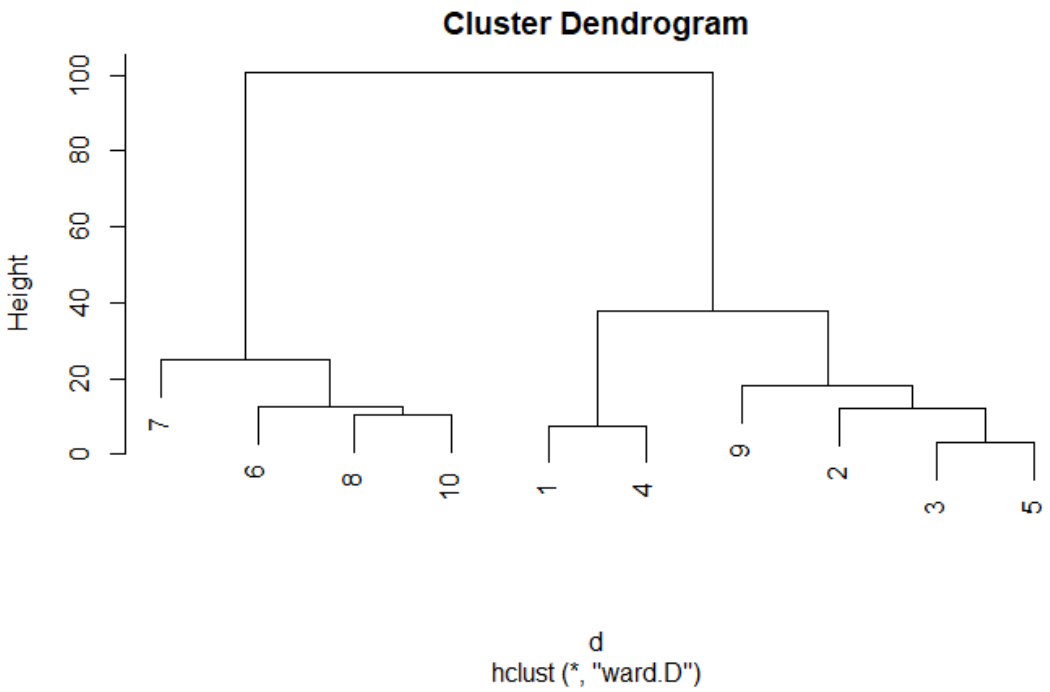
Extracted kinematic variables

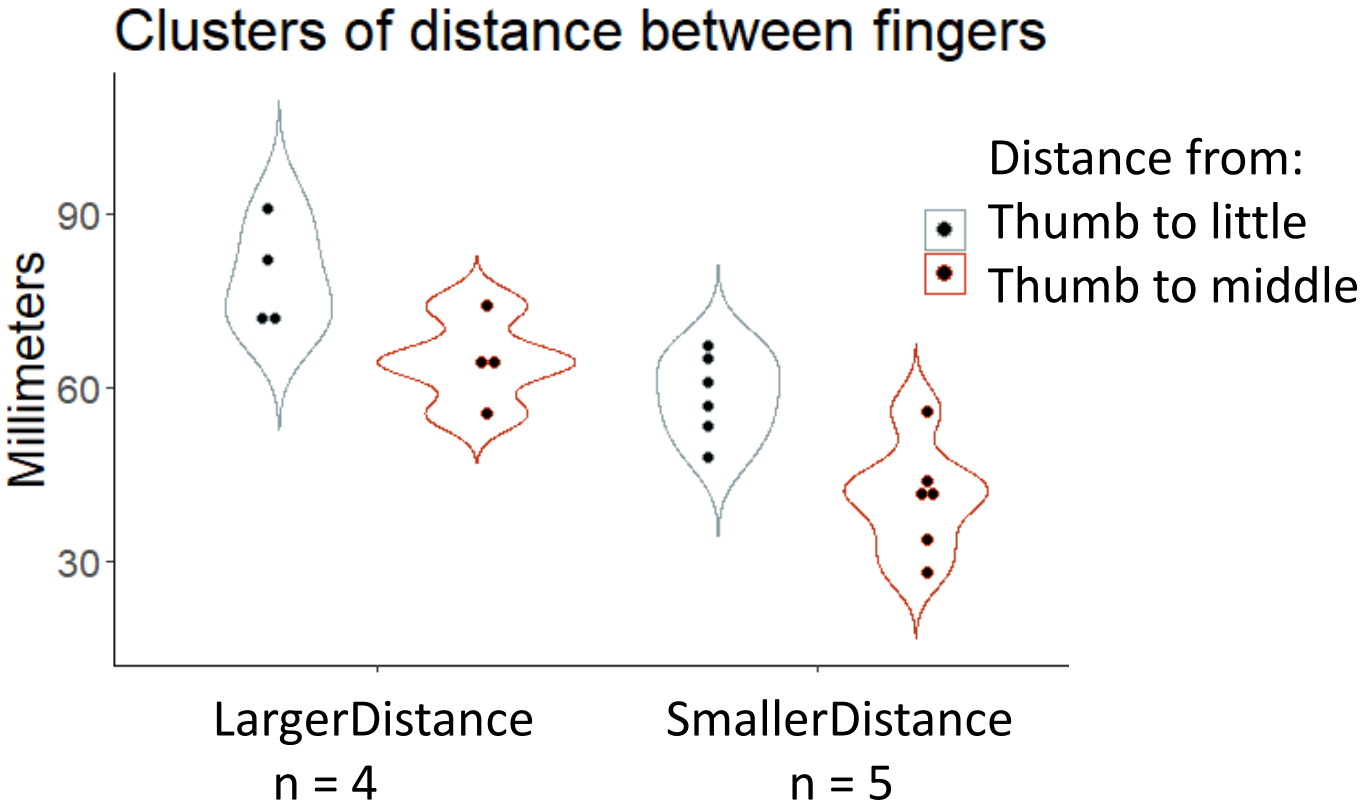
- Distance from thumb-to-middle (TM)
- Distance from thumb-to-little (TL)

Kinematic profile of grasp maturity at 9 months



Kinematic profile of grasp maturity at 9 months





Finger stimulation and EEG recording in the lab

Shen et al., 2018

Finger stimulation protocol

Experimental (oddball) paradigm

- 80% of stimuli to middle
- 10% of stimuli to thumb
- 10% of stimuli to little

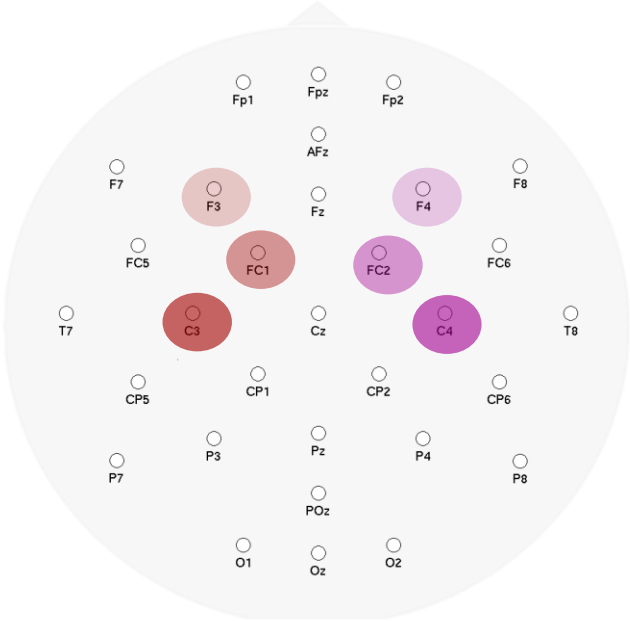
Control paradigm

- 1 minute to thumb only
- 1 minute to little only

EEG processing

- Channels of interest:

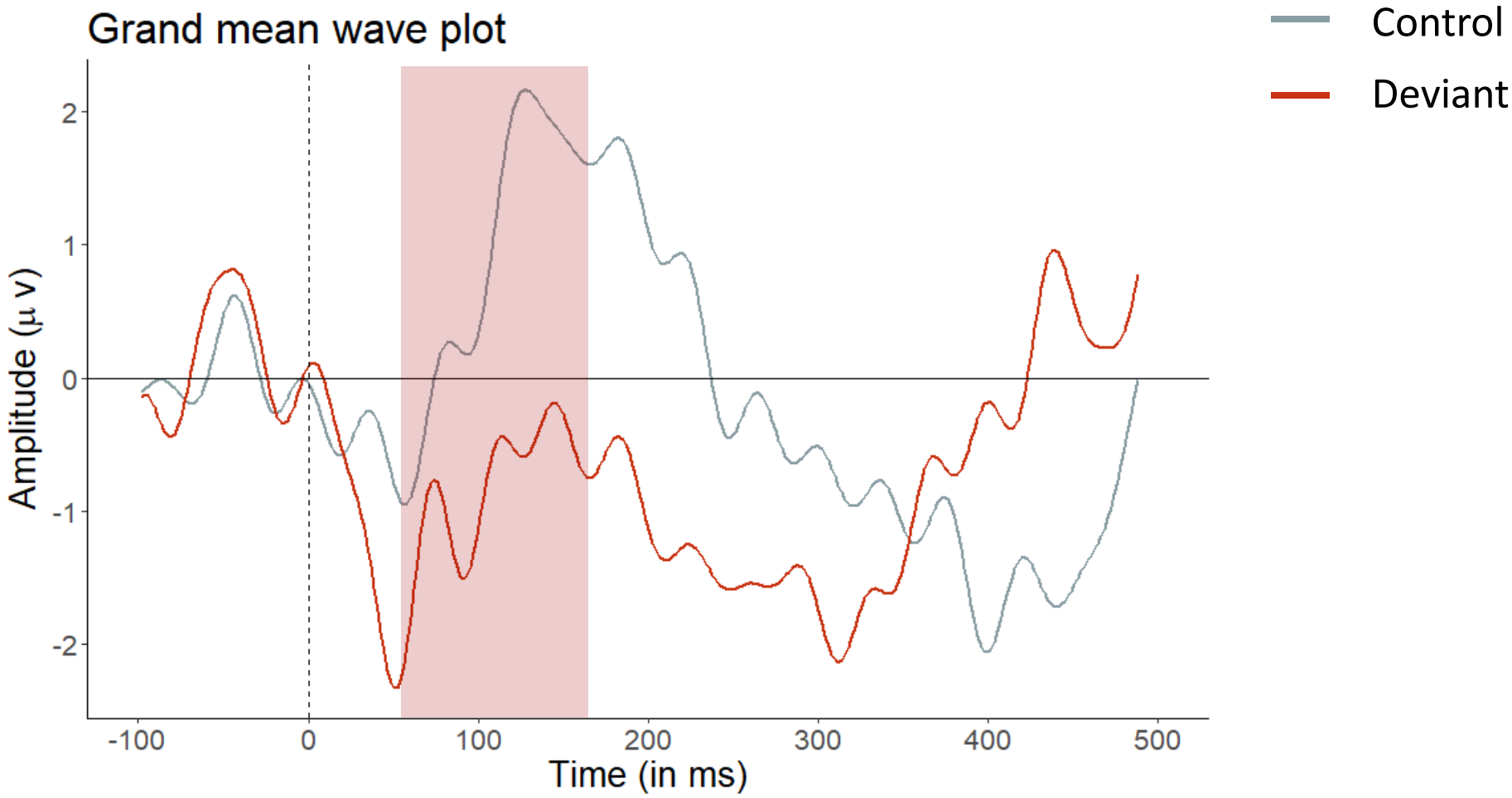
Based on Shen et al., 2020



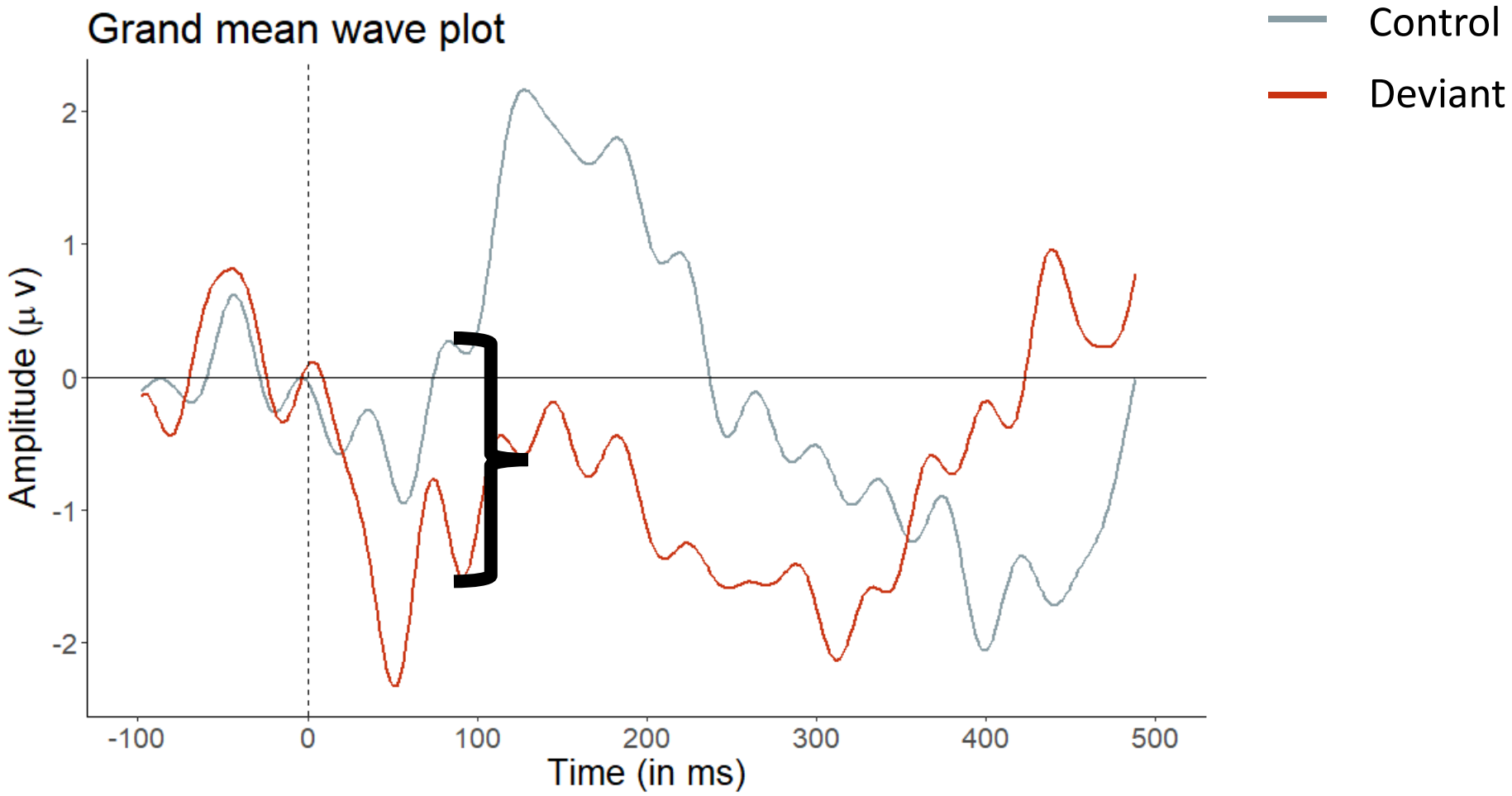
- Epochs range from -100 ms before stimulus presentation to 500 ms after
- Minimum of 40 good epochs per condition

sMMN

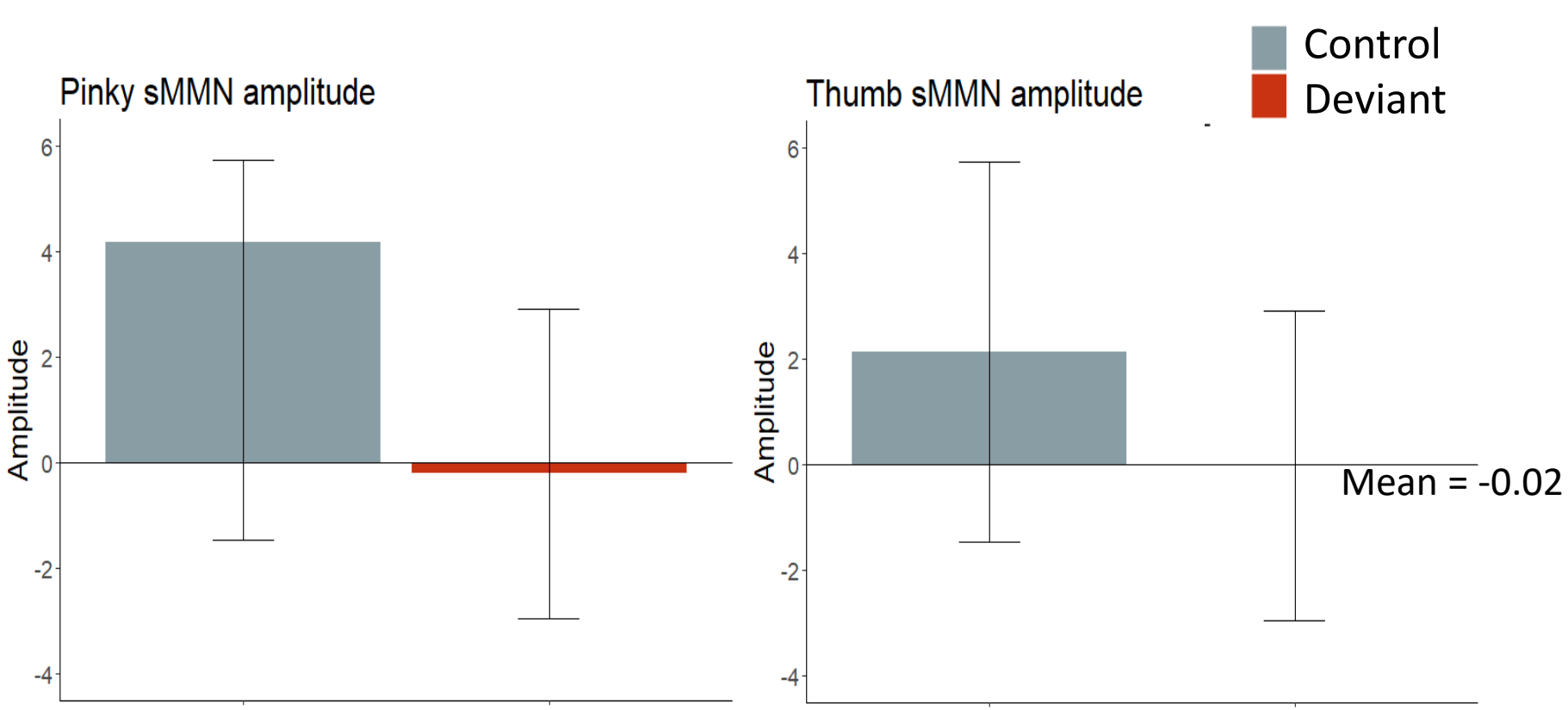
FC1

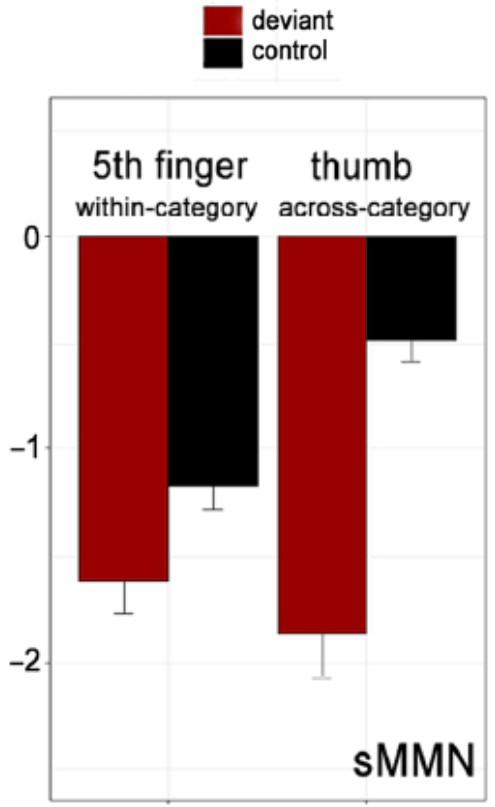

Grand mean wave plot
Amplitude (μ v)
2
1
0
-1
-2
-100
0
100
200
300
400
500
Time (in ms)
Control
Deviant

sMMN


Grand mean wave plot
Amplitude (μ v)
2
1
0
-1
-2
-100
0
100
200
300
400
500
Time (in ms)
Control
Deviant

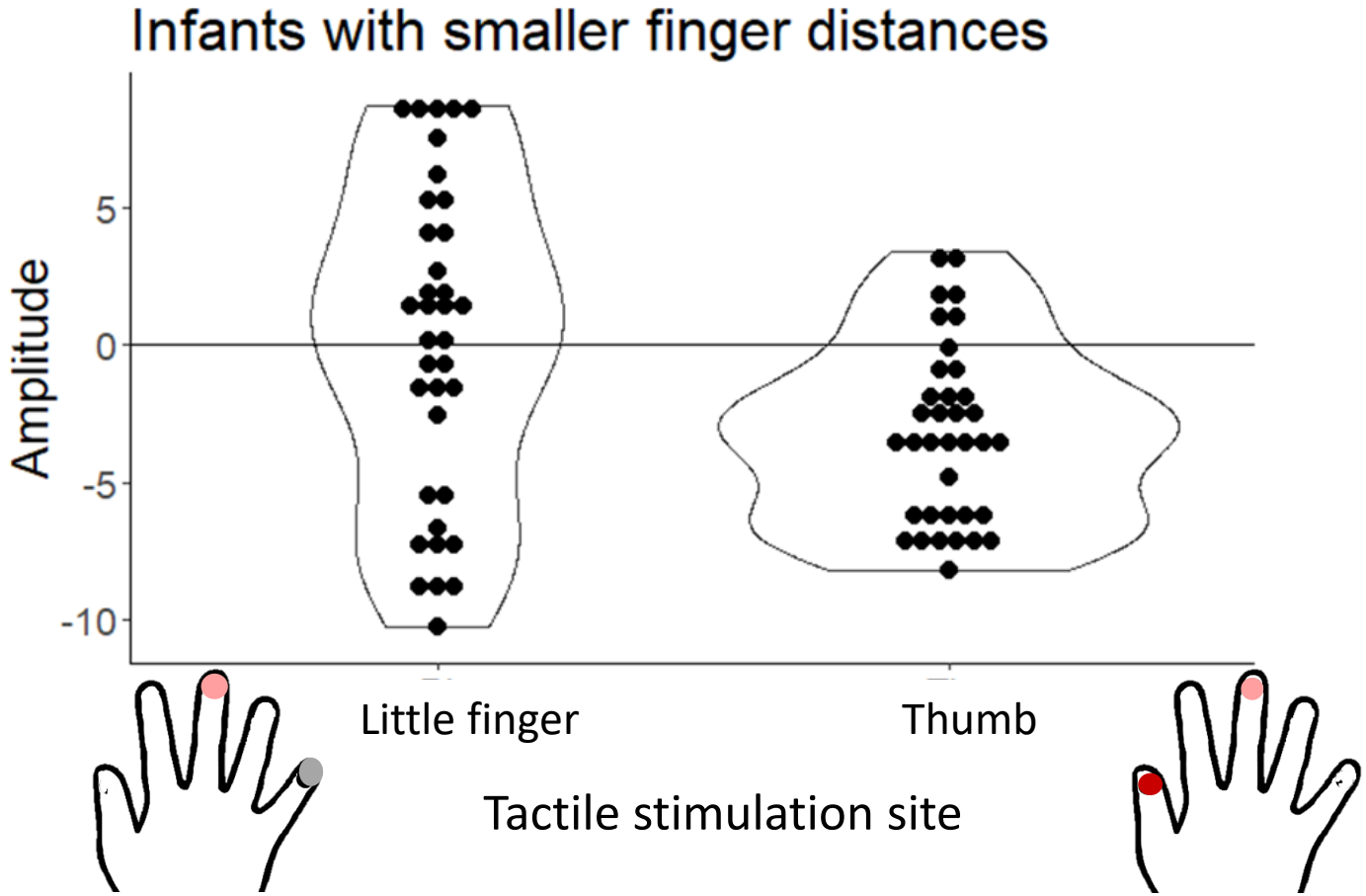
Amplitude of sMMN across finger comparisons



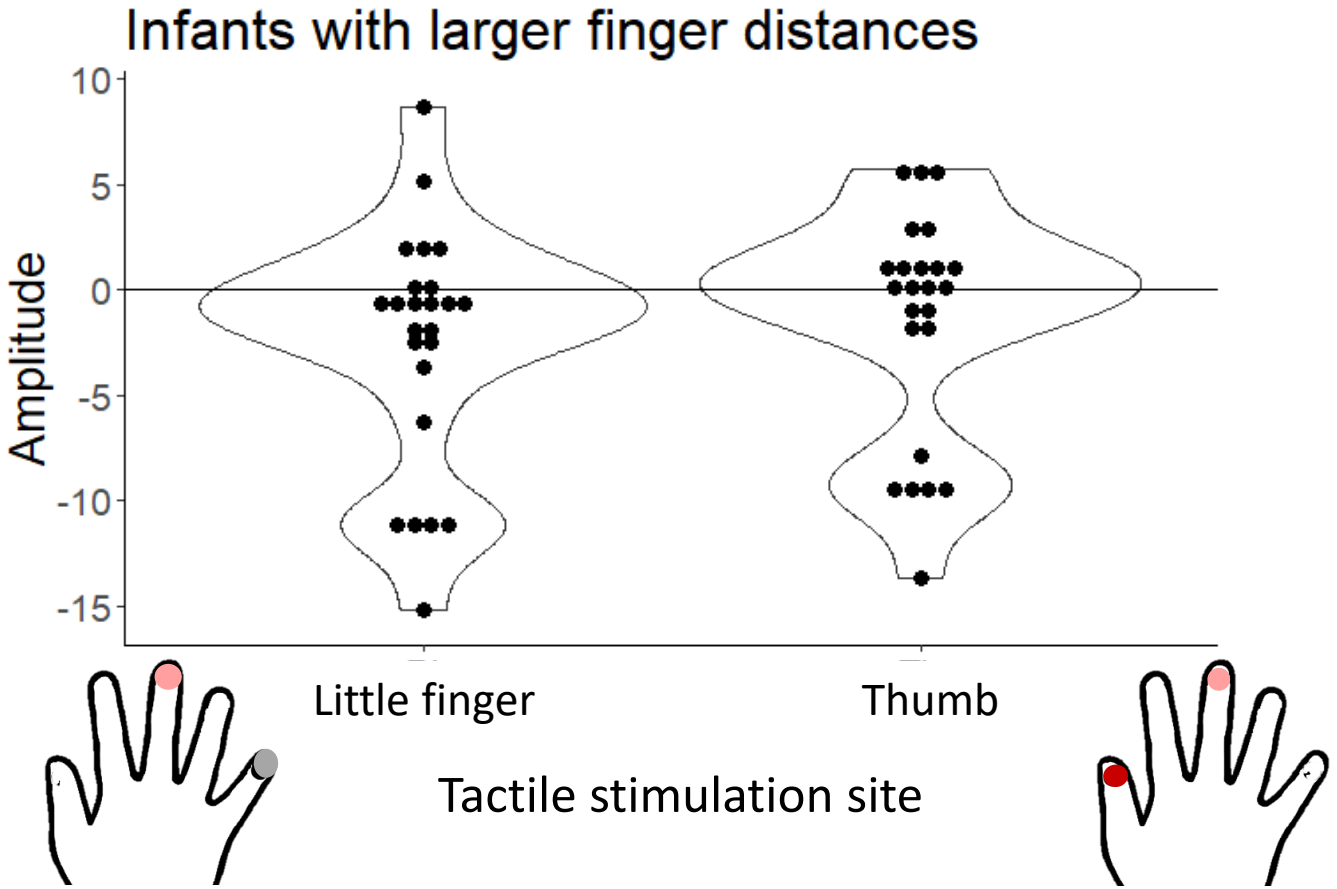


Shen et al., 2018

Smaller finger distance is associated with more distinct thumb representation



Larger finger distance is associated with more distinct representation of the little finger?



Relation between brain and behavior

- Takeaways:
  - Kinematic profiles
    - Smaller finger distance = greater coupling across all fingers
    - Greater finger distance = more independence
  - Neural representations (sMMN)
    - In both groups, thumb is emerging as differentiated
    - In those with greater distances, little finger also becoming distinct

Future (and in-progress) research

- Development of reaching-to-grasp from 6 to 14 months
- Additional behavioral measures at lab visit

Acknowledgements

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