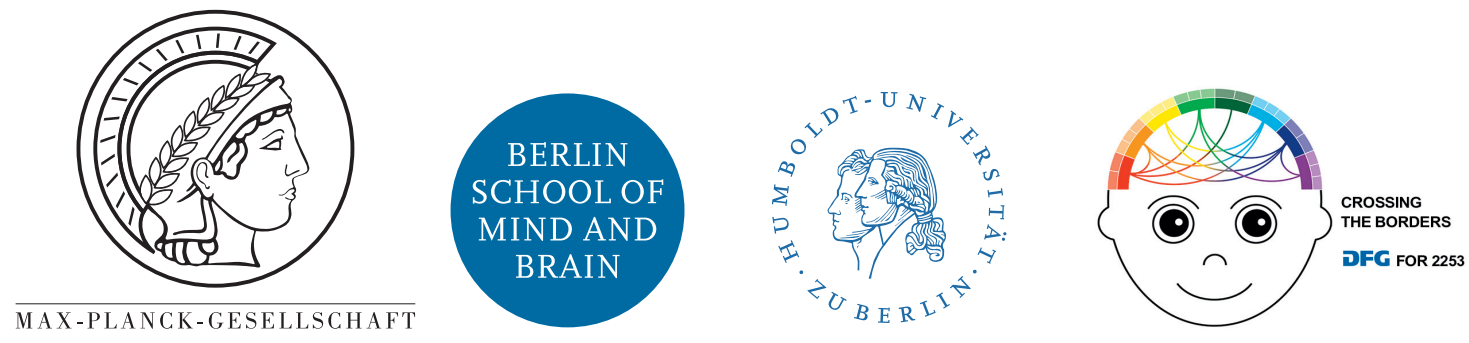


The sensitive period for associative learning of non-adjacent dependencies: ERP evidence from 24-month-olds

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Introduction

- Children are able to learn the grammatical rules of their native language with remarkable ease during their first years of life. Infants as young as 4 months are able to learn non-adjacent dependencies (NAD) associatively by merely listening to correct examples as evidenced by event-related potentials (ERPs) [1].
- While infants show associative learning mechanisms, adults exhibit more controlled learning mechanisms and are only able to learn NADs under active task conditions [1,2].

Research Questions for the ERP experiments (Figure 1)

Developmental trajectory of NAD learning

- At which developmental time point does the change from *associative learning* observed in infants to *more controlled learning* of NADs reported for adults occur?

Domain-generality/domain-specificity of NAD learning

- Does NAD learning in the non-linguistic domain have the same developmental trajectory as in the linguistic domain?

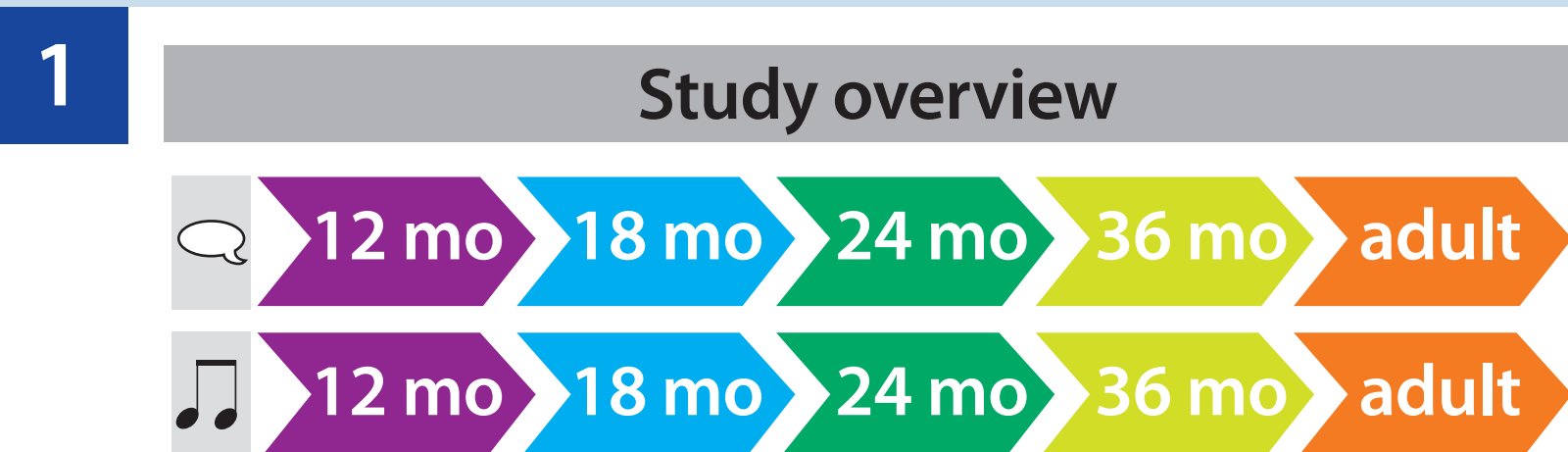


Figure 1: Overview of experiments for the linguistic (🗨️) and the non-linguistic (🎵) domain

Methods

Participants

- 34 24-month-olds (16 female, mean age: 24.90 months, SD 0.90)
- 35 24-month-olds (16 female, mean age: 24.78, SD 0.82)

Stimuli

- Italian sentences with an NAD between auxiliary and verb suffix (Figure 2A)
- Tone sequences with one tone replacing each syllable of the linguistic stimuli, preserving NADs (Figure 3A)

Procedure

- Passive-listening learning-test paradigm* (Figure 4): Alternating learning and test phases. Learning phases contain only correct items with NADs (Figure 2A, 3A), while test phases contain 50% correct and 50% incorrect items with NAD violations (Figure 2B, 3B).
- SETK-2 [3], eyetracking (behavioral tests of cognitive and language development)

EEG recording and analysis

- Recording: Fz, F3/4, F7/8, Cz, C3/4 CP5/6, T7/8, Pz, P3/4, P7/8, O1/2; online reference: Cz
- Preprocessing: offline reference: linked mastoids, band-pass filter: 0.3-30 Hz, trial length: -400 ms to 1500 ms relative to suffix onset, semi-automatic artifact rejection and artifact correction (ICA)
- Analysis: cluster-based permutation test [4]

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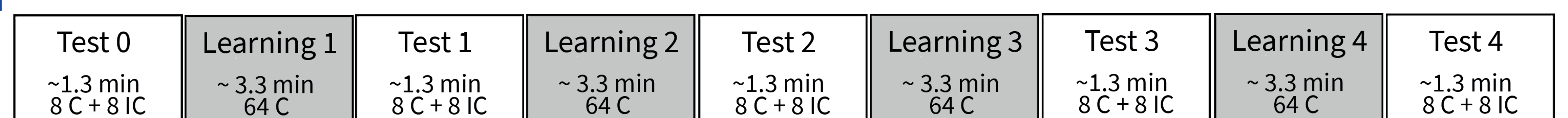


Figure 4: Participants listened to alternating learning and test phases. C = correct, IC = incorrect.

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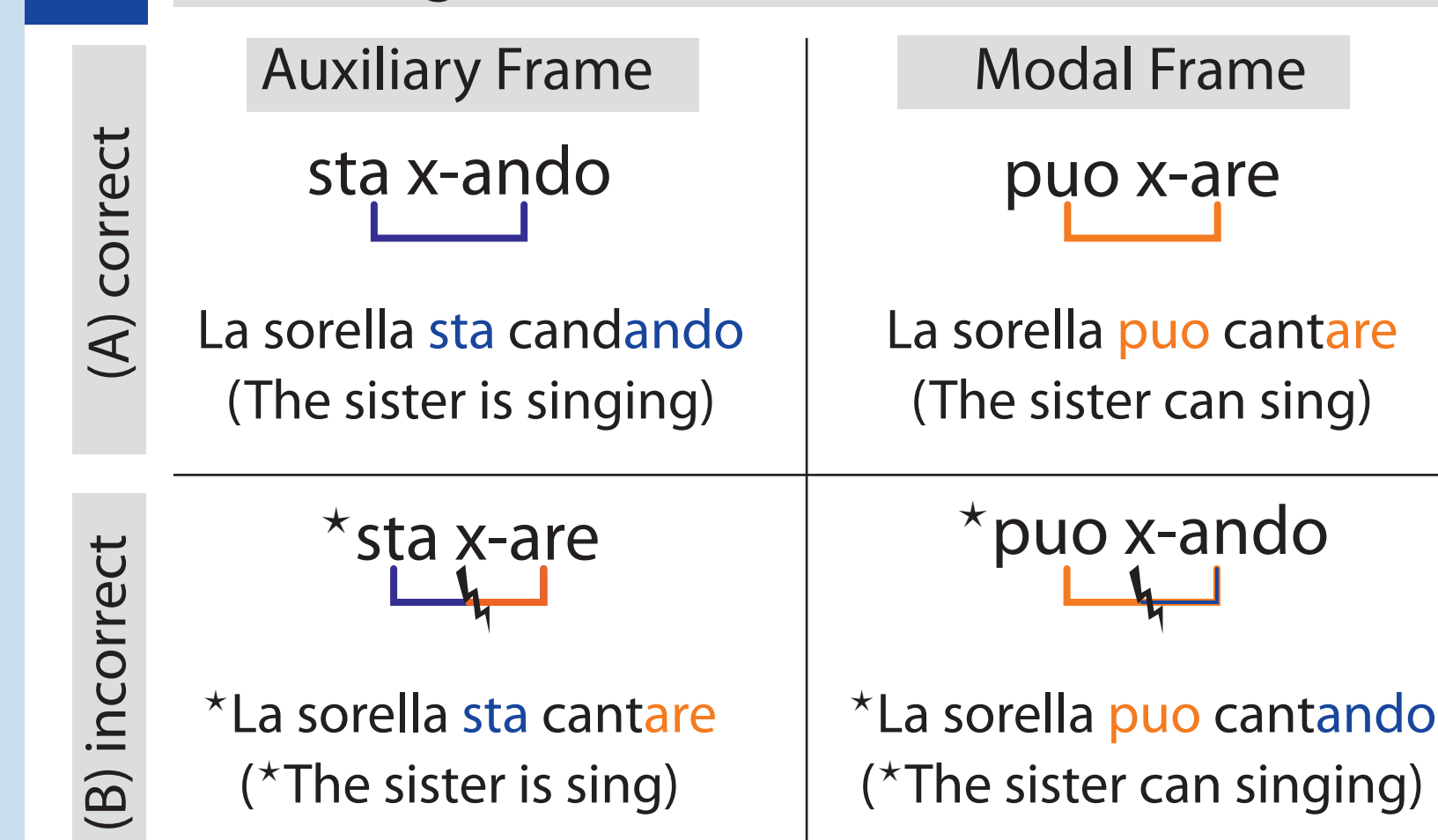


Figure 2: Example of linguistic stimuli. ⚡ indicates NAD violations

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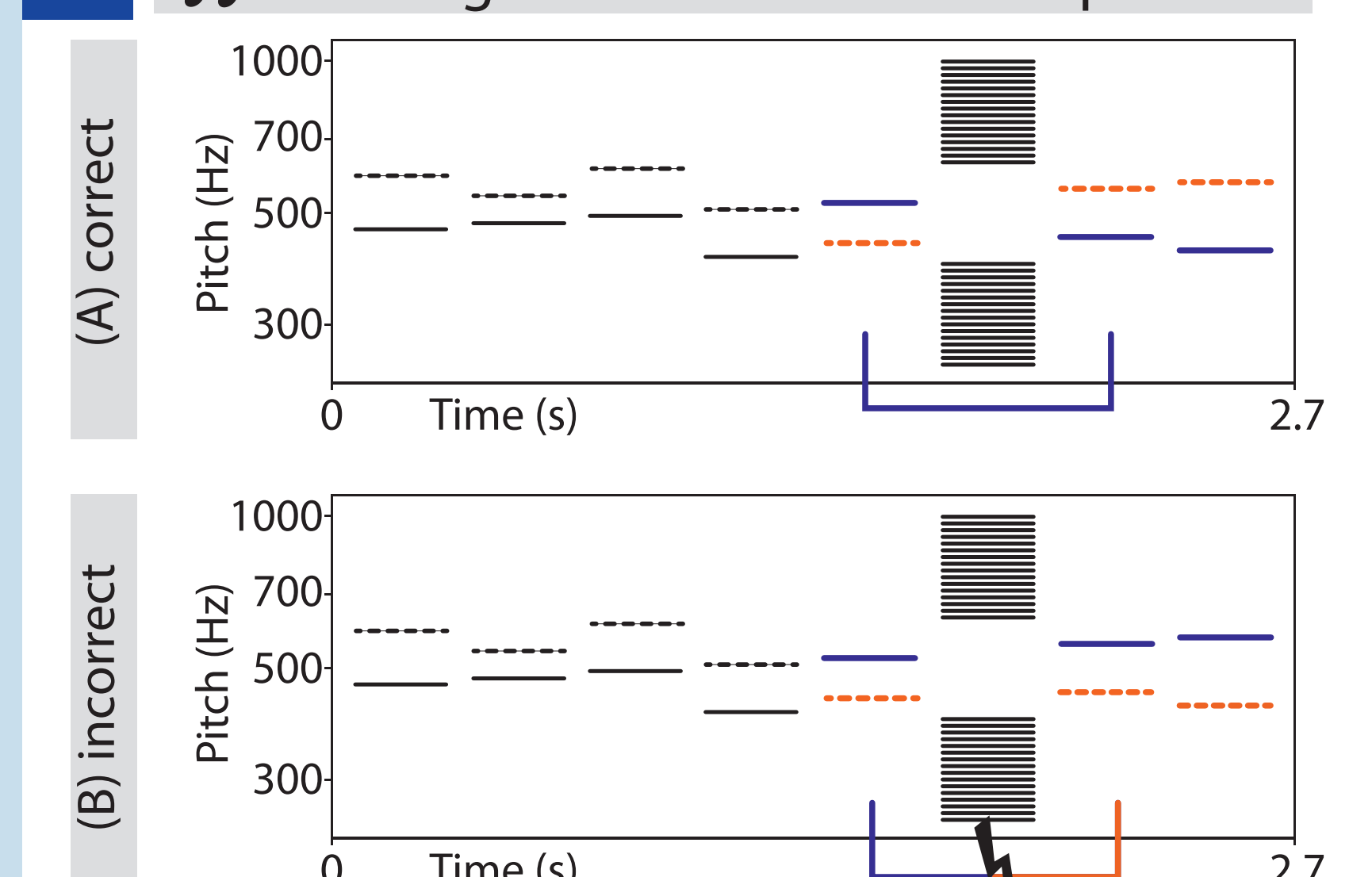
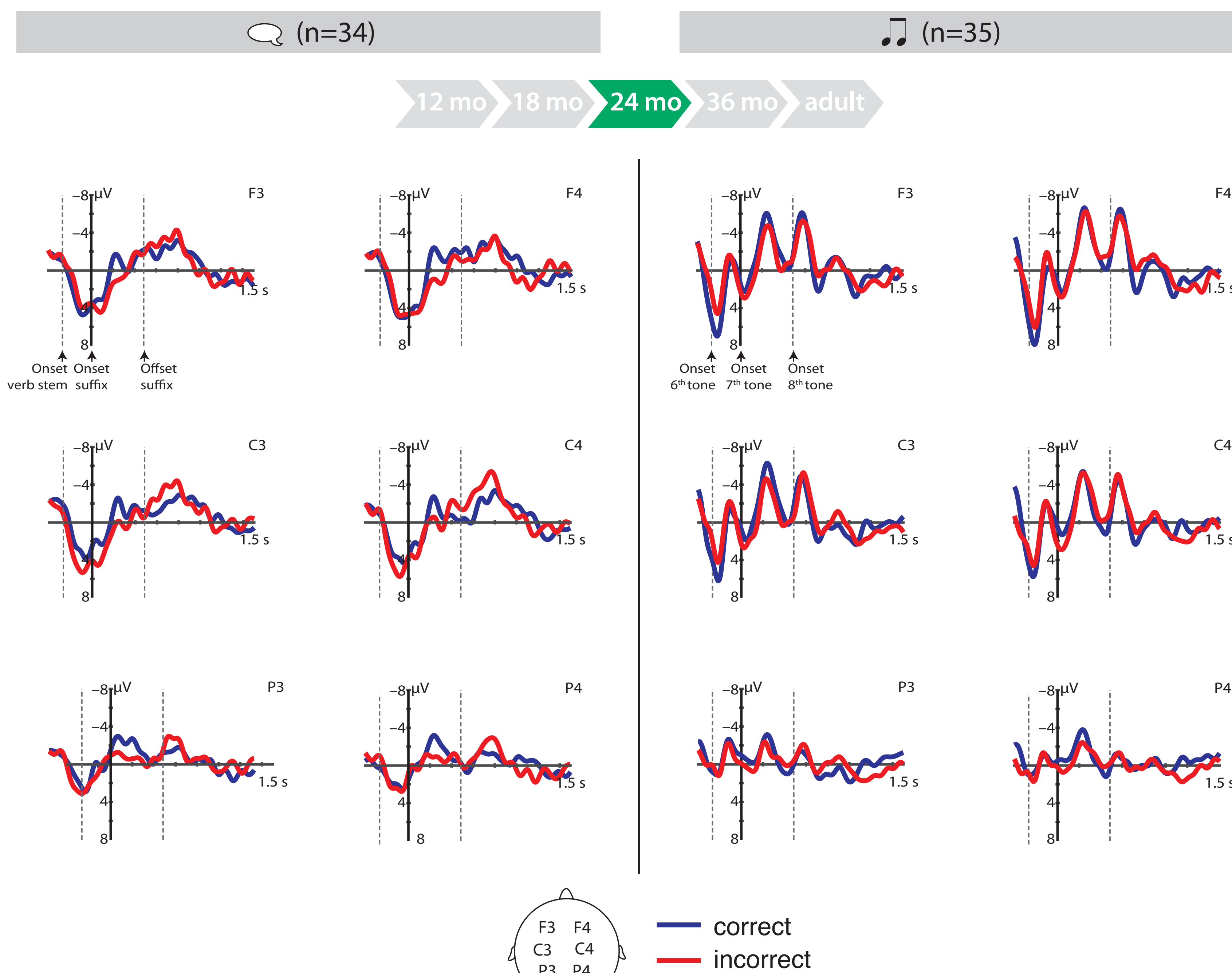


Figure 3: Example of non-linguistic stimuli. ⚡ indicates NAD violations

Results

5 ERPs to correct (NAD) and incorrect stimuli (NAD violations) across all test phases



➔ No difference in response to correct and incorrect stimuli in the linguistic or non-linguistic domain

Additional analyses (not shown) did not reveal significant differences:

- Median split based on SETK-2 scores
- Difference of first two vs. second two test phases

Discussion and next steps

Developmental trajectory of NAD learning

- Our data suggest that 24-month-old children are unable to detect violations of NADs in our linguistic and non-linguistic stimuli under passive listening conditions.
- 24-month-old children thus show the pattern observed in adults, but not 4-month-old children [1,2].
- The developmental change from associative to more controlled learning seems to take place before 24 months of age.**

Domain-generality/domain-specificity of NAD learning

- Our data show that 24-month-olds did not detect violations of NAD in either domain.
- Thus, there is no domain-specificity of NAD learning at the age of 24 months.**

Next steps:

- Investigating NAD learning in other age groups:* Finishing data collection from 36-month-olds, data collection from 12- and 18-month-olds
- Relating ERP data to measures of cognitive and language development*
- Examining learning mechanisms:* Analysis of the ERPs of learning phases

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