Using event related potentials to understand the effect of feedback timing on learning systems

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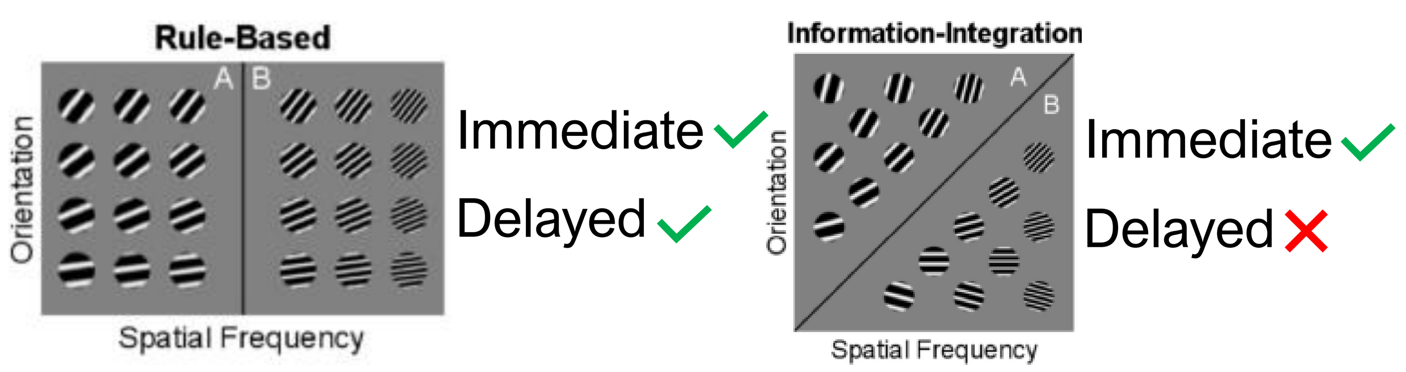
Introduction

Manipulating feedback timing can influence learning outcomes depending on the learning paradigm (Smith et al., 2014). This suggests that manipulating feedback timing may engage different feedback processing systems.



Images: Paul and Ashby, 2013

How can this be measured?
Two event related potentials (ERPs), the feedback related negativity (FRN) and the N170.

FRN	N170
A negativity with a latency of 200-300ms following feedback (Miltner et al., 1997).	A negativity with a latency of 140-200ms following an eliciting event (Bentin et al., 1996).
Larger for immediate than delayed feedback (Peterburs et al., 2016).	Larger for delayed than immediate feedback (Arbel et al., 2017).
Associated with dopaminergic reward processing in the dorsal anterior cingulate cortex (Holroyd and Coles, 2002).	Hypothesized to reflect information binding in the medial temporal lobe (Arbel et al., 2017, Kim and Arbel, 2019).

Purpose

The current study aims to explore the electrophysiological response to immediate and delayed feedback during an A/B prototype distortion task in younger and older adults.

Participants

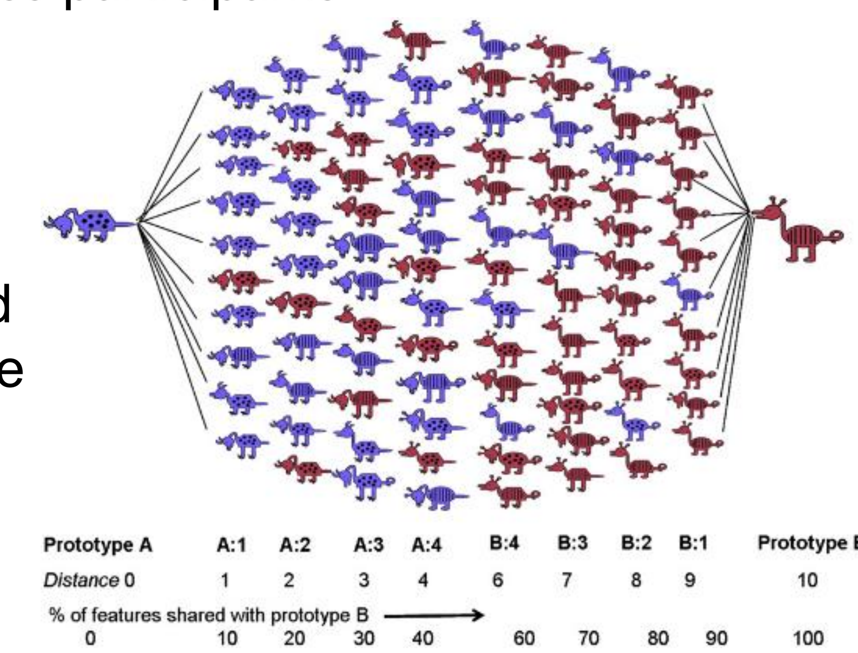
Group	Total
Young Adult Age (M, SD)	18 (24.4,2.5)
Older Adult Age(M, SD)	14 (60.9,8.9)

Inclusionary criteria: WFL cognitive function, no history of speech, language, or neurological disorder.

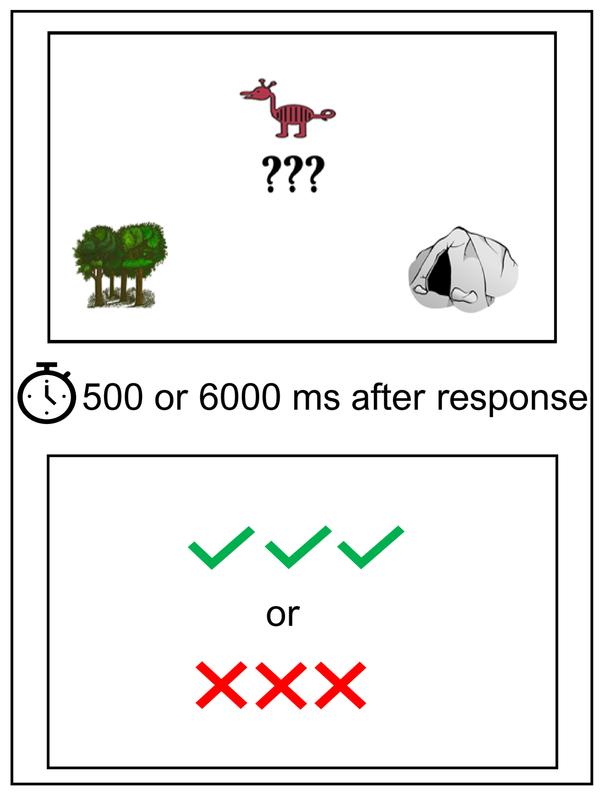
Method

Procedure:
- Each participant completed two A/B prototype distortion tasks: one with immediate feedback (500 ms) and one with delayed feedback (6000 ms)
- Tasks were counter-balanced across participants

Task Stimuli: (Zeithemova et al., 2008)
- A and B protypes varied along 10 binary dimensions (e.g., blue vs. red)
- Category membership was defined as sharing 60-90% of features with the prototype



Training:
- 80 trials consisting of 20 unique animals (10 'A', 10 'B') presented 4 times each
- Feedback presented

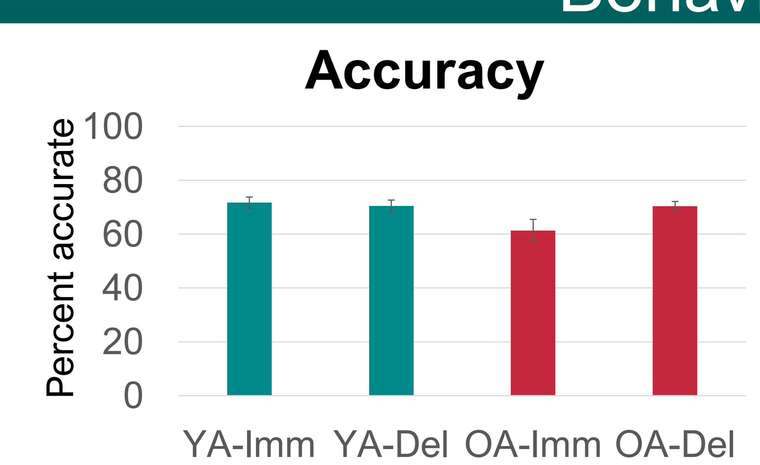


Testing:
- 28 unique animals (13 'A', 13 'B', 2 ambiguous), 6 trained and 22 untrained
- No feedback presented

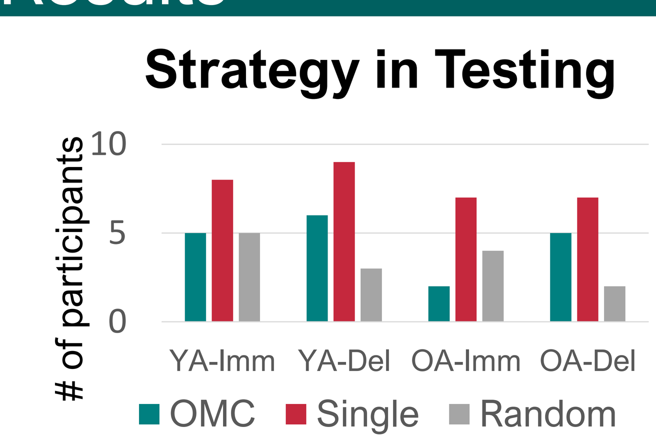
EEG Recording and Analysis Parameters:
An Electrical Geodesics Inc. system and a 32-channel HydroCel Geodesic sensor net was utilized. EEG was sampled at a rate of 1000 Hz and filtered using a 0.1-30 Hz bandpass. Data was segmented into epochs from 200 ms before feedback to 800 ms after feedback.

ICA was performed to remove eye-blinks and noise. Temporal PCA was performed to separate ERPs of interest from components that overlapped in time. Individual factor scores were derived for each participant in each condition and for each electrode of interest.

Behavioral Results



No significant difference in accuracy across groups (F (1,29) = 1.9, p = .17) or feedback timing conditions (F (1,29) = 2.1, p = .16). No significant interactions.

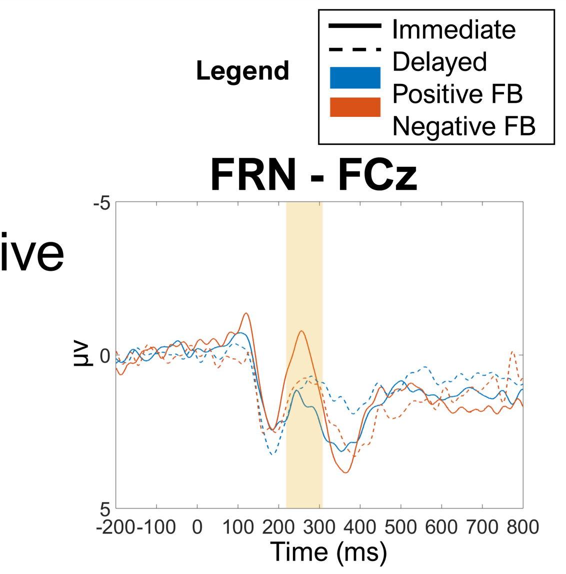


No association between strategy use and group in the immediate (χ^2 = .675, p = .71) or delayed (χ^2 = .042, p = .98) conditions.

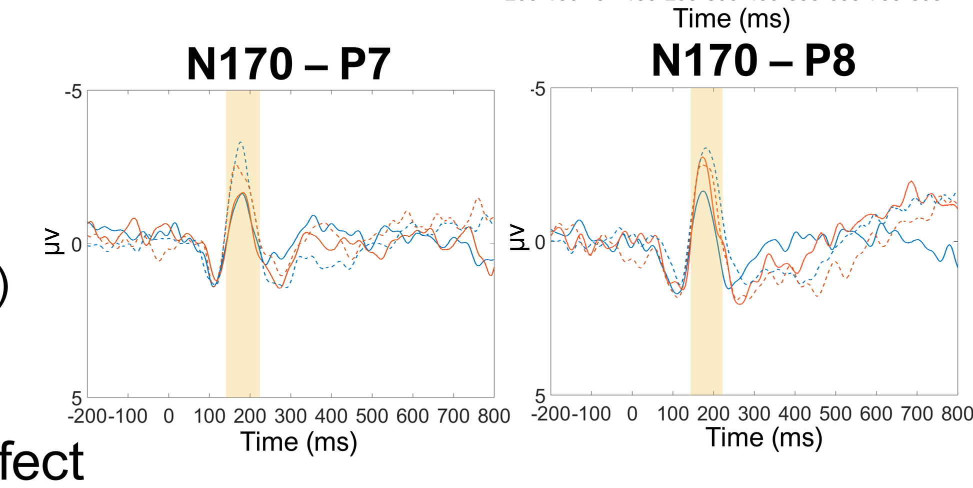
Note: Due to a technical error, data was lost for 1 OA.

ERP Results

Young Adults

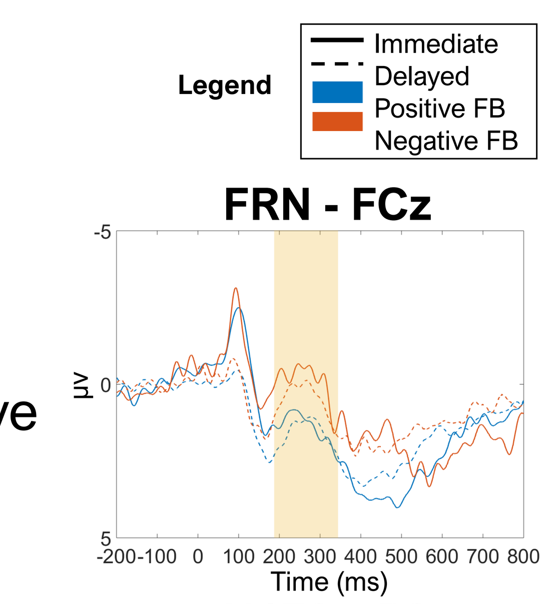


FRN
Timing: No main effect
Valence: Larger amplitude for negative vs. positive feedback (F (1,16) = 6.5, p = .02)
Valence x Timing Interaction: Difference in amplitude across valence conditions with immediate but not delayed feedback (F (1,16) = 8.5, p = .01)

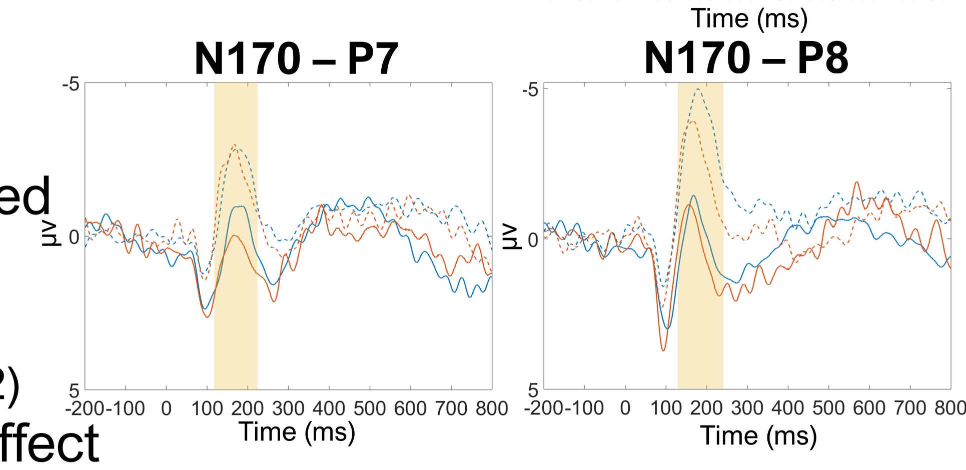


N170
Timing: No main effect
Valence: No main effect
Electrode: No main effect

Older Adults



FRN
Timing: No main effect
Valence: Larger amplitude for negative vs. positive feedback (F (1,9) = 8.3, p = .02)



N170
Timing: Larger amplitude for delayed vs. immediate feedback (F (1,9) = 19.5, p = .002)
Valence: No main effect
Electrode: No main effect

Note: Due to a technical error, data was lost for 1 YA-Delayed, 1 OA and 1 OA-Delayed. One OA was excluded due to noise.

Conclusions

While behavioral performance was equivalent across groups and conditions, electrophysiological response to feedback differed. The N170 in older adults was found to be sensitive to manipulations of feedback timing.

Dopaminergic reward processing and declarative learning in older adults warrants further exploration.

References: See Reference Section