Feedback Processing and Working Memory in Children with Typical and Atypical Language Development

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INTRODUCTION

Children with a developmental language disorder (DLD) receive intervention that relies heavily on feedback-based learning, but it is unclear to what extent limitations in working memory and feedback processing affect their ability to learn from feedback. Feedback-based learning (FBL), otherwise known as errorful learning, is accomplished through trial and error guided by performance feedback. It requires an individual to process both positive and negative feedback to facilitate learning, while it also depends on one's ability to hold and process information in real time (i.e., Working Memory). Alternatively, in a typical errorless learning paradigm, learners are passively exposed to correct information and learning does not involve the processing of feedback. This research aimed to evaluate the relationship between feedback processing and working memory in children with typical language development (TD) and children with DLD performing a declarative learning task while electrophysiological data were recorded.

METHODS

- **Participants**: 27 children (aged 8-12), 14 with typical language development (TD) (Mean age= 10.7; 6 females, 8 males) and 13 with developmental language disorder (DLD) (Mean age= 10.6; 5 females, 8 males). Inclusionary criteria for DLD were based on a reported delay in language development and below average scores on a language test (CELF-5, TILLS). Exclusionary criteria for all participants included: below-average non-verbal IQ scores and any diagnosis of a neurological disorder including but not limited to ADD, ADHD, & Autism.
- **Task**: Participants completed two declarative learning tasks, one with feedback (errorful) and one without feedback (errorless).
- **With Feedback (errorful) Task**: Participants were presented with two images of novel objects and heard a name (nonword). On a trial-by-trial basis they were asked to select the object associated with the name. Each of their selections were followed by feedback indicating the correctness of their choice.

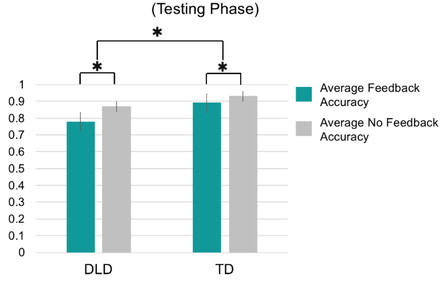
- **No Feedback (errorless) Task:** Participants were presented with two images of novel objects and heard a name (nonword). The image of the novel object associated with the name (i.e., the correct answer) was marked with a green border. Participants pressed a button to proceed to the next trial, and no feedback was provided.

- **Testing Phase:** Each of the two declarative learning tasks had a testing phase with an identical structure in which two images and a name were presented. The participant was asked to select the novel object associated with the name. No feedback was provided.

- **Follow-Up Test**: Participants completed a follow-up test one week after testing, which was identical to the testing phase and used the same stimuli in order to test participants' retention of the learned associations.
- **Working Memory (WM) Standardized Score**: The WM score was calculated from the CELF-4 assessment, combining the total correct responses in the number repetition and familiar sequences categories.
- **EEG Data Collection and Analysis:** EEG data were recorded from 32 electrodes using a 32-channel GES 400 System by Electrical Geodesics Inc. (EGI). EEG data were time-locked to the onset of feedback presentation. Two event related potentials (ERP's) associated with feedback were evaluated, the feedback related negativity (FRN) and the fronto-central positivity (FCP). Temporal Principal Component Analysis was conducted.

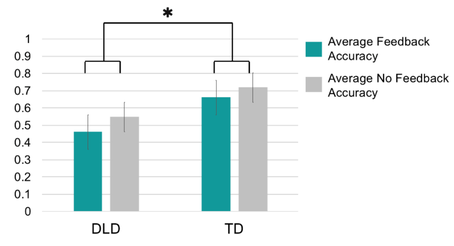
RESULTS

Accuracy in the Declarative Task with and without Feedback (Testing Phase)

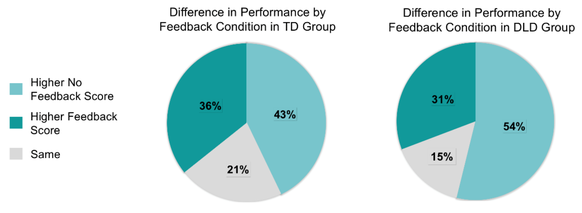


- TD group performed better than DLD group in Testing Phase (p=.044)
- Both TD and DLD groups performed better in ***no feedback*** (errorless) condition than in the ***with feedback*** (errorful) condition (p=.049).

Accuracy in the Declarative Task with and without Feedback (Follow-Up Test)

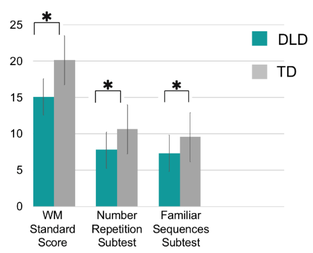


- TD group performed better than DLD group on Follow-up Test regardless of feedback condition (p=.009).

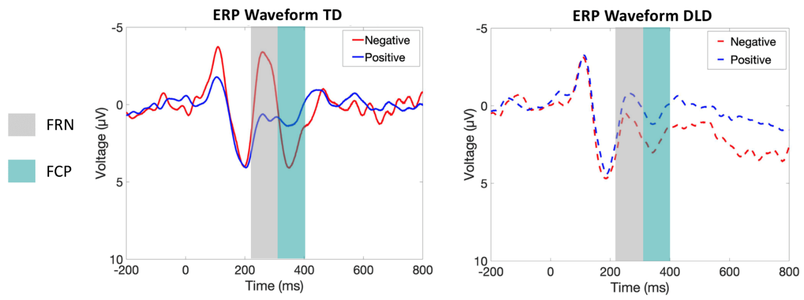


- More children with DLD performed better in the ***no feedback*** (errorless) condition than did TD, suggesting that DLD group may benefit more from errorless learning.

Averages of Working Memory Scores



- The DLD group had significantly lower WM standard scores (p=.004), Number Repetition subtest scores (p=.006) and Familiar Sequences subtest scores (p=.01) than the TD group



- While differences in FRN amplitude between positive and negative feedback were observed in the TD group (p=.005), they were absent in the DLD group (p=.174). Negative feedback elicited a larger (more negative) FRN amplitude than positive feedback in the TD group.
- Differences in FCP amplitude between positive and negative feedback were found regardless of group (p=.014). Negative feedback elicited a larger (more positive) FCP amplitude than positive feedback in both TD and DLD groups.
- A significant positive correlation was found between WM and FRN to positive feedback across groups, suggesting that a greater WM score was related to a smaller amplitude of the FRN to positive feedback.

CONCLUSION

Declarative learning in children with DLD was found inferior to that of children with TD regardless of the learning condition (with and without feedback), with errorless learning being beneficial for both groups.

ERP data suggest that feedback processing among children with DLD as measured by the FRN is different from that observed in children with TD and may reflect an inefficient processing of positive and negative feedback during learning.

Greater working memory scores were associated with a smaller amplitude of the FRN to positive feedback. These results are in line with previous findings that smaller FRN to positive feedback is associated with faster learning in young children (Arbel, in press), and may imply that better WM leads to faster learning and to a faster reduction in FRN to positive feedback in children.

Arbel, Y., & Donchin, E. (2014). Error and feedback processing by children with Specific Language Impairment—an ERP study. *Biological Psychology, 99,* 83-91.

This material is based upon work supported by the NIDCD under grant #R15 DC016438-01A1 awarded to Arbel, Y.