

Proof-of-concept of a tablet-based rhythmic game for children with autism: Effects on sensorimotor and executive functioning

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INTRODUCTION

“Serious games” are games empirically validated for strengthening/restoring physical and cognitive functions^{1,2}.

Autism includes sensory and movement atypicalities that co-occur with auditory-motor timing and cerebellar deficits and likely contribute to cognitive, speech and social impairments^{3,4,5,6}.

Rhythm has a special role in providing a predictable temporal structure that facilitates movement and attention (sensorimotor coordination and attention modulation)^{7,8,9,10,11}.

Rhythmic training could train sensorimotor and executive functioning via overlapping neural resources^{1,12}.

This study focuses on RhythmWorkers (RW), a tablet-based serious game that trains rhythmic skills. The game has proven successful in training rhythmic skills in adults with Parkinson’s disease^{11,13,14}. In our laboratory we recently adapted the musical stimuli, interface, enjoyment and ease of play to suit training in children.

Research objectives:

This pilot study investigated if children on the autism spectrum:

Aim 1: were able to perform a tablet-based rhythmic training using RW and complied to training targets in comparable way to a control game.

Aim 2: improved in other forms of sensorimotor synchronization after training on RW compared to a control game and as a function of training duration and symptom severity.

Exploratory Aim: improved in executive functioning (EF) after training on RW compared to a control game and as a function of training duration and symptom severity.

METHODS

Participants:

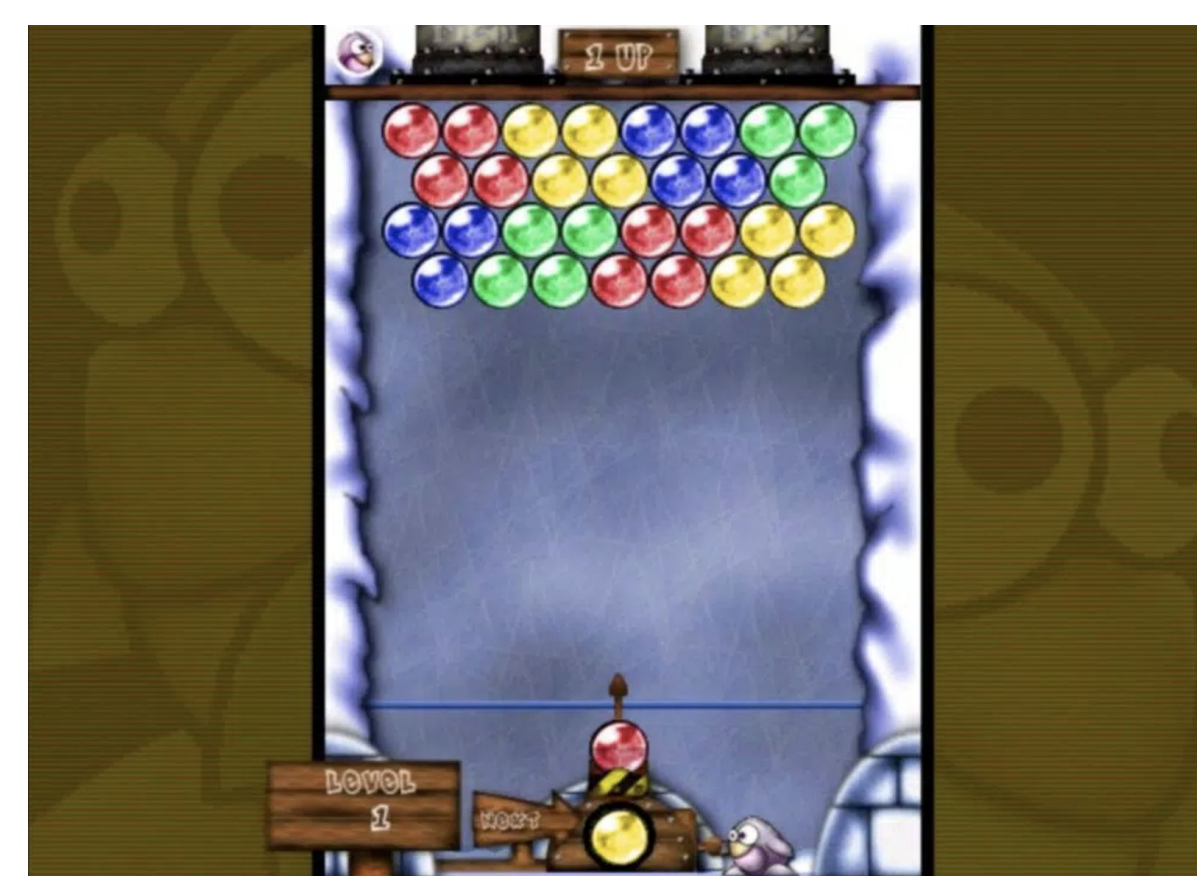
31 participants with an autism diagnosis, aged 7-13 years, were randomly assigned to play either RW or the control game (Frozen Bubble). Five participants did not complete the study. The analysis sample (N = 26) was group-matched on age, social symptom severity, non-verbal IQ, and in-game motor demands ($p > .3$).

Participants played the game for 2 weeks, ~150 min/week (1h max/day), for a total of ~300 minutes, representing half the dose planned for a future randomized control trial (RCT).

Rhythm Workers (RW)



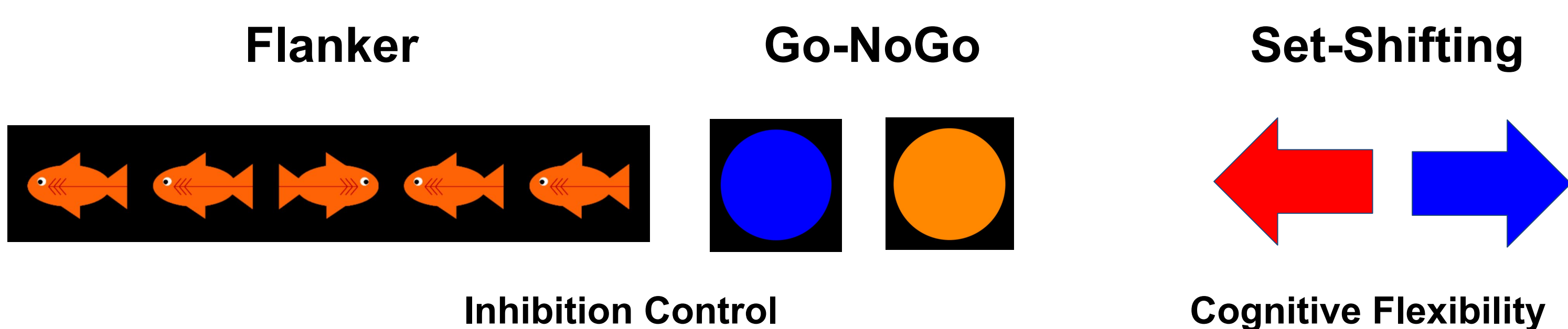
Frozen Bubble (FB)



Measures:

Assessment of rhythmic functioning: selected tests from the Battery for the Assessment of Auditory and Sensorimotor Timing Abilities (BAASTA): Beat Alignment Test, finger tapping in synchrony to simple (metronome) and complex (beat of a musical excerpt) rhythmic stimuli. To obtain a composite score that reflects both perceptual and sensorimotor rhythmic abilities, we computed the Beat Tracking Index (BTI)^{15,16}.

Assessment of executive functioning:



RESULTS

Aim 1: Compliance and Endorsement

Characteristic	Rhythm Workers N = 12 ¹			Frozen Bubble N = 12 ¹			p-value
	M	SD	Min-Max	M	SD	Min-Max	
Training Duration (Min)	274.3	99.0	117.6-431.9	274.2	118.7	49.1-417.2	0.7
Continuous Play (Min)	196.5	76.6	69.0-318.3	237.2	106.5	31.3-355.4	0.2
Taps Per Training Minute	54.8	8.7	34.3-62.6	57.1	11.5	36.2-74.1	0.6
Enjoyment ²	3.1	0.6	2.0-4.0	3.5	1.0	1.7-4.6	0.2
Perceived Difficulty ²	3.1	1.0	1.9-4.9	2.6	0.5	1.4-3.2	0.7
Positive Recommendation			83%			73%	0.2

¹ One report missing in each group from different participants for each measure ² Overall mean across sessions

Aim 2: Sensorimotor Improvement (BAASTA)

Figure 1: Sensorimotor improvement on the BTI was greater for children playing RW than the controls

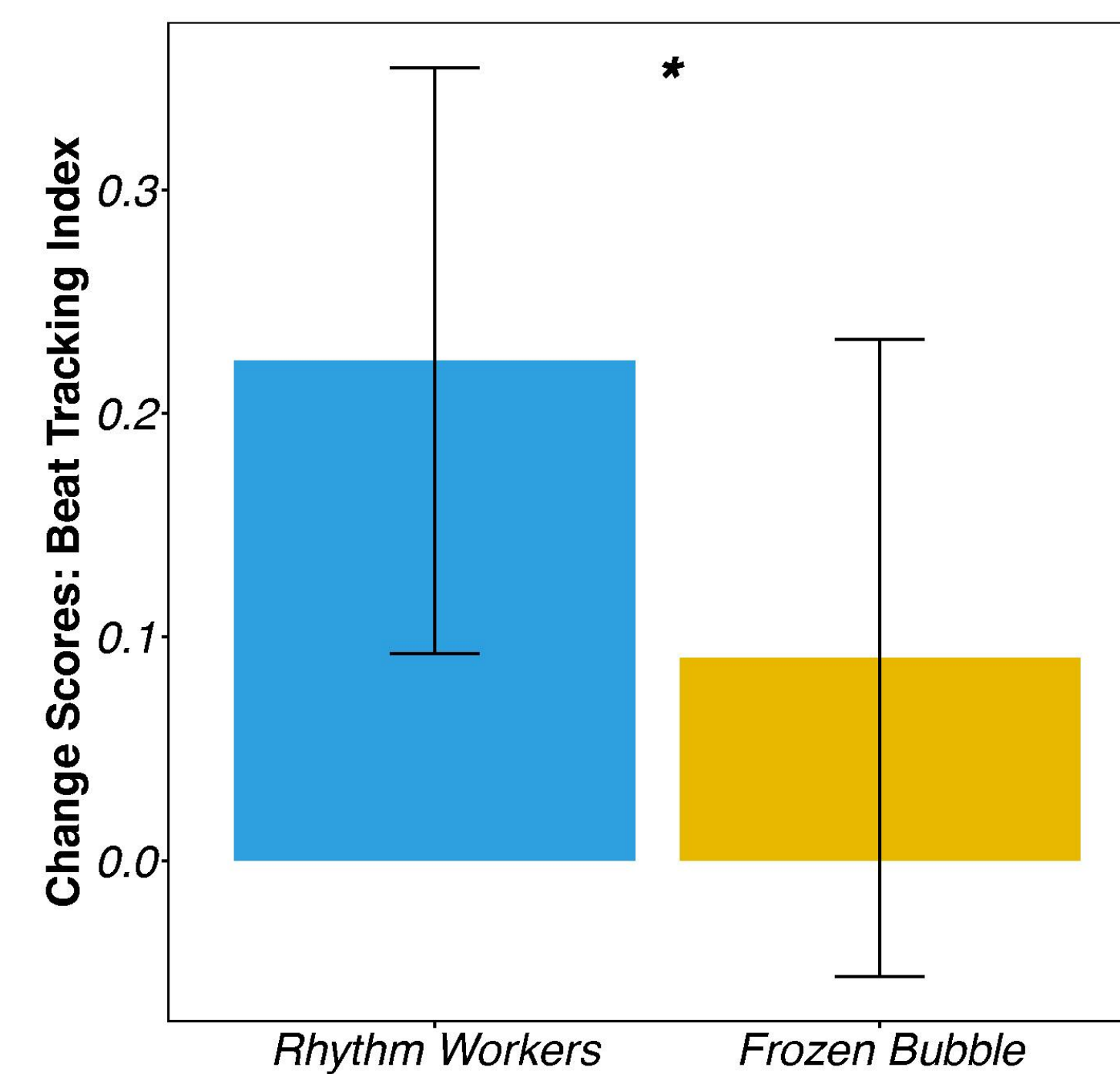
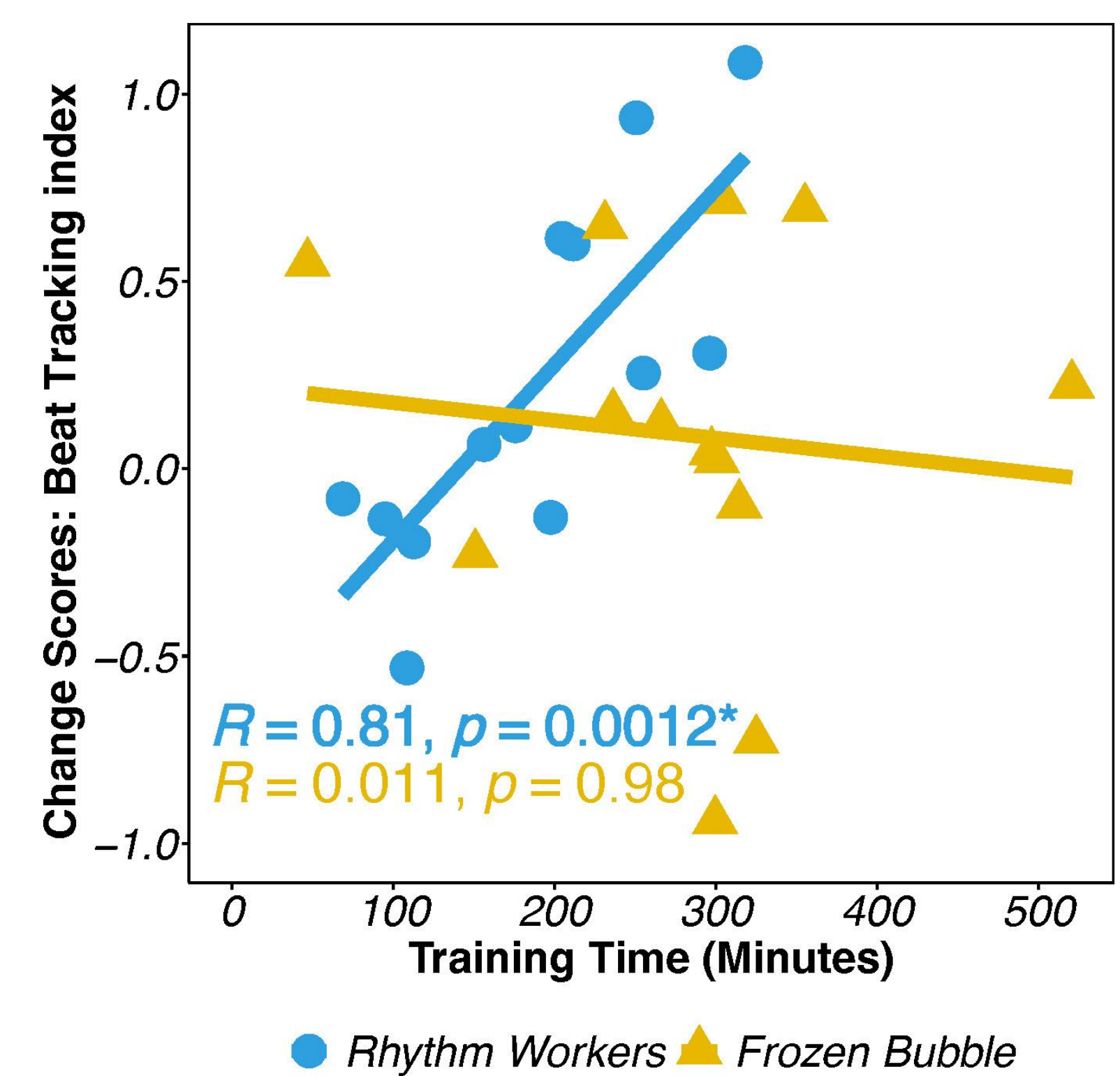


Figure 2: Training duration and sensorimotor improvement on the BTI were positively related for those playing Rhythm Workers



❖ Change scores indicate improvement (post- minus pre-test) using z-scores

Exploratory Aim: EF Improvement and Symptom Severity

Figure 3: Children playing RW showed better accuracy in executive functioning after training compared to controls. Bars indicate standard error; * $p < .05$

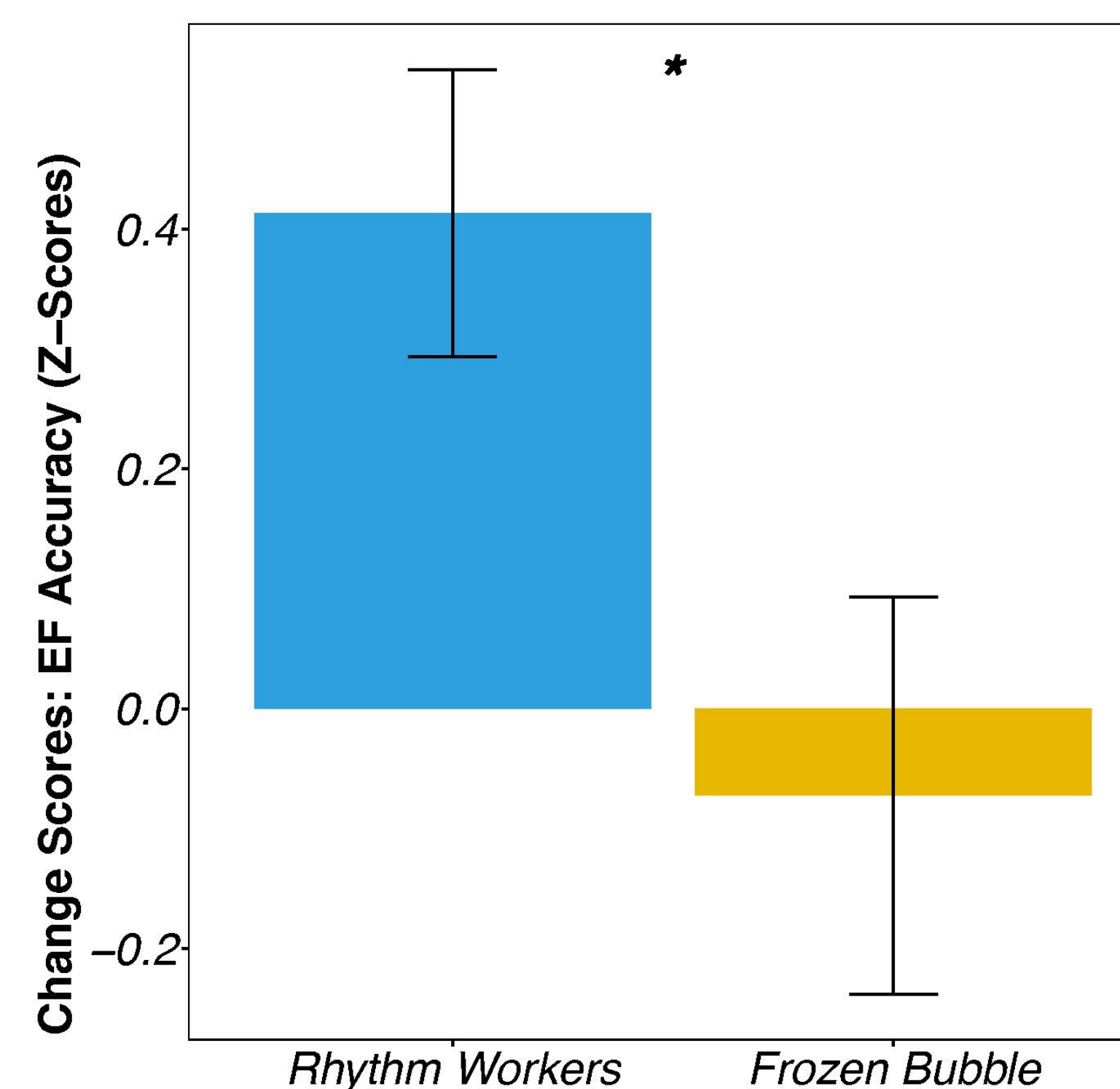
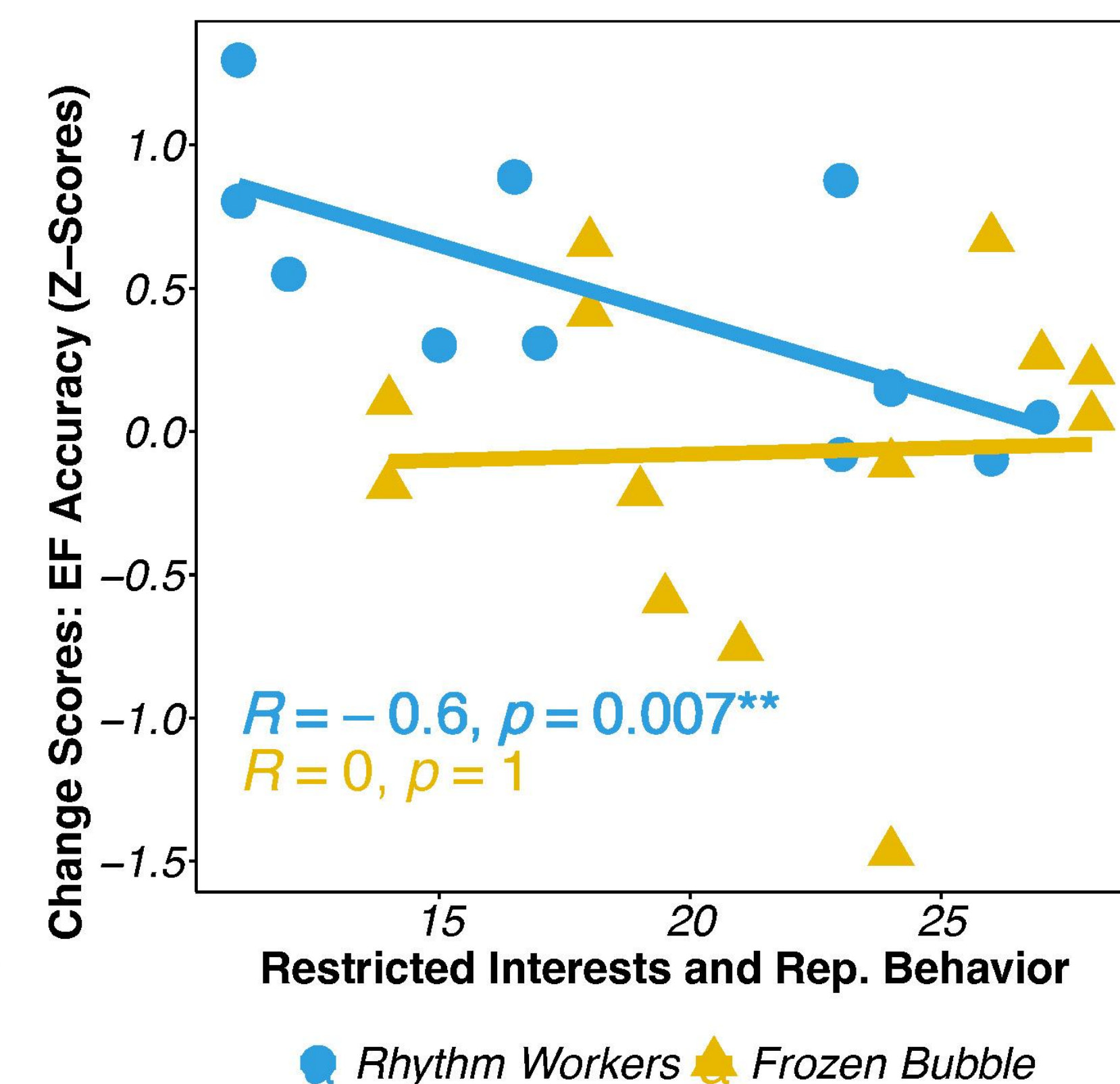


Figure 4: The relationship between EF improvement for children playing RW was negatively related to restricted interests and repetitive behaviors symptom severity (SRS-II).



CONCLUSIONS

Aim 1: Compliance with the training protocol was achieved for participants in both groups. Both games were matched in terms of:

- ❖ Training duration
- ❖ Game engagement
- ❖ Perceived difficulty
- ❖ Recommendations

Aim 2: Improvement on the BTI was stronger for children who played RW than FB and was strongly related to training duration

Exploratory Aim: Improvement in EF was stronger for those who played RW compared to FB and was strongly related to training duration. Those who played RW and had less severe restricted interests and repetitive behaviors symptomatology benefited most in EF improvement after training.

Other insights:

- Minimal training duration to see improvements ~ 200 minutes

Future work will:

- ❖ Validate these findings with a larger sample and on a wider range of measures
- ❖ Examine neural correlates of underlying mechanisms (e.g., fMRI, EEG)
- ❖ Examine effects on speech/social deficits and family quality of life
- ❖ Examine if RW can help improve symptoms on other neurological disorders (e.g., ADHD¹⁷, Stuttering)

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