

Background

- Children with autism spectrum disorder (ASD) and co-morbid attention deficit/hyperactivity disorder (ADHD) symptoms experience significant impairments in attention and executive function skills.¹
- These children also demonstrate lower adaptive functioning skills, more severe maladaptive behaviors, poorer responses to social skills treatment, and less successful transitions to independence as adults.²⁻⁴
- Relative to an ADHD population, frontline medications for ADHD, such as stimulants, have a lower success rate and greater rates of side effects in ASD.⁵
- Thus, there is a need to develop alternative treatments targeting attention and executive function in individuals with ASD and comorbid ADHD symptoms.

Objective

- To examine the feasibility and initial efficacy of an interactive, multitasking and an educational training “app” for attention and executive function.

Methods

- Participants:** Nineteen of 42 children screened met inclusion criteria, which included a verbal mental age of 8 years, a nonverbal reasoning standard score of 70 or higher, and an Attention Performance Index (API) less than zero* on the Test of Variables of Attention (TOVA). See Figure 1 and Table 1.
- Assessment Battery:**
 - Primary Outcome:** API from TOVA
 - Secondary Outcome:** ADHD Rating Scale-IV (ADHD-IV-RS)
- Treatment Procedures:** If children met screening criteria, they were assigned to the multitasking or educational treatment condition. Multitasking treatment included rapidly switching between a perceptual discrimination attention task and a continuous visuomotor driving-type task. Educational treatment included a word generation/spelling task. Children were instructed to access the treatment in twenty ~30 minute sessions over four weeks on an iPad.
- To evaluate feasibility and acceptability:** Feasibility was measured with treatment compliance rates. Acceptability was measured with consumer satisfaction and parent perception of the value of time spent on treatment.
- Preliminary Efficacy:** Within-group change on outcomes

*The first six children had an inclusion criterion of -1.8.

Methods/Results

Figure 1. Consort Diagram

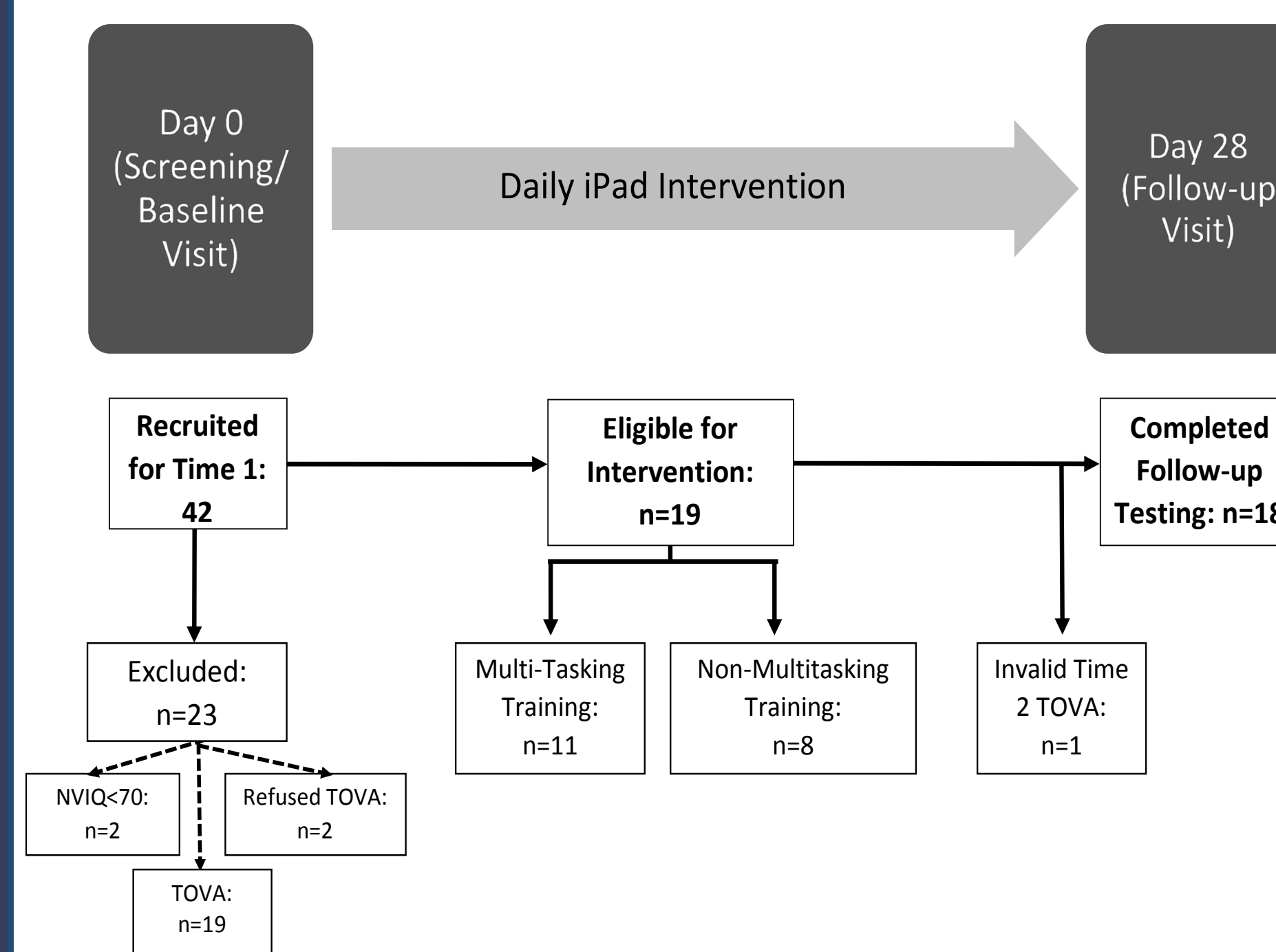


Table 1. Participant Details

	Multitask n=11	Educational n=8	t(df) Hedges' g, p-value
Age	11.25 (1.12)	11.26 (1.88)	t(10.62)=-0.02, g=0.01, p=0.99
Full-scale IQ	98.36 (13.11)	111.12 (16.99)	t(12.71)=-1.77, g=0.82, p=0.10
Sex-Ratio (M:F)	11:0	6:2	--
ADOS-2 Total Score	12.64 (2.80)	13.86 (3.44)	t(10.97)=-0.79, g=0.38, p=0.45
SCQ Total Score	21.55 (5.01)	20.88 (4.91)	t(15.42)=0.29, g=0.13, p=0.77
ADHD-IV Inattention	19.91 (3.42)	18.88 (3.83)	t(14.13)=0.61, g=0.27, p=0.55
ADHD-IV Hyp/Imp	16.45 (3.45)	16.38 (2.62)	t(16.94)=0.06, g=0.02, p=0.96
ADHD-IV-RS Total	36.36 (4.01)	35.25 (4.20)	t(14.80)=0.58, g=0.26, p=0.57
TOVA API (at Baseline)	-3.27 (3.32)	-4.53 (2.62)	t(16.83)=0.92, g=0.39, p=0.37

Feasibility and Acceptability:

- Game play was high for both groups (Figure 2).
- Consumer satisfaction ratings were high (Figure 3).
- Parent ratings of the value of time spent on treatment was high in both conditions (Figure 4).

Figure 2. Acceptability

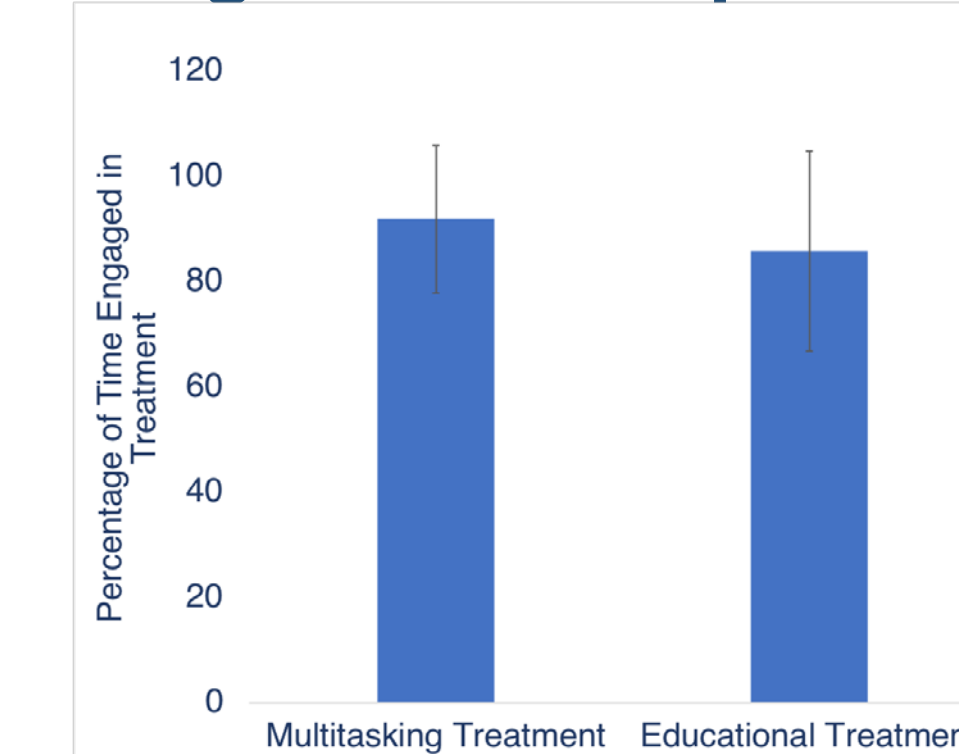


Figure 3. Consumer Satisfaction

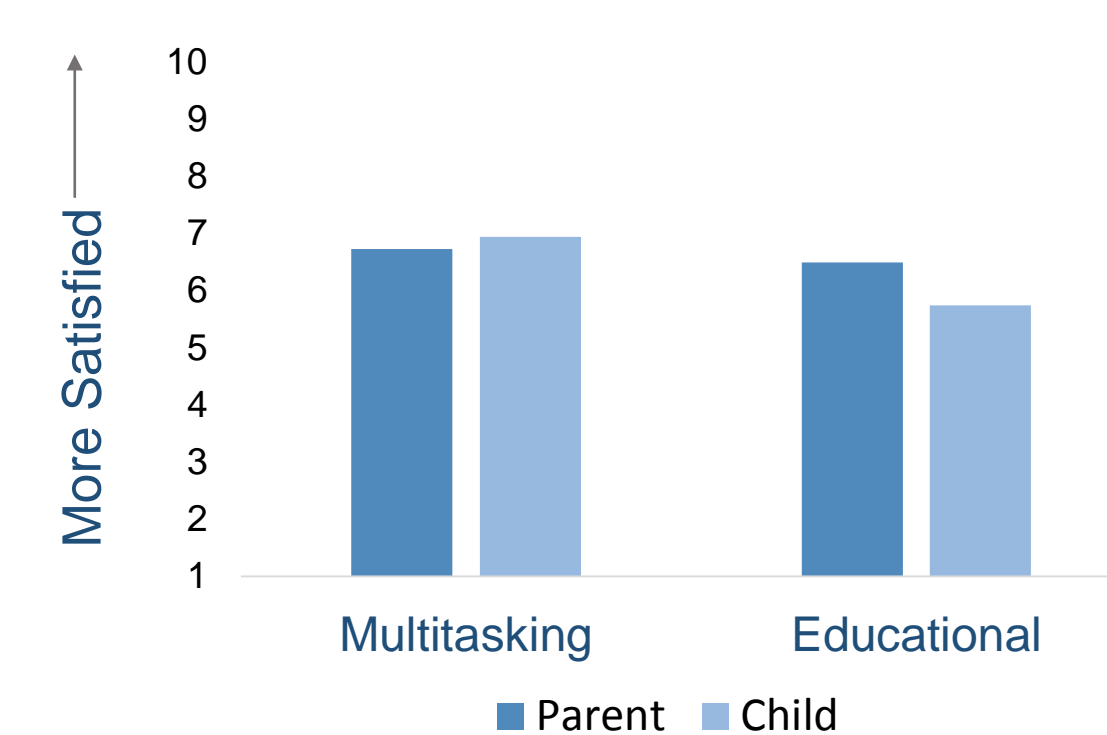
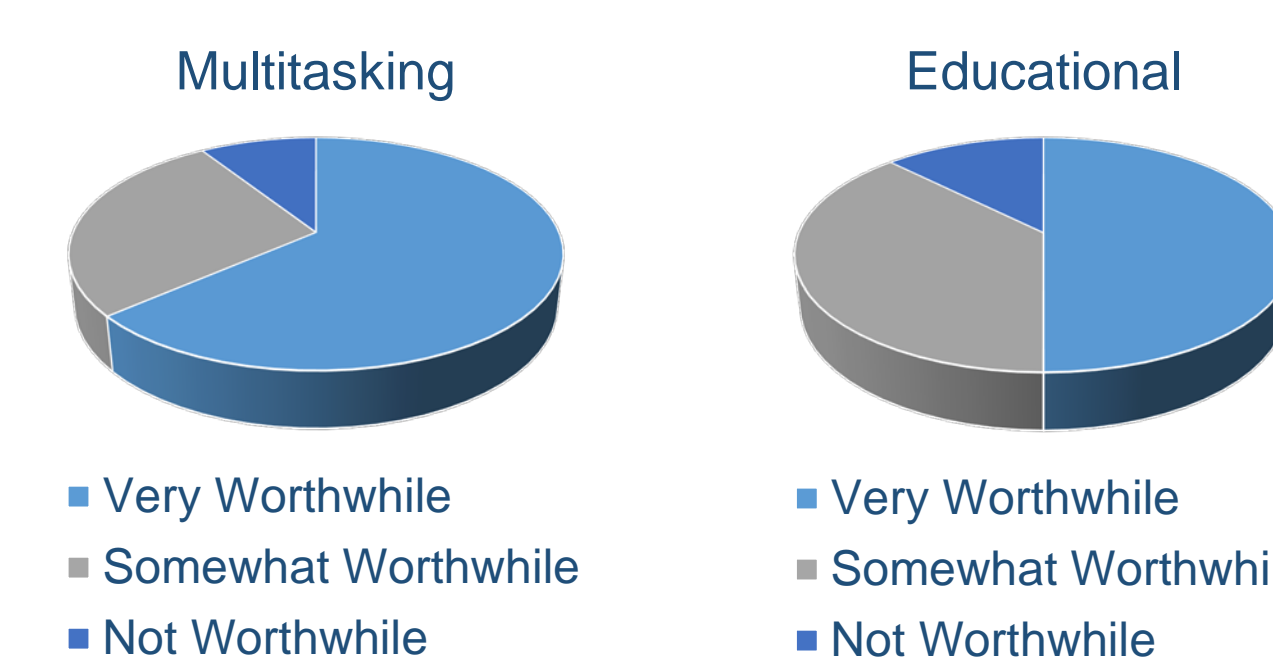


Figure 4. Parent Expectation for Change



Preliminary Efficacy:

- The multitasking treatment had a large positive effect on TOVA from baseline to follow-up (Figure 5).
- The educational treatment showed a moderate worsening on TOVA from baseline to follow-up.
- The multitasking treatment had a large positive effect on ADHD-IV-RS Total from baseline to follow-up, with an effect size over twice that of the educational treatment (Figure 6).

Figure 5. Effect Size of TOVA API

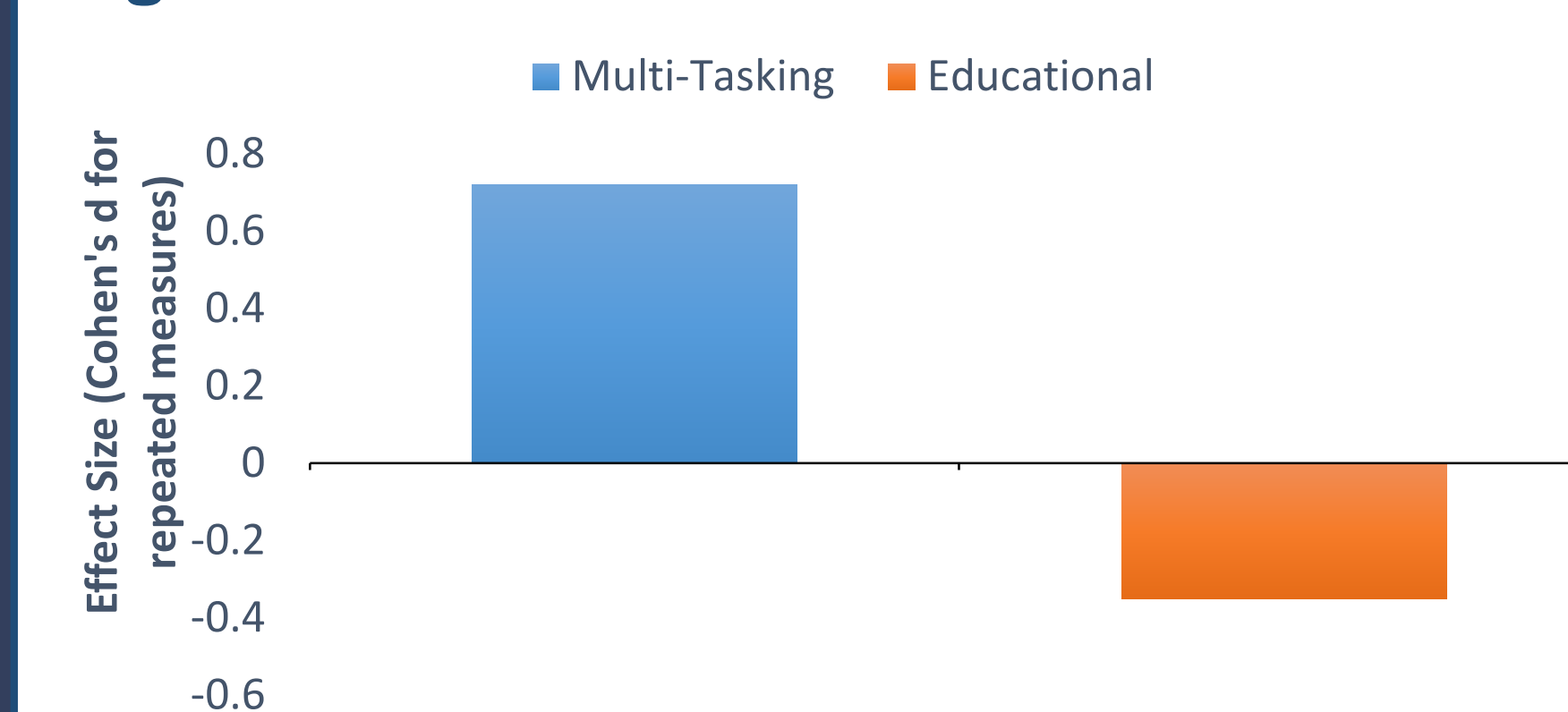
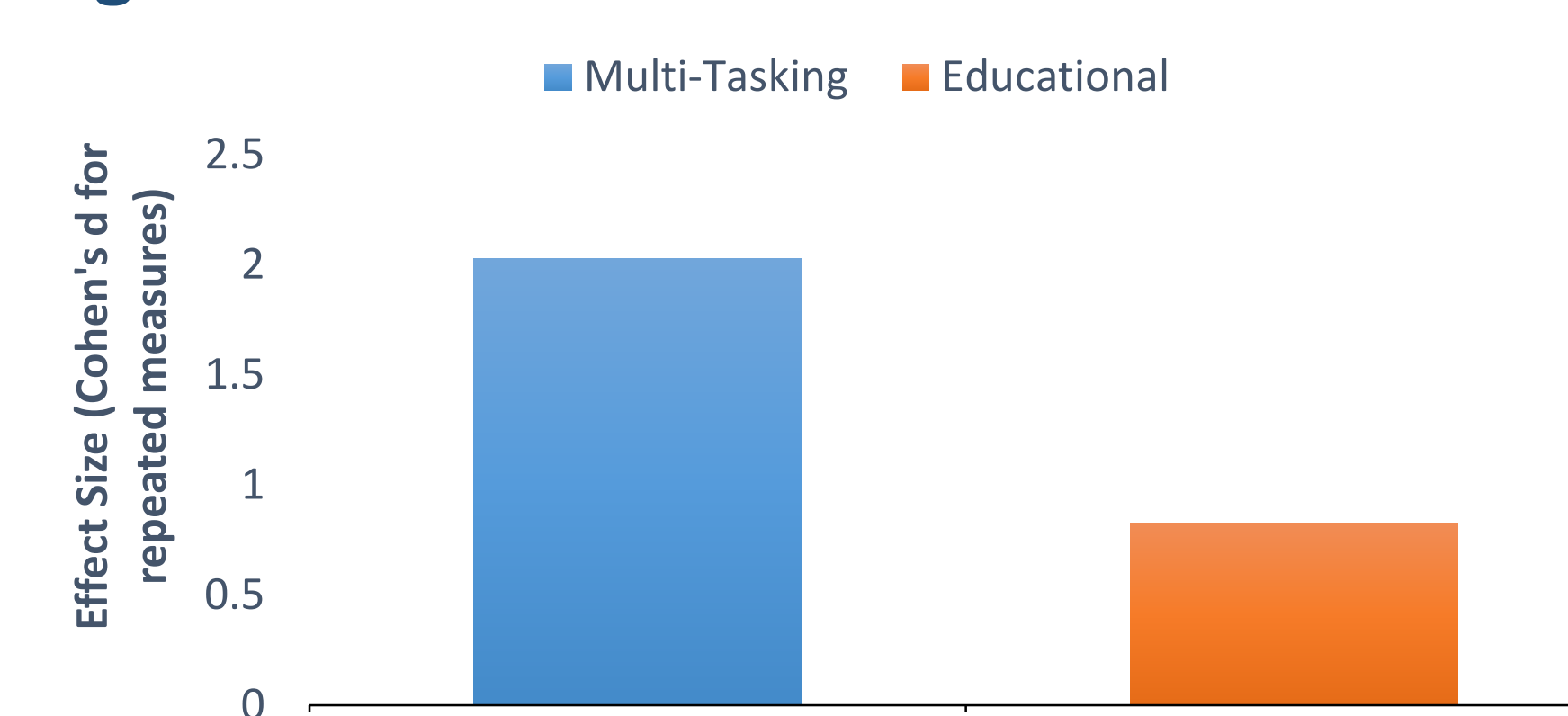
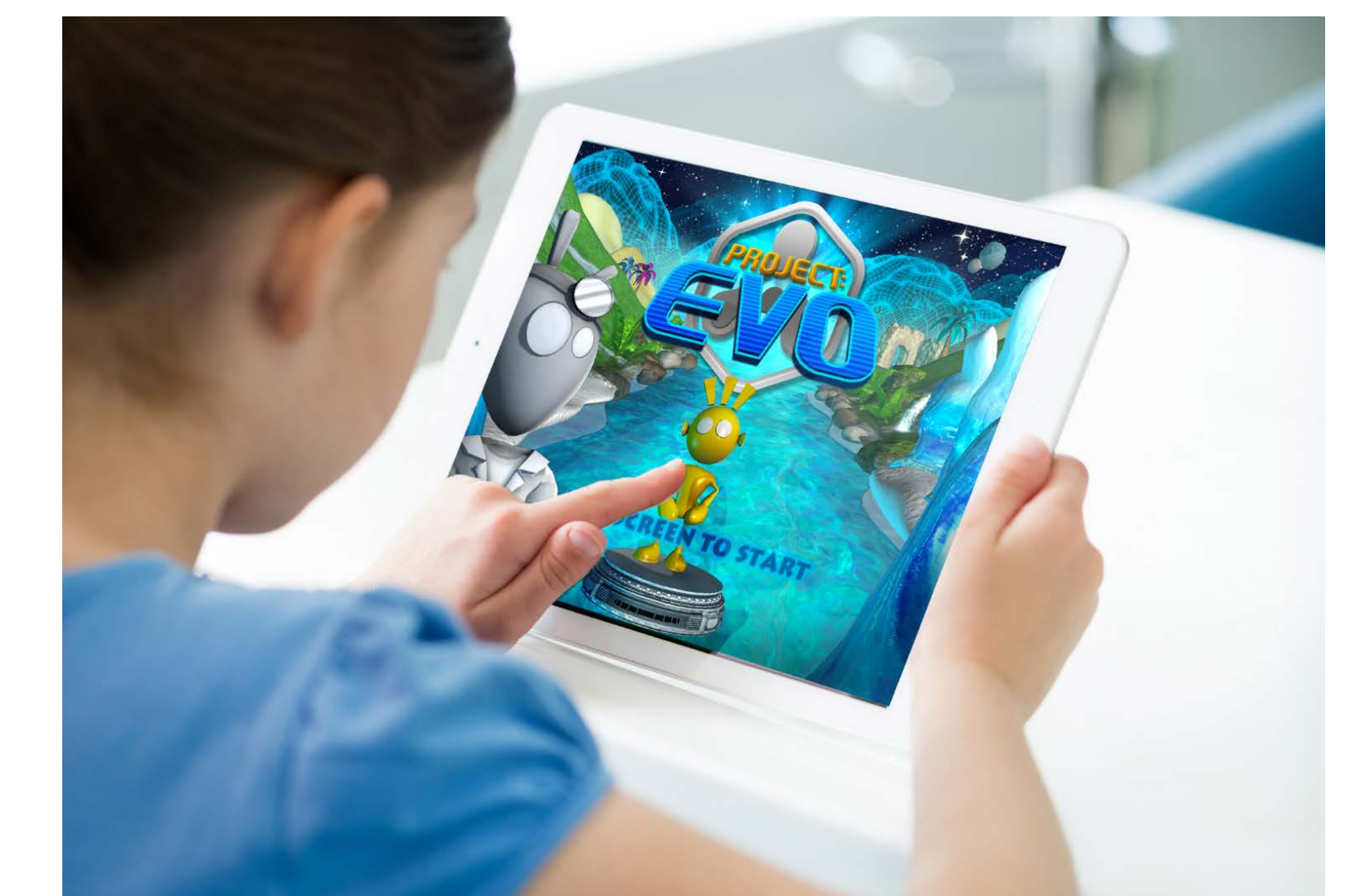


Figure 6. Effect Size of ADHD-IV-RS Total



Conclusions

- High exclusion rate ensures that treated children have impairments in the targeted skills.
- Feasibility and acceptability measures indicate high engagement, satisfaction, and belief of treatment potential.
- Preliminary efficacy findings from the TOVA API for the multitasking treatment align with prior Project EVO studies.^{6,7}
- Large effects on the primary and secondary outcome for multitasking relative to the educational treatment condition, suggest Project: EVO may potentially improve comorbid ADHD symptoms in ASD.



References

- Wallace, G. L., Yerys, B. E., Peng, C., Dlugi, E., Anthony, L. G., & Kenworthy, L. (2016). Assessment and treatment of executive function impairments in autism spectrum disorder: An update. In *International Review of Research in Developmental Disabilities* (Vol. 51, pp. 85–122). Elsevier. Retrieved from <http://linkinghub.elsevier.com/retrieve/pii/S2211609515000147>
- Yerys, B. E., Wallace, G. L., Sokoloff, J. L., Shook, D. A., James, J. D., & Kenworthy, L. (2009). Attention deficit/hyperactivity disorder symptoms moderate cognition and behavior in children with autism spectrum disorders. *Autism Research*, 2(6), 322–333. <https://doi.org/10.1002/aur.103>
- Antshel, K. M., Polacek, C., McMahon, M., Dygert, K., Spenceley, L., Dygert, L., ... Faisal, F. (2011). Comorbid ADHD and anxiety affect social skills group intervention treatment efficacy in children with autism spectrum disorders. *Journal of Developmental and Behavioral Pediatrics*, 32(6), 439–446. <https://doi.org/10.1097/DBP.0b013e318222355d>
- Hume, K., Loftin, R., & Lantz, J. (2009). Increasing independence in autism spectrum disorders: a review of three focused interventions. *Journal of Autism and Developmental Disorders*, 39(9), 1329–1338. <https://doi.org/10.1007/s10803-009-0751-2>
- Research Units of Pediatric Psychopharmacology. (2005). Randomized, controlled, crossover trial of methylphenidate in pervasive developmental disorders with hyperactivity. *Archives of General Psychiatry*, 62(11), 1266–1274. <https://doi.org/10.1001/archpsyc.62.11.1266>
- Davis, N. O., Bower, J., & Kollins, S. H. (2018). Proof-of-concept study of an at-home, engaging, digital intervention for pediatric ADHD. *PLOS ONE*, 13(1), e0189749. <https://doi.org/10.1371/journal.pone.0189749>
- Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., ... Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature*, 501(7465), 97–101. <https://doi.org/10.1038/nature12486>

Acknowledgements

This project was sponsored by funding from Akili Interactive Labs. The sponsor did not contribute to data collection of outcome measures, data analysis, interpretation, or the decision to publish.

We would also like to thank the families for their participation in this study.