The Construct and Criterion Validity of a Cognitive Game-based Assessment: Cognitive Control, Academic Achievement, and Prefrontal Cortex Connectivity

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Abstract

Cognitive control—the ability to execute goal-relevant responses in the presence of competing goal-irrelevant response alternatives—predicts academic achievement, delinquency, and occupational success. Assessing children's cognitive control is challenging due to the tedious nature of cognitive assessments and children's low attention spans. This study examined whether a cognitive game-based assessment (GBA) may alleviate these challenges by investigating the construct and criterion validity of implementing game-based features into a traditional cognitive assessment, and the associations between GBA performance, academic achievement outcomes, and associated neural substrates in children ages 3-5. Performance on the GBA was significantly associated with performance on a traditional measure of cognitive control, functional brain connectivity, and mathematical and verbal test outcomes. Children also showed a stronger preference and higher ratings of enjoyment for the GBA compared to the traditional cognitive control assessment.

Keywords: educational technology; cognitive control; gamification; functional connectivity; fNIRS

Introduction

Cognitive control is a set of processes that support adaptive goal-directed behavior in the face of changing task demands (Crone & Stienbeis, 2017; Munakata et al., 2012). Cognitive Control is widely agreed to play an important role in supporting academic success, life outcomes, and well-being (Blair & Diamond, 2008; Riggs et al., 2004; Rimm-Kaufman et al., 2009). The development of the prefrontal cortex (PFC) has also been found to be linked with the development of cognitive control (Chevalier et al., 2019; Crone & Stienbeis, 2017). More recently, studies have utilized functional near-infrared spectroscopy (fNIRS) with evidence linking performance on tasks of cognitive control and PFC development in children (Masataka et al., 2015; Moriguchi & Hiraki, 2013). Evaluating children's cognitive control can be challenging due to lengthy experimental protocols. Children's engagement and attention spans with tedious tasks may dwindle (Anguera, et al., 2016a), and pediatric populations may not comply with the instructions to produce usable data (e.g., Fisher & Kloos, 2016).

One potential solution to this problem is to administer cognitive tasks as a Game Based Assessment (GBA), with aspects of gamification such as rewards, a narrative, competition, adjusting to individual skill level, and employing evidence-based principles related to motivation and learning (Kiili & Ketamo, 2018; Berger et al., 2000). GBAs have the potential to sustainably engage children without sacrificing the quality of the data. Importantly, these game-based tasks are capable of including algorithms for continuously adapting the difficulty level based on children's individual performance, so they are challenged at the right level, preventing floor or ceiling effects often encountered when a study includes participants of different ages. Furthermore, there is recent evidence that in school-age children, GBAs provide better test sensitivity for assessing cognitive control in clinical populations than either paper-and-pencil tasks or non-adaptive computerized tasks (Anguera, et al., 2016b). Providing children with an enjoyable activity while simultaneously collecting accurate and reliable data is a challenge, but transforming widely utilized cognitive assessments into GBAs might be a potential solution.

The present study was designed to evaluate the construct and criterion validity of a game-based assessment based on the child-friendly adaptation of the widely used Flanker Task (Eriksen & Eriksen, 1974; Rueda et al., 2004). The Flanker Task assesses cognitive control by requiring participants to suppress attending to distractors and to focus narrowly on a target stimulus. Participants are instructed to press a button corresponding to the direction of a central target arrow flanked by peripheral arrows. Incongruent trials require cognitive control processes because the flanking arrows face the opposite direction of the central target arrow (Best, 2010). This task predicts academic achievement in Kindergarten and First grade better than other widely used cognitive control tasks (Vandenbroucke et al., 2017).

Given the limited research on the feasibility and validity of GBA of cognitive control in research and clinical settings, the goals of this study were as follows. First, we aimed to conduct a psychometric validation of a GBA based on the Flanker task with preschool-aged children. Specifically, we examined whether addition of game features to the Flanker task changes the well-established patterns of task performance. Second, we examined whether or not the addition of game features to the Flanker task obscured the association between task performance and standardized academic achievement measures observed in prior research. Third, we examined whether or not addition of the game features to the Flanker task obscured the association between performance and PFC brain connectivity using fNIRS, a neuroimaging method particularly well-suited for research with young children (Chevalier et al., 2019; Lloyd et al., 2010; Moriguchi & Hiraki, 2013). Finally, we assessed whether adding game features to the Flanker task increases children's enjoyment. We hypothesized that adding game-based features to a traditional task of cognitive control would improve children's enjoyment of the task, while still preserving construct and criterion validity.

Method

Participants 21 children were recruited from a pre-primary school in a Northeastern city in the United States. Of the 21 children, 1 participant was excluded due to noncompliance on the Flanker Task. The remaining 20 participants were ages 3 to 5 (M_{years}=4.77, *SD*=.97; 13 Males; 7 Females). The school environment represents local racial and economic diversity with children being 54% White, 24% Asian or Pacific Islander, 5% African American, 12% Middle-Eastern, 5% Hispanic, and 28% of children attending with financial aid. The experimental protocol was approved by the University Institutional Review Board. Signed consent was obtained from the parents of participants. Children were given stickers for participating.

Procedure and Measures

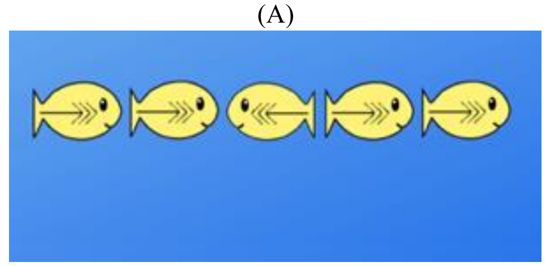
For this study, a within-subjects design was implemented in which children participated in two conditions of a cognitive control assessment: the Flanker Task (traditional) Condition and a GBA Flanker Condition: *Frankie's Big Adventure* (Eng et al., 2020). To control for order, practice, and fatigue effects, the order of which each task was played was counterbalanced. After playing each condition, enjoyment was assessed. During subsequent lab visits within the same week, PFC resting-state connectivity utilizing fNIRS and performance on standardized assessments of Verbal and Mathematical tests were collected. Testing sessions were administered to participants in the same room each day, by an experimenter naive to the study hypotheses.

Assessments

The Flanker Task (Rueda et al., 2004): The Flanker Task modified for children with fish instead of arrows was presented on a computer screen (see Fig. 1A). The task presented 5 fish in a row facing either right or left. The task goal was to make a response in accordance with the direction of the middle fish while ignoring the surrounding fish. The flanking fish either faced the opposite (incongruent trials) or same direction (congruent trials) of the central target fish. For incongruent trials, the prepotent response is to choose the direction of the distractor fish, so participants need to narrowly focus on the central target while inhibiting distraction from the flanking distractors surrounding the target (Best, 2010). Children completed 8 practice trials to ensure directions were understood, followed by 42 test trials. Children were given encouragement during the practice trials to respond as quickly and accurately as possible. No encouragement or correction was given during the testing block. The primary outcome measure was accuracy for the incongruent trials.

GBA Flanker The game-based version of the Flanker Task had existing game interface design features that were applied to the standard task, but the main goal of responding in the direction of a central fish remained the same (Deterding et al., 2011). Children were presented with a narrative to help Frankie, the center fish, collect ocean treasures. For correct responses, in which children helped Frankie go in the correct direction, participants earned a reward, an ocean treasure in a jar, as positive feedback. The GBA had the feature of children being able to see their progress as they progressed throughout the game as ocean treasures were collected in their jars (see Fig. 1B).

(A)



(B)

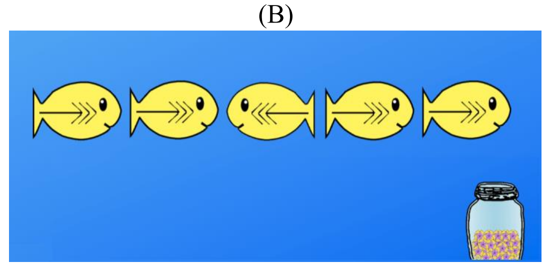


Figure 1: Display of an incongruent trial for the (A) Flanker Task and (B) Game-Based Assessment of the Flanker Task.

The game features were designed from evidence-based approaches in the learning sciences such as including a narrative that helps learners imagine they are on quests, and player feedback such as anticipating an opponent's behavior (see Fig. 2; Schwartz et al., 2016). If children took too long to make a response or responded in the wrong direction, Dolphie the Dolphin would come and take a treasure as negative feedback. The game features included a narrative, player feedback, and a computational algorithm to provide incremental challenge by continuously adapting the difficulty level based on performance. Like the traditional Flanker Task, the GBA involved the cognitive control skill of inhibiting distraction from the flanking fish and narrowly focusing attention to a central target.

Children completed 50 trials, 8 practice trials and 42 test trials. During the practice trials with the gamification features, children were given encouragement to respond as quickly and accurately as possible. No form of encouragement was given during the testing block.

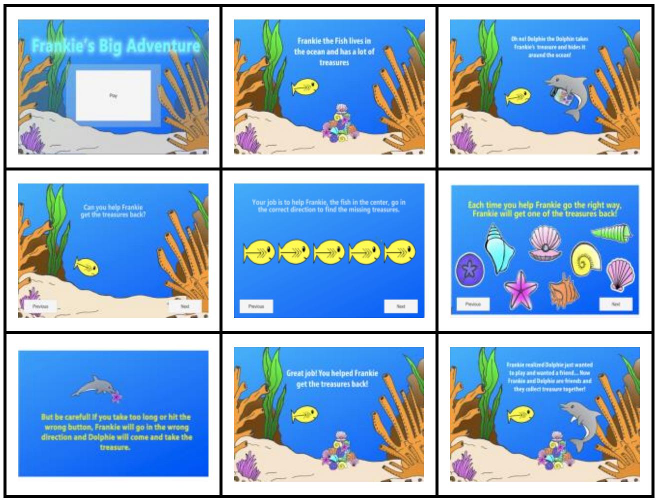


Figure 2: GBA narrative, instructions, and feedback. GBA features were illustrated and developed by Cassondra Eng, the last author.

The initial allotted response time started at 5000 milliseconds and adjusted to individual capabilities utilizing a machine learning algorithm. For correct trials when children responded correctly, difficulty advanced by decreasing the allotted response time by 500 ms. For incorrect trials when children responded in the incorrectly or took too long to respond, difficulty decreased by increasing the allotted response time by 500 milliseconds to optimally challenge children's skills with explicit feedback across conditions. GBA Flanker and the Flanker Task were programmed in Unity Technologies: a software permitting game customization to carefully control features (see Table 1 for similarities and differences between the two conditions).

Table 1: Summary of Flanker Task versus GBA Features

Summary of Flanker Task vs. GBA Features

	Flanker	Flanker GBA
Practice Trials	8	8
Inter-trial Duration	450 ms	450 ms
Auditory Feedback	✓	✓
Number of Trials	42	42
Narrative	X	✓
Visual Feedback	X	Rewards/Competitor
Music	X	✓
Player Adaptability/Trial Duration	1700 ms (fixed)	Incremental challenge to 1700 ms

Enjoyment Measures We used a 5-point Smileyometer likert scale with five faces ranging from a frowny face (really disliked) to a big smiley face (really liked) to measure enjoyment at the end of the task. Additionally, we asked children an *Again-Again* question, a valid measure of children's enjoyment which assesses which activity children would rather play again (Read & MacFarlane, 2006).

Standardized Academic Achievement Measures We administered two Wechsler Prseschool and Primary Scale of Intelligence (WPPSI-P; Petermann, 2011) subtests: Verbal Information and Matrix Reasoning. The Verbal Information subtest consisted of 34 questions that assess knowledge of general acquired facts as a proxy for verbal intelligence. The Matrix Reasoning subtest consisted of children viewing an incomplete matrix followed by the children's selection of which option completed the matrix. These 29 problem sets measure classification and spatial capacity, knowledge of part-whole relationships, and perceptual organization.

Resting-State Prefrontal Cortex Connectivity fNIRS is a neuroimaging technique that uses low-levels of light to measure changes in cerebral blood volume and oxygenation. Optical imaging was collected with a continuous wave realtime fNIRS system (TechEn, Inc.). There were 4 light sources, each containing 690-nm and 830-nm laser light and 8 detectors, with a source-detector distance of 3.0 cm to give oxygenation measures in 10 channels. Probes were positioned referenced to the 10–20 EEG international coordinate system covering areas Fp1-F8 on the PFC. Sensors were mounted on a probe strip and secured with a child-friendly Neoprene Cap. Inscapes (Vanderwal et al., 2015)—a movie paradigm designed to measure resting-state—has been found to be a useful condition between task-free rest and movies for children. It features abstract shapes without a social narrative and has been associated with patterns of connectivity that most closely resembles those obtained during rest. fNIRS recordings were available for 12 participants in this study.

Results

Construct Validity of GBA There were no significant differences in accuracy on the Incongruent trials of the Flanker Task (53.73 ± 33.16%) compared to the GBA Flanker Task (60.86 ± 26.58%), paired-sample $t(19)=1.69$, $p=.12$ (see Fig. 3). The mean accuracy values are consistent with prior studies showing accuracy with children of similar age varying greatly from 22%-90% on incongruent trials for cognitive control tasks (Jones, Rothbart, & Posner 2003) Accuracy on the incongruent trials in both conditions were also positively and significantly correlated, $r(20) = .81$, $p< .0001$ (see Fig. 3), providing evidence that the addition of gamification features does not change children's performance.

Manipulation Check Paired t-tests indicated that mean accuracy for the congruent trials were significantly higher than mean accuracy for the incongruent trials in the GBA Condition,($t(19) = 3.83$, $p = .001$) and the Flanker Task

Condition ($t(19) = 2.65$, $p = .016$). Similar to the pattern of results found for the incongruent trials, accuracy on the congruent trials in both conditions were positively and significantly correlated, $r(20) = .67$, $p<=.001$.

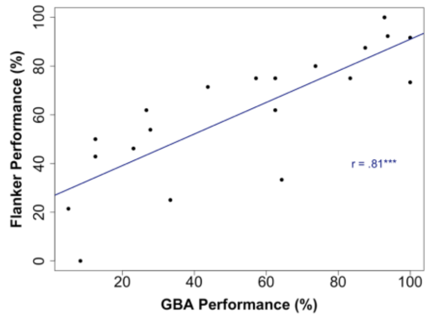


Figure 3: GBA performance was significantly correlated with performance on the traditional measure of cognitive control.

Enjoyment Outcomes: Engagement was measured on 5 point Smileyometer likert scale. To assess possible order effects, we conducted a mixed factorial analysis of variance (ANOVA) on enjoyment, factoring order as a between-subject variable and task condition as the within-subject variable. There was a main effect of condition, in that children's enjoyment ratings were significantly higher in the GBA Condition (*M*=4.45, *SD*=1.05) compared to the Flanker Task Condition (*M*=3.05, *SD*=1.70), $F(1, 18)=13.67$; $p=.002$; $\eta p2=.43$. There was no main effect of order, $F(1, 18)=.34$, $p=.57$. Children selected the GBA more than the Flanker Task as their free-choice game option when asked which game they would play again: 80% of children (16 out of 20) selected the GBA while 15% of children (3 out of 20) selected the Flanker Task, and only one participant did not respond. A chi-square test of independence was performed to examine the relation between game choice and task order (GBA-then-Flanker vs. Flanker-then-GBA). The relation between these variables was not significant, $X^2(2, N=20)=1.33$, $p=.51$, indicating that regardless of which order children played the tasks, the choice to play the GBA over the Flanker Task was still chosen by the majority of children. Taken together, these results indicate that children's enjoyment ratings of the GBA Condition were higher compared to the Flanker Task Condition, regardless of the order in which the tasks were played (see Fig. 4-5).

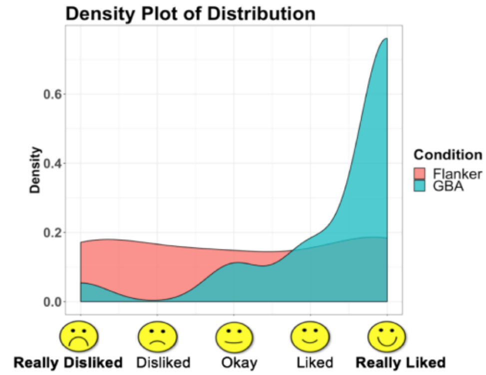


Figure 4: The density plot displays children rated the GBA as more enjoyable than the Flanker Task.

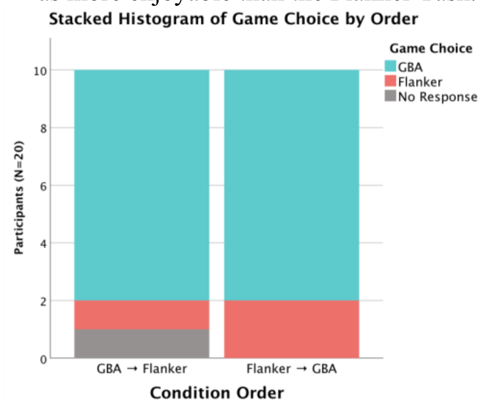


Figure 5: Regardless of order, 80% of the children preferred GBA Flanker over the traditional Flanker Task.

Association of Cognitive Control with Standardized Academic Achievement Measures Higher accuracy on the incongruent trials on the GBA Task, $r(20) = .75$, $p = .0001$, and the Flanker Task, $r(20) = .65$, $p = .002$, were positively associated with children's WPPSI-P Verbal Subtest scores (see Fig. 6A). Similarly, accuracy on the incongruent trials on the GBA Task, $r(20) = .76$, $p = .00009$, and the Flanker Task, $r(20) = .78$, $p = .00005$, were positively associated with children's WPPSI-P Matrix Reasoning Subtest scores (see Fig. 6B).

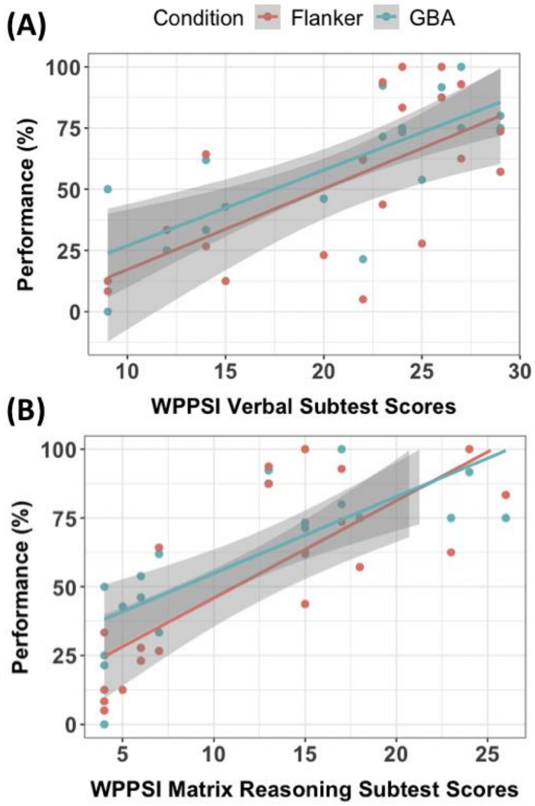


Figure 6: Performance on the Flanker Task and GBA were associated with (A) Verbal and (B) Mathematical scores.

Association of Cognitive Control with Resting-state Prefrontal Cortex Connectivity Twelve participants returned to the laboratory for fNIRS data collection. Preprocessing and rsFC analyses were carried out using the NIRS Brain AnalyzIR toolbox (Santosa et al., 2018). Raw fNIRS intensity signals were first converted to changes in optical density. The data were then corrected for motion artifacts using the Temporal Derivative Distribution Repair method. This uses a motion correction procedure based on robust regression that effectively reduces the magnitude of large fluctuations (i.e., motion) in the signal, while leaving small fluctuations (i.e., hemodynamics) intact to prevent physiological artifacts from biasing the results (Fishburn et al., 2019). Signals were then converted to oxygenated hemoglobin concentrations using the modified Beer Lambert relationship. Resting-state functional connectivity was quantified by concatenating the individual block timecourses, and the Pearson correlation coefficient was computed between all 45 channel-pairs. A Fisher's r-to-Z transformation was then applied to normalize the variance of the correlation values. Z-scores were averaged together, resulting in a single global resting-state functional connectivity value. Increased performance on the GBA Task, $r(10) = .78$, $p = .002$, and the Flanker Task, $r(10) = .81$, $p = .002$, were positively associated with children's mean resting-state functional connectivity in the PFC (see Fig. 7).

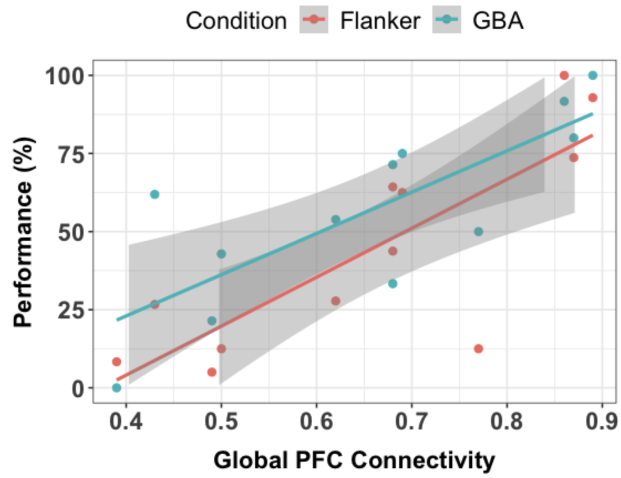


Figure 7: Performance on both the Flanker Task and GBA was associated with global resting state functional connectivity in the prefrontal cortex.

Discussions

The goal of the present study was to investigate both the construct and criterion validity of a cognitive GBA in addition to assessing children's enjoyment. The results demonstrate that a cognitive control GBA exhibited high construct validity. With the addition of gamification features, the assessment was still capable of measuring the intended construct of cognitive control: children's performance on the Flanker Task and the GBA showed an equivalent level of performance. Performance on the GBA was also significantly and positively correlated with the existing measure of cognitive control (i.e., the traditional Flanker Task). The results indicated that a cognitive control GBA exhibited high criterion validity: performance on the GBA version of the Flanker Task was positively and significantly associated with resting-state functional connectivity in the PFC and performance on standardized mathematical and verbal academic achievement assessments.

These findings suggest that the addition of gamification patterns and features to a traditional assessment of cognitive control did not change children's performance and preserved the criterion validity of the assessment. Importantly, children exhibited a stronger preference and higher ratings of enjoyment for the GBA compared to the traditional version of the Flanker Task. These results provide evidence that GBAs can potentially be utilized as valid and reliable assessments of cognitive control in pediatric populations to maximize children's enjoyment, while simultaneously preserving data quality.

Although this study has contributed to the investigation of the construct and criterion validity of a cognitive control GBA, there are limitations that warrant future research on this topic. The sample size (N=20) was limited and more participants are needed to evaluate both the robustness and replicability of these findings. The addition of learning curve data would provide a deeper understanding of changes in task performance over time. Implementing learning curve analyses would also clarify the point(s) at which children begin to improve and eventually plateau with further practice on both tasks, if at all (Ritter & Schoolar, 2001). Investigating cognitive GBAs with several more trials for longer testing durations would clarify the efficacy of adding gamification features on both children's performance and engagement (specifically, when it begins to dwindle) over longer periods of time. Addressing such limitations in future studies would provide novel insight into whether GBAs can not only serve as a potential solution to the current challenges of administering tedious cognitive assessments with young children, but also potentially minimize data loss from more lengthy testing sessions.

Developing engaging assessments of cognitive functioning is of increasing importance, given the wide-spread implementation of remote data collection in the wake of stay-at-home orders due to the COVID-19 global pandemic. The addition of game-based features to existing cognitive assessments is inexpensive and GBAs can be made widely available. Importantly, GBAs are perceived as enjoyable by children. These attributes make GBAs ideal for remote developmental research because the assessments can potentially promote sustained engagement in young children with short attention spans throughout typically tedious cognitive tasks. Cognitive GBAs show considerable promise of providing a feasible method to collect accurate and reliable data, while simultaneously providing young children with an enjoyable activity.

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References

Anguera, J. A., Brandes-Aitken, A. N., Rolle, C. E., Skinner, S. N., Desai, S. S., Bower, J. D., ... & Marco, E. J. (2016a). Characterizing cognitive control abilities in children with 16p11. 2 deletion using adaptive 'video game'technology: a pilot study. *Translational psychiatry*, *6*(9), e893-e893.

Anguera, J. A., Jordan, J. T., Castaneda, D., Gazzaley, A., & Areán, P. A. (2016b). Conducting a fully mobile and randomised clinical trial for depression: access, engagement and expense. *BMJ innovations*, *2*(1).

Berger, A., Jones, L., Rothbart, M. K., & Posner, M. I. (2000). Computerized games to study the development of attention in childhood. *Behavior Research Methods, Instruments, & Computers*, *32*(2), 297-303.

Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. *Developmental Review*, *30*(4), 331-351.

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and psychopathology*, *20*(3), 899.

Chevalier, N., Jackson, J., Roux, A. R., Moriguchi, Y., & Auyeung, B. (2019). Differentiation in prefrontal cortex recruitment during childhood: Evidence from cognitive control demands and social contexts. *Developmental cognitive neuroscience*, *36*, 100629.

Crone, E. A., & Steinbeis, N. (2017). Neural perspectives on cognitive control development during childhood and adolescence. *Trends in cognitive sciences*, *21*(3), 205-215.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011, September). From game design elements to gamefulness: defining" gamification". In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments* (pp. 9-15)

Eng, C. M., Pocsai, M., Fishburn, F. A., Calkosz, D. M., Thiessen, E. D., & Fisher, A. V. (2020). Adaptations of Executive Function and Prefrontal Cortex Connectivity Following Exergame Play in 4-to 5-year old Children. In Proceedings of the 42nd Annual Conference of the Cognitive Science Society.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & psychophysics*, *16*(1), 143-149.

Fisher, A., & Kloos, H. (2016). *Development of selective sustained attention: The role of executive functions.* In J. A. Griffin, P. McCardle, & L. S. Freund (Eds.), *Executive function in preschool-age children: Integrating measurement, neurodevelopment, and translational research* (p. 215–237).

Jones, L. B., Rothbart, M. K., & Posner, M. I. (2003). Development of executive attention in preschool children. *Developmental science*, *6*(5), 498-504.

Kiili, K., & Ketamo, H. (2017). Evaluating cognitive and affective outcomes of a digital game-based math test. *IEEE Transactions on Learning Technologies*, *11*(2), 255-263.

Lloyd-Fox, S., Blasi, A., & Elwell, C. E. (2010). Illuminating the developing brain: the past, present and future of functional near infrared spectroscopy. *Neuroscience & Biobehavioral Reviews*, *34*(3), 269-284.

Masataka, N., Perlovsky, L., & Hiraki, K. (2015). Near-infrared spectroscopy (NIRS) in functional research of prefrontal cortex. *Frontiers in human neuroscience*, *9*, 274.

Moriguchi, Y., & Hiraki, K. (2013). Prefrontal cortex and executive function in young children: a review of NIRS studies. *Frontiers in human neuroscience*, *7*, 867.

Munakata, Y., Snyder, H. R., & Chatham, C. H. (2012). Developing cognitive control: Three key transitions. *Current directions in psychological science*, *21*(2), 71-77.

Petermann, F. (2011). *WPPSI-III: Wechsler Preschool and Primary Scale of Intelligence-: Deutschsprachige Adaptation nach D. Wechsler*. Pearson Assessment and Information.

Read, J. C., & MacFarlane, S. (2006). Using the fun toolkit and other survey methods to gather opinions in Child Computer Interaction. *Proceeding of the 2006 Conference on Interaction Design and Children* (pp. 81–88).

Riggs, N. R., Blair, C. B., & Greenberg, M. T. (2004). Concurrent and 2-year longitudinal relations between executive function and the behavior of 1st and 2nd grade children. *Child Neuropsychology*, *9*(4), 267-276.

Rimm-Kaufman, S. E., Curby, T. W., Grimm, K. J., Nathanson, L., & Brock, L. L. (2009). The contribution of children's self-regulation and classroom quality to children's adaptive behaviors in the kindergarten classroom. *Developmental psychology*, *45*(4), 958.

Ritter, F. & Schooler, L. (2001) The learning curve. *International Encyclopedia of the Social and Behavioral Sciences*, 8602–8605.

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., & Posner, M. I. (2004). Development of attentional networks in childhood. *Neuropsychologia*, *42*(8), 1029–1040.

Santosa, H., Zhai, X., Fishburn, F., & Huppert, T. (2018). The NIRS Brain AnalyzIR toolbox. *Algorithms*, *11*(5).

Schwartz, D. L., Tsang, J. M., & Blair, K. P. (2016). *The ABCs of how we learn: 26 scientifically proven approaches, how they work, and when to use them*. WW Norton & Company.

Vandenbroucke, L., Verschueren, K., & Baeyens, D. (2017). The development of executive functioning across the transition to first grade and its predictive value for academic achievement. *Learning and Instruction, 49*, 103-112.

Vanderwal, T., Kelly, C., Eilbott, J., Mayes, L. C., & Castellanos, F. X. (2015). Inscapes: A movie paradigm to improve compliance in functional magnetic resonance imaging. *NeuroImage*, *122*, 222–232.