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Brief Report

Validation of new online game-based executive function tasks for children

Verena E. Johann [a,b,*], Julia Karbach [b,c]

[a] Department of Psychology, Goethe University Frankfurt, 60323 Frankfurt am Main, Germany
[b] Center for Research on Individual Development and Adaptive Education of Children at Risk (IDeA), 60486 Frankfurt, Germany
[c] Department of Psychology, University of Koblenz-Landau, 76829 Landau in der Pfalz, Germany

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ABSTRACT

Numerous tasks are available to measure executive functions (EFs; working memory, inhibition, and flexibility) in children. However, they differ massively in the way they are presented and framed. Some contain child-friendly stimuli, feedback, or game elements likely to increase motivation and interest to perform the tasks, whereas others do not. Yet, it is unclear whether these apparent differences affect task performance. Therefore, the aim of our study was to develop and validate new game-based tasks assessing EFs in children. We designed three tasks for each dimension of EF and implemented them in a game version (based on the motivational framework proposed by Ryan and Deci (2000) and a standard version. The game-based tasks included elements designed to improve perceived competence (appealing feedback), autonomy (choosing how the protagonists proceed), and relatedness (a child-friendly cover story). To investigate whether adding these game elements influenced the motivation to engage in these tasks and task performance, 60 children (third and fourth graders) performed the game-based version and the standard version in two sessions (counterbalanced across participants). Because both the game-based and standard versions of the tasks should tap the same cognitive processes, we also tested whether performances in both versions were correlated. We found higher self-reported motivation in terms of interest, perceived competence, and relatedness after performing the game-based version as compared with the standard version. Performance on the game-based and standard versions of most of the tasks was significantly correlated, and there

* Corresponding author at: Department of Psychology, Goethe University Frankfurt, 60323 Frankfurt am Main, Germany.
E-mail address: johann@psych.uni-frankfurt.de (V.E. Johann).

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were no performance differences between the game-based and standard versions.

Introduction

The scientific interest in the development of executive functions (EFs) and correlates of EFs has been rapidly increasing over the last decade. EFs describe higher-level cognitive control processes supporting the adaptation to continuous changes in the environment. Miyake et al. (2000) assumed that there are three core EFs: maintenance and selection of task goals in working memory (updating or working memory [WM]), inhibition of prepotent action tendencies (inhibition), and switching between tasks (cognitive flexibility). There are numerous tasks measuring EFs in children, but they often differ in the way they are presented and framed (Chan, Shum, Toulopoulou, & Chen, 2008). For instance, some tasks contain child-friendly stimuli, feedback, or game elements, whereas others do not. Despite these apparent differences, it is unclear whether they affect how well children perform in the tasks even though many of these elements are likely to increase the willingness and motivation to perform the tasks.

According to Locke and Braver (2010), motivation can be defined as a current state that modulates the effort someone is willing to invest in achieving goals. This suggests that increasing motivation may lead to increased task engagement and, as a consequence, to higher performance. This hypothesis is supported by Ryan and Deci's (2000) self-determination theory (SDT), suggesting that specific factors contribute to motivational outcomes. SDT assumes that intrinsic motivation (engaging in a behavior because it is personally satisfying or fulfilling) is increased if three basic psychological needs have been met: (a) relatedness, which refers to the need to feel belongingness and connectedness with others; (b) competence, which refers to the need for challenge and for feelings of efficacy; and (c) autonomy, which refers to the need to experience one's behavior as self-determined. Thus, tasks fulfilling these three needs should result in higher intrinsic motivation to engage in the tasks. It has been suggested that adding game elements to EF tasks may be one way to enhance intrinsic motivation (e.g., Dörrenbächer, Müller, Tröger, & Kray, 2014).

Research on the effects of motivation on task performance mostly focused on the effects of rewards, showing that incentives modulated task performance and brain activity (Locke & Braver, 2010). Furthermore, increased motivation led to improved efficiency in orienting and reorienting of attention. In addition, motivation recalibrated the allocation of processing resources available to EFs to maximize potential reward (Pessoa, 2009). For instance, Padmala and Pessoa (2010) found that participants who were rewarded for performance on go trials in a stop signal task exhibited impaired inhibitory performance. The authors concluded that, to maximize reward, participants enhanced attention to the go stimuli, leaving fewer resources to process stop stimuli. Whereas these studies focused on the effects of enhancing extrinsic motivation on task performance, there is a lack of research investigating the effects of increasing intrinsic motivation on task performance.

Furthermore, there currently is no study investigating the effects of adding different game elements to EF tasks regarding motivation and task performance in children. EF training studies showed that training willingness, motivation, and performance were enhanced in training settings with video game elements as compared with settings without video game elements over the course of the training (Dörrenbächer et al., 2014; Prins, Dovis, Ponsioen, ten Brink, & van der Oord, 2011).

Therefore, we designed a battery of new EF tasks for children (three tasks for each of the three EF domains, i.e., nine new tasks). All tasks were designed in game-based and standard psychometric settings with the aim to compare them in a within-participant design. The aim of the current study was, first, to investigate whether adding game elements to EF tasks influenced the self-reported motivation to engage in these tasks. Given that the game elements were designed to enhance intrinsic motivation, we expected children to report higher motivation in the game-based version than in the standard

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