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The Assessment of Different Types of Attention in Children Using a Computerized Test Battery

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Использование компьютеризированной батареи тестов для оценки различных аспектов внимания у детей

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Abstract. We designed a computerized test battery that was used to assess sustained, selective and divided attention in children aged 8 vs. 9 years. A group of children aged 8.34 ± 0.48 years (n = 30, 14 male, 16 female) and a group of children aged 9.33 ± 0.51 years (n = 42, 21 male, 21 female) participated in the study. The test battery included one simple reaction time task, two divided attention tasks, two sustained attention tasks, and one selective attention task. The analysis of task performance revealed age-related difference in the efficiency of sustained attention: the reactions of 9-year-old children to target stimuli were significantly faster than the reactions of 8-year-old children. The computerized battery showed sensitivity to different aspects of attention and might become a useful tool for the neuropsychological assessment of attention in children with and without developmental disorders.

Keywords: *selective attention; divided attention; sustained attention; computerized test battery; Go/NoGo; SRT; Flanker task*

Аннотация. Разработанная компьютеризированная батарея тестов предназначена для исследования длительного (устойчивого), избирательного и распределенного видов внимания у детей. В исследовании приняли участие две группы детей разного возраста: 30 детей в возрасте 8.34 ± 0.48 года (14 мальчиков, 16 девочек) и 42 ребенка в возрасте

9.33 ± 0.51 года (21 мальчик, 21 девочка). Батарея тестов включала один тест на скорость реакции (Simple Reaction Time Task), два теста на распределенное внимание, два теста на непрерывное внимание и один тест на избирательное внимание. Анализ результатов выполнения тестов детьми выявил возрастные различия: время реакции у детей 9–10 лет было значительно ниже, чем у детей 8–9 лет при выполнении монотонных задач, требующих длительного удержания внимания. Разработанная батарея тестов показала «чувствительность» к различным аспектам внимания и может стать полезным диагностическим инструментом для нейропсихолога при оценке внимания у детей с нарушениями и без нарушений развития.

Ключевые слова: *избирательное внимание; распределенное внимание; длительное внимание; компьютеризированная батарея тестов; Go/NoGo; SRT; Flanker task*

Introduction

In psychology, attention is regarded as a set of cognitive processes including orienting (e. g., Herreros, Lambert, & Chica, 2017; Plude, Enns, & Brodeur, 1994; Posner, 1980), filtering (e. g., Akhtar & Enns, 1989; Das, Biesmans, Bertrand, & Francart, 2016; Plebanek & Sloutsky, 2018; Plude et al., 1994), searching (e. g., Plude et al., 1994; Woodman & Luck, 1999; Yantis & Jonides, 1984), and expecting (e. g., Brunia, Hackley, van Boxtel, Kotani, & Ohgami, 2011; Plude et al., 1994; Talalay, Kurgansky, & Machinskaya, 2018; Weiss, Meltzoff, & Marshall, 2018). However, this description is incomplete because it does not encompass all aspects of attention. On the basis of experimental studies (e. g., Gray, James, & Winterbottom, 2016; Richards, Samuels, Turnure, & Ysseldyke, 1990), we selected three components of attention that might play a major role in the regulation of cognitive processes and behavior.

These components include *selective attention* (the ability to focus on relevant stimuli while ignoring irrelevant or conflicting stimuli, *divided attention* (the ability to focus on two or more stimuli at the same time, and *sustained attention* (the ability to focus on monotonous tasks during a long period of time).

Neuropsychologists use various methods to quantitatively assess different types of attention. However, there are only few computerized tests for children that include all the above-mentioned components. Therefore, we decided to develop a computerized battery of attention tests, specially designed for school-age children.

Materials and Method

The test battery is implemented in Octave 6.1.0 (https://www.gnu.org/software/octave) on the basis of Psychtoolbox-3 (http://psychtoolbox.org) and consists of six tests.

(1) *The Simple Reaction Time task (SRT)* measures the level of general arousal (e. g., Deary, Liewald, & Nissan, 2011; Stebbins, 2007). Participants are asked to press

a response key when the target stimulus (*Fig. 1(A)*) occurs. The stimulus is presented 30 times with a stimulus onset asynchrony of 1000–2000 ms.

(2) *The Flanker task (FLANKER)* is used to assess selective attention in the neutral, congruent, and incongruent conditions (e.g., Eriksen & Eriksen, 1974; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Gratton, Cooper, Fabiani, Carter, & Karayanidis, 2018; Santhana Gopalan, Loberg, Hämäläinen, & Leppänen, 2019; *Fig. 1(F)*). In FLANKER, five horizontally aligned stimuli (either arrows or lines) occur simultaneously. A participant should detect the direction (left or right) of the target arrow in the middle and then press a corresponding key. The sets of stimuli are presented one by one at 2000 ms intervals. The test consists of 90 trials.

(3) *The Go/No-Go task with infrequent Go trials (GNG-1)* is used to assess sustained attention (e.g., Casey et al., 1997, Gratton et al., 2018). In GNG-1, three different stimuli (*Fig. 1(D)*) are presented one by one at 2000 ms intervals. A participant should react to one of them (*Fig. 1(D, 1)*) by pressing a response key. The third drawing in *Fig. 1(D)* is considered as a "trap" stimulus because of its similarity to the target stimulus. The test consists of 120 trials, 36 of which are target.

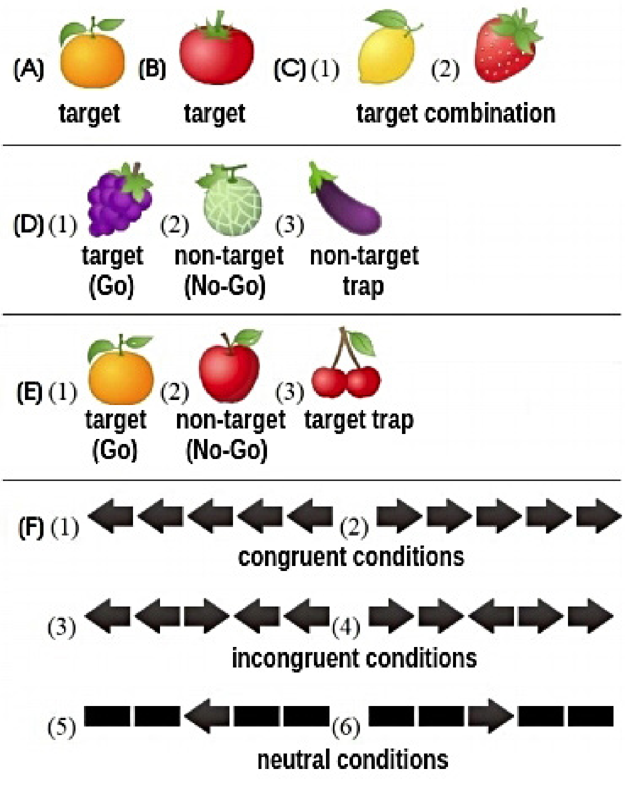

Figure 1. The stimuli used in (*A*) SRT, (*B*) DIV-1, (*C*) DIV-2, (*D*) GNG-1, (*E*) GNG-2, and (*F*) FLANKER. All stimuli are inserted in a white square with 1.5° × 1.5° angular size. All stimuli (or matrices) are presented at the center of a gray display screen

(4) *The Go/No-Go task with infrequent No-Go trials (GNG-2)* is used to assess sustained attention and response inhibition (e. g., Casey et al., 1997, Gratton et al., 2017). In GNG-2, three different stimuli (*Fig. 1(E)*) are presented one by one at 2000 ms intervals. A participant should ignore one of them (*Fig. 1(E, 2)*) and react to the other stimuli by pressing a response key. The third drawing in *Fig. 1*, *E* is considered as a "trap" stimulus because of its similarity to the non-target stimulus. The test consists of 120 trials, 48 of which are non-target.

(5) *The Divided Attention task with one target stimulus (DIV-1)* is used to assess attention divided among nine spatial sources of visual information. In DIV-1, 3-by-3 matrices of different stimuli (the drawings of fruits and vegetables) are presented one by one at 2000 ms intervals. A participant should find the target stimulus (*Fig. 1(B)*) and then press a response key. The test consists of 60 trials, in 30 of which the target stimulus appears in a random location.

(6) *The Divided Attention task with two target stimuli (DIV-2)* is a more difficult version of DIV-1. The procedure of DIV-2 is similar to the procedure of DIV-1. The only difference is that a participant should respond only when both target stimuli occur (*Fig. 1 (C, 1, 2)*). The test consists of 70 trials, in 15 of which both target stimuli appear in random locations.

The sequence of trials in each test is pseudorandom.

Two groups of children participated in the study: 30 children (14 male, 16 female) aged 8.34 ± 0.48 years and 42 children (21 male, 21 female) aged 9.33 ± 0.51 years.

All participants performed 6 attention tests. The tests were presented in two different sequences: (1) SRT, FLANKER, DIV-1, GNG-1, DIV-2, GNG-2; (2) SRT, GNG-1, DIV-1, GNG-2, DIV-2, FLANKER. The sequences were counterbalanced across participants. Participants were instructed to respond as quickly and accurately as possible for all tasks.

Results

Reaction times (RT) was analyzed that corresponded to correct-response trials and the percentage of correct responses in both groups. The analysis of task performance revealed age-related differences in the efficiency of sustained attention (*Fig. 2*).

Reaction Time

For GNG-1, the statistical analysis showed a significant difference in RT between 9-year-old ($M = 591 \pm 74$ ms) and 8-year-old ($M = 651 \pm 82$ ms) children, $t\,(70) = 3.217$, $p = .002$.

For GNG-2, a similar difference in RT between the groups was observed ($M = 661 \pm 90$ ms vs. $M = 701 \pm 77$), but it was found to be nearly significant, $t\,(70) = 1.962$, $p = .054$.

The RT values are shown separately for each attention test and each age group in *Fig. 2(1)*.

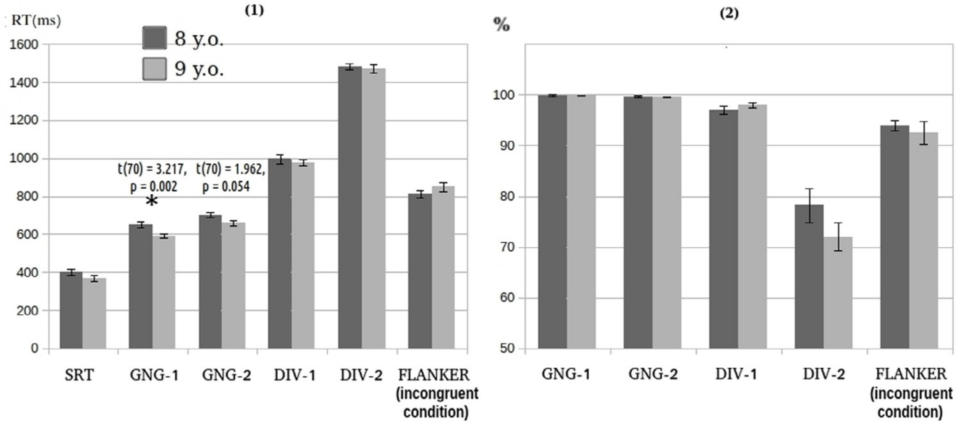

Figure 2. Averaged RT in milliseconds (1) and accuracy score percentage (2) are shown for each attention test and each age group. Error bars correspond to the standard error of mean (*SEM*). Significant differences are marked with stars

The Percentage of Correct Responses

The statistical analysis revealed no significant or nearly significant difference in the accuracy of task performance between the two groups.

The percentage of correct responses is shown separately for each attention test and each age group in *Fig. 2(2)*.

Conclusion

A computerized test battery was designed for the assessment of selective, divided, and sustained types of attention in school-age children. The battery was used to compare the efficiency of attention in typically developing children aged 8 vs. 9 years. The analysis of task performance revealed age-related difference in the efficiency of sustained attention: the reactions of 9-year-old children to target stimuli were significantly faster than the reactions of 8-year-old children.

The computerized test battery is found to be sensitive to different aspects of attention and might become a useful tool for the neuropsychological assessment of attention in children with and without developmental disorders.

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