METRICAL CHARACTERISTICS OF THE TEST FOR DETERMINING REACTION SPEED USING SIMPLE MOVEMENT WITH CHILDREN OF PRESCHOOL AGE

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Abstract:

This study was conducted in order to analyze the metrical characteristics of the test for determining reaction speed using simple movement with children of the preschool age. The sample group of 96 both sex preschool children, average age of 5,91 ±0,49 decimal years, was subject to a specially constructed system for regulating reactionary speed using simple movement. The computerized system consisted of a measuring board with a control light, a system for transferring the signal to the computer and software for registering and storing data. The subjects were in a standing position, positioned at arm's length waiting for the signal light to flash, at which they would as swiftly as possible reach out and touch the measuring board. The task was conducted in five uneven intervals, randomly generated by the software. The data of the five task performances comprised the composite variable, which was then used for analyzing the metrical characteristics of the measuring process by using the RTT11G Script program in the statistical pacage IBM SPSS 20. The determined measures were: Kaiser's measures of adequacy PSI2 (0,96), Spearman-Brown-Kuder-Richardson-Guttman-Chronbach alpha measure of reliability (0,87), Lord-Kaiser-Caffrey beta measure of adequacy of the first main component (0,87), Momirić's lower border of reliability BETA 7 (0,90) and Guttman-Nicewandor coefficient RHO measure of reliability under Guttman's model of measuring (0,95). All of the measures mentioned showed satisfying results which enabled us to conclude that the process of measuring that was used gave satisfying results with children of the preschool age. Analysis of the applicability of the measuring process showed that in practical use of the analyzed system it is enough to do 3 attempts with one trial attempt, which provides the necessary level of reliability of the measurement.

Key Words: *response time, arm movement, measuring, children, reliability*

Introduction

Reaction time, defined as the time between presentation of a stimulus and initiation of a response to that stimulus, is one of the most commonly used measures of neurological function. A common paradigm for assessing reaction time is to measure the time between presentation of a light stimulus and subsequent pressing of a response button or switch (Crabtree, & Antrim, 1988). This method is considered acceptable for determining reaction time, although the measured interval actually represents response time, the sum of reaction time and movement time. Many different types of reaction times can be measured, including responses to visual, auditory, and tactile stimuli (Schmidt, & Lee, 2005). Simple reaction time paradigms involve only one stimulus and require only one action in response. In these situations, the desired response is known in advance of the presentation of the stimulus. In choice reaction time paradigms, on the other hand, 2 or more different stimuli are involved. The stimulus conveys information about the desired response, so that the subject cannot anticipate which movement to make. Some researchers have demonstrated that reaction time increases with age in adulthood (Kiselev, Espy, & Sheffield, 2008), but no evidence about gender differences (Deary, & Der, 2005).

Relatively little is known about the nature of development of processing speed in very young children. In the developmental literature, one account of the mechanism underlying age differences in processing speed is a general developmental mechanism (Cerella, & Hale, 1994; Kail, 1993). Kiselev at al. (2008) also reported process-specific, age-related differences in processing speed in preschool children that support heterochronicity of brain development during childhood were revealed. There are few accounts on the reliability and validity of the instruments used for measuring the reaction speed in small children. Determining the validity of the measurement process was mostly achieved through the test-retest method, calculation of the coefficient of correlation or determining the interclass cross asset correlation, as well as determining the Cronbach alpha coefficient of reliability. The measuring procedures are usually computerized (eg. Deary, Liewald, & Nissan, 2011) which are based upon a specially designed software and displaying of the stimulus on a computer screen. Apart from registering the speed of a reaction to a stimulus, these systems also enable multiple choice reactions. While working on a larger project which,

among other things, consisted of assessing the motor skills of children of the preschool age we have constructed a special computerized system for measuring the time of reaction using simple hand movement. The assessment of the metrical characteristics of the measuring procedure using this system is the subject of this research. We were interested in the reliability, representability, homogeneity, and discrimination ability of the measurements on children of the preschool age while using this system.

Material & methods

The research was conducted on a sample of 96 children of the preschool age, belonging to both sexes, their average age being 5.91±0.49 decimal years. All the children attended preschool institutions in the city of Novi Sad, they were healthy and without any recorded mental or physical issues. The measurement was conducted during October of 2013 in the faculty and the preschool institution "Petar Pan" in Novi Sad.

In order to measure the reaction speed of the children's simple hand movement a unique measuring instrument was constructed; it consisted of two parts, one electromechanical and one software. The electromechanical part consisted of a copper block which acted as the touch sensor, one red diode light, a portable cable and a notebook computer which enabled the registration of the incoming signal from the measuring board and general software support. The software part of the instrument was a specifically written program – RefleXz (Figure 1) which had several functions, the most important of them being: formulating a list of users with basic data, adjusting the sensitivity of the measuring board (calibrating), adjusting the way in which the light signal was being given (manual, random), the number of times and interval in which the light signal appeared, as well as storing data and exporting it into MS Excel.

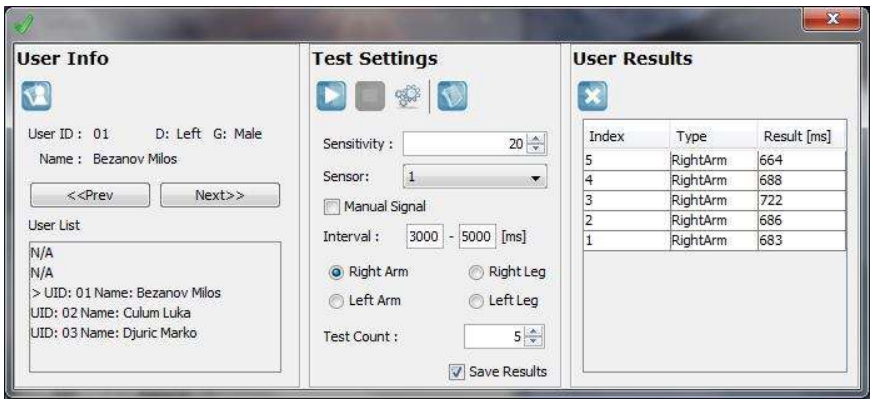

Figure 1. The main window of the test reaction time in RefleXz with preset parameters

Apart from the instruments and gear already mentioned, the measuring process also required additional space next to the wall bars of a 2x2m diameter, a table, and an available outlet of electrical energy. The measuring board would then be fastened, shoulder high, to the wall bars using two velcro straps, and from there connected to the computer using the appropriate cable. Before the measuing process the measuring board's sensitivity was calibrate to an optimal value.

The measuring protocol consisted of the following steps. The subject stood facing the board on a distance appropriate to the length of his/hers outstretched arm, so that the palm of his/her hand was resting on the board (Figure 2). After the necessary distance was establish the subjact had to stand still, in an upright position with arms lowered to the sides of the body. For the completion of the task, the subjects used their dominant hand. The taks consisted of performing five consecutive movements of the arm, as quickly as possible, until the hand met with the surface of the measuring board, upon seeing the light signal. After completing each stage of the task, the subject would return their arm to the initial position. If any premature arm movements were made, or some other unanticipated event occurred, or if there was any sort of interference, the attempt would be repeated so that five proper attempts were registered. There were no trial runs. The measuring instrument was adjusted so that the light signals appeared in random intervals (3000-5000ms), and the results were record in milliseconds.

Figure 2. Start position of body, arm position and contact with the measuring board

For all five attempts some basic descriptive statistics were calculated, the mean, standard deviation and coefficient of variation, and tested for normality of distribution using the Kolmogorov-Smirnov test. The data of the five task performances comprised the composite variable, which was then used for analyzing the metrical characteristics of the measuring process by using the RTT11G script program (Momirović, Wolf & Popović, 1999) in the statistical pacage IBM SPSS 20 (SPSS ID: 729225). The determined measures were:

- Kaiser's measures of adequacy PSI2 - measure of Sampling Adequacy (MSA) is an indicator of factorability for a collection of variables,
- Sperman-Brown-Kuder-Richardson-Guttman-Chronbach ALPHA - measure of reliability based on the classical summation measurement model that takes into account all particles, in quantitative terms,
- Lord-Kaiser-Caffrey BETA - represents the reliability of the first principal component, which means the priority of the calculation is the principal component and the projection of a single particle on it.
- Momirić's BETA7 - lower border of reliability,
- Guttman-Nicewandor coefficient RHO - measure of reliability under Guttman's model of measuring.
- Momirović's H2 - measure of homogenity that tends towards the maximum, the unit values, in those cases where the main subject of measuring predominantly enhanced when the scale is probably one-dimensional structures.

Results

Before the analysis of the metrical characteristics of the test for determining the reaction time using simple arm movement, an analysis of the basic descriptive statistics was conducted, along with the testing of the importance of the differences between boys and girls. In all the measuring items it was determined that the boys reached higher average values than the girls. However, the analysis of the speed of the simple arm movement of children of both sexes (Table 1) showed that there was no statistically signifficant differenc in any item. It was also determined that the distribution of results between the items does not stand out in a statistically relevant manner from regular distribution. These findings enabled us to conduct further analyses on the entire research sample regardless of their gender by applying the standard parametric statistical proceduress.

The realtion of average vlues and standard deviation of the measurement particles indicates a somewhat increased homogeneity of the result distribution but the discrimination ablity of the test can be interpreted as satisfying. The coefficient varation value is somewhere in between 12.24% and 17.73%.

Results should be presented precisely and should not contain material that is appropriate in the discussion. Units, quantities, and formulas should be expressed according to the International System (SI units). All measurements should be given in metric units.

Table 1. Basic descriptive statistics and the results of the differences between boys and girls

ITEM (ms)	GENDER	MEAN	SD	CV	KS	SIG.	T	SIG.
Reaction Time 1	Male	650.43	104.61	16.08	.71	.69	-1.01	.32
	Female	671.62	94.37	14.05				
Reaction Time 2	Male	662.73	112.33	16.95	1.15	.14	-.39	.70
	Female	671.18	93.29	13.89				
Reaction Time 3	Male	647.16	104.07	16.08	.79	.56	-.59	.56
	Female	683.87	83.75	12.24				
Reaction Time 4	Male	668.70	118.59	17.73	1.32	.06	-.59	.93
	Female	682.49	102.45	15.01				
Reaction Time 5	Male	693.93	118.81	17.12	.94	.34	-.36	.72
	Female	702.36	97.96	13.94				

Legend: ms - millisecondes; MEAN – average value; SD – standard deviation: T – t test value; SIG – signification; KS – Kolmogorov-Smirnov test; V – coefficient of variation (%)

The average item correlation was on a satisfactory level and it indicated a well defined first measuring subject (Table 2). This was confirmed by the high value of Caiser's PSI2 coefficient of the variable sample's adequacy ($\psi 2 = .954$), as well as a hight representability of all the items. The overall reliability of the test is on a satisfactory level ranging from .877 on the classical sumational model of measuring, to .961 on Gutman's model of measuring (Guttman, 1953). Momirović's lower border of reliability has a high value as well (.902). The assessment of the item's homogeniety showd a satisfactory value.

Table 2. Basic descriptive statistics of items and the results of the metric characteristics of items and the entire test

			Intercorrelations							
ITEM (ms)	MEAN	SD	1	2	3	4	5	REP	REL	H
Reaction Time 1	659.13	100.57	1.00					.94	.32	.61
Reaction Time 2	666.20	104.49	.58	1.00				.96	.66	.89
Reaction Time 3	662.23	97.48	.59	.76	1.00			.96	.67	.89
Reaction Time 4	674.36	111.89	.44	.56	.60	1.00		.97	.46	.79
Reaction Time 5	697.39	110.25	.43	.59	.54	.67	1.00	.96	.43	.75

Cronbach α =.877 ; Momirovic $\beta 7$ = .902 ; Lord-Kaiser-Caffrey β = .878
Guttman-Nicewander ρ = .961 ; Caiser $\psi 2$ = .954 ; Momirovic H2 = .865
Average Correlation = .589

Legend: REP – measures of item adequancy;REL - measures of item reliability; H – correlaltion of items with first common component

The second and third item had the most projection on the first main component, the first item had the lowest, which showd low reliability as well. After repeating the task for the third time the correlation values with the first subject of measuring show significant decreases in value. The average values of the items showd a tendency to grow, but those values express stability and balance after the first attempt.

Discussion

Some authors pointed our problems with distributing data received from assessing the speed of reaction (Whelan, 2008). They list the appearance of asymetrical distribution with result groupin in the zone of lower values and the appearance of extreme results in the zone of higher values. This research showed the appearance of such characteristics on the sample of preschool children as well (Figure 3). A graphycal analysis of the distribution of the measurement's five particles data showed that the described asymetry of distribution is more present with completed items, especailly with the fourth item. The linearity of the

relation is most pronounced with the first three items, and later on drops off with the end items. This can probably be attributed to loss of attention and concentraion in the last attempts of performing the task in small children. If the previously mentioned low correlation of last items with the first subject of measurement and the low coefficient of reliability are added to this, then it is possible to deduce that five consecutive repetitions of measurement was too much for a stable assessment of reaction speed in preschool children.

These findings suggest that for an optimal assessment of reaction speed in preschool children, using this system, three attempts, with one trail attempt of the given task, would be enough. This is confirmed by the calculation of Cronbach's alpha coeffient value for the first three items, which is slightly lower at .845 without performing the trial attempt.

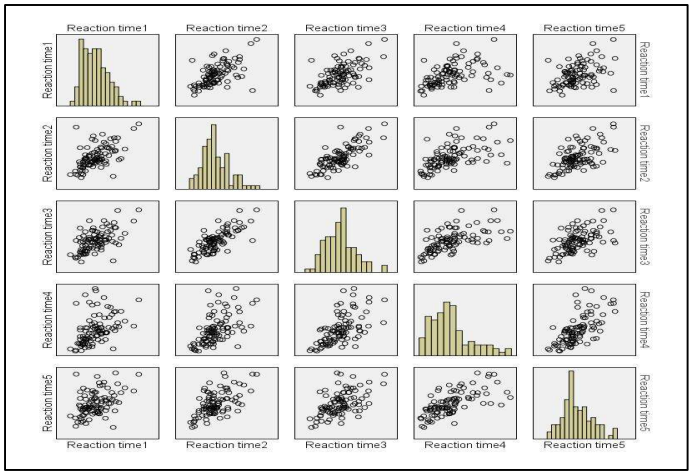

Figure 3. Matrix Scatter and Distrubution graphs for all five items

All the values of reliability attained by applying this system for measuring the reaction speed using simple arm movement in children of the preschool age, significantly surpass the limit of good reliability of .80 (George, & Mallery, 2003), and some, primarily under Gutman's model of measuring, have a value of over .90 which is considered as an excelent value of reliability of the measurement. The representability of the test as a whole, and some of its items, is high and indicates a good level of informativeness of the measuring process.

Conclusions

The protocol that was applied in measuring the reaction speed of simple arm movement in children of preschool age showed good metrical characteristics. The reliability of the measurement values were high as was the representability of the test. The practical application of the constructed aparatus showed itself to be precise and with small corrections, primarily of the measuring protocol, could be standardized. A conclussion was reached that for the optimal measuring of reaction speed using simple movement in preschool children 3 attempt at completting the taks were necessary, with one trial attempt. By applying a simple protocol for measuring, with software and accompanying tools, the system can be recommended for further use, especailly with small children.

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