The Dynamics of Simple and Complex Movement Coordination Development in Children Between the Age of 7 and 14

by
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Thanks to a long term experiment on children between the age of 7 and 14, it was possible to state that the development of hand to eye coordination based on speed of reaction to simple and complex stimuli has a similar trend. This is confirmed by the estimated relationships between the analyzed variables and the age of tested children with the use of correlation coefficients and linear regression. The research material included 679 children (285 females and 394 males) between the age of 7 and 14 years. The testing procedures included two motor tasks, a single simple motor task and a complex one, both evaluated electronically by time. In case of both types of movements the developmental trend was similar.
Key words: *hand-eye coordination, developmental trend, movement scheme*

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Introduction

The most studied and understood motor predispositions in the area of coordination include the speed of reaction, movement frequency, kinesthetic differentiation as well as balance. Also extensively researched is the eye to hand coordination ability (Szopa et al 1996). This feature is best defined as the integration of different types of movements in the process of adjusting contraction force and speed to external demands. The scientific research related to the structure and function of factors determining sensory and motor abilities has evolved significantly. The most data on the relationships between cause and effect of movements was obtained by behavior studies, in which the main objective was most often the determination of the external stimuli initiating particular movements or behaviors (Raczek et al 2000). These ideas had a strong influence on the development of applied psychology in which a basic scientific paradigm was formed, the Stimulus-Reaction formula. There are numerous examples of reactive experiments (Woodworth and Schlosberg 1963, Linhart 1972, Machnacz 2000). Schemes of reaction may be defined as relatively simple forms of motor activity, evoked by a particular stimulus. According to Tomaszewski et al (1975) they are the most elementary forms of intentional behavior, fully sufficient in common repeatable situations. Such movement responses to a particular well defined stimulus are easy to observe and evaluate. Even though this method is outdated, its practical value is still very high. This method has also found its application in physical education and sport science studies related to movement coordination. The scope of such research projects is very wide thus different testing and evaluation procedures occur.

The main objective of this research was the comparison of developmental trends in two distinct movement schemes evoked by visual stimuli. The first type of task included single movements of the fingers, classified as fine motor coordination, based primarily on the eye-hand coordination phenomena. The second type of task included gross motor coordination with complex movements of the whole body.

The following research questions were formed.

1. Are there significant differences in the development of fine and gross motor coordination in children between the age of 7 and 14?
2. Which factors determine the differences in developmental trends of fine and gross motor coordination of children between the age of 7 and 14?

Material and methods

The research material included 679 children (285 females and 394 males) between the age of 7 and 14 years. There were no significant differences in age between the tested females and males. All of the tests were conducted during physical education classes in elementary schools of Wroclaw. The research was approved by the local Ethics Committee and written consent of parents was received for the conductance of motor tests.

The research was aimed at evaluating the movement schemes in relation to the muscles engaged in performance of the specified task. The analyzed movement schemes included:

- Single simple movement. The test was based on the speed of simple reaction time to visual stimulus. The tested subject reacted as quickly as possible by pressing a knob on the electronic device with his thumb. The programmed light signals appeared in different time sequences over 110s. Ten trials were conducted with both the left and right hand. The result was registered as total reaction time of the 10 trials.
- Complex movements. The test was based on performing a complex motor task with the whole body which included running over a distance of 3m, bending forward and turning 180 degrees according to the procedures described by Hirtz (1985) and Mynarski (1995). The test was initiated by a light signal. The evaluation was electronic and expressed in seconds with the precision of 0.01s.

Basic descriptive statistics were calculated for each age category, separately for male and female children. The relationships between particular variables were determined upon Pearson's correlation coefficients. For prognostic purposes linear regression method was used (Ferguson and Takane 2003). The significance level was set at $p=0.05$.

Results

The results of the single simple movement scheme are presented in tab 1. The x-axis represents the values of the independent variable grade or age of the tested subjects. The values of the dependent variable, which included the total time of reaction to visual stimuli are presented on the y-axis. It is easy to observe from the diagram that a tendency to decrease the time to complete the simple movement task occurs with age. At the youngest considered age of 7 years the total movement time was 0.38s shorter in boys in comparison to girls (5.74 vs. 6.13). In the oldest age category considered, the 8th graders the time to complete the simple movement task significantly decreased in both sexes yet the difference (0.28s) between males and females remained at the same level as in the 7 year old children (3.51 vs. 3.79s). In case of both sexes there is a significant relationship between age and the time to complete the movement task. The correlation coefficients were (males r=0.96, females r=0.93). The regression coefficient B, equaled -0.34 in case of boys and -0.37 in case of girls what indicates the annual margin of improvement in regard to simple movement schemes.

Table 1

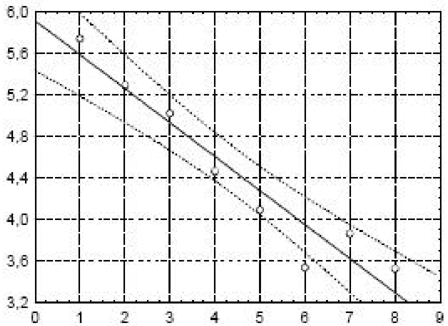
Relationships between single simple movement time and age based upon linear correlation and regression in a) boys and b) girls.

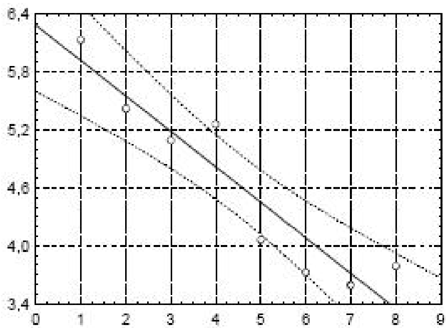
Linear regression for dependent variable: TEST_1
R= ,960 R2= ,920 Correct R^2= ,910
F(1,6)=72,89 p<,00 Err.of std.estim.: ,25

		Stand. Err.		Stand. err.		
	BETA	BETA	B	B	t(6)	p
Free exp.			5,91	0,19	30,51	0
Class	-0,96	0,11	-0,33	0,04	-8,54	0

Linear regression for dependent variable: TEST_1
R= ,94 R2= ,880 Correct R^2= ,860
F(1,6)=44,6102 p<,000 Err.of std.estim.: ,36

		Stand. err.		Stand. err.		
	BETA	BETA	B	B	t(6)	p
Free exp.			6,28	0,28	22,64	0
Class	-0,94	0,14	-0,37	0,05	-6,68	0





In case of the second type of movement scheme considered there is a clear developmental trend (Tab. 2a, b). In first graders at the approximate age of 7 there are no significant differences between boys and girls in the performance of complex movement tasks, since the results are almost identical (2.20s). In the 8th grade at the age of 14 the time of the complex movement scheme was 0.15s shorter in boys. The relationship between this variable and age is also very strong for both males (r=0.91) and females (r=0.95). It is a negative relationship because the time of the complex movement decreases with age. The linear regression for boys indicated statistical significance (p=0.05). The model explained 92% of the common variance. In females the estimated equation of regression showed statistical significance of the model (F (1.6) =86.57 p=0.05), which explains 94% of the variance of complex movement time in children by age.

Table 2

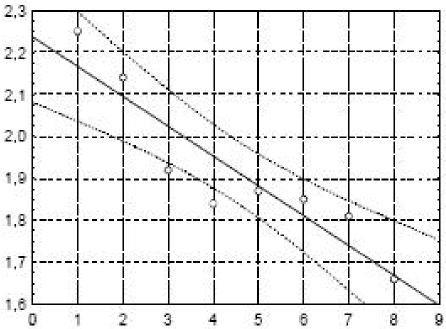
Relationships between complex movement time and age based upon linear correlation and regression in a) boys and b) girls.

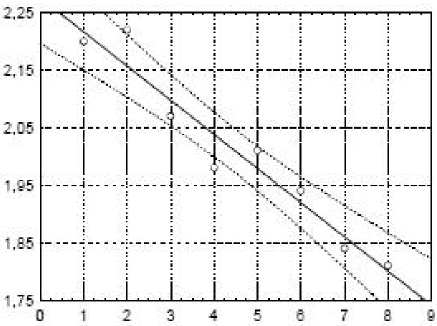
Linear regression for dependent variable: TEST_1
R= ,92 R2= ,84 Correct. R^2= ,82
F(1,6)=32,27 p<,00 Err.of std.estim.: ,08

		Stand. err.		Stand. err.		
	BETA	BETA	B	B	t(6)	p
Free exp.			2,24	0,06	35,46	0
Class	-0,92	0,16	-0,07	0,01	-5,68	0

Linear regression for dependent variable: TEST_1
R= ,97 R2= ,94 Correct R^2= ,92
F(1,6)=86,57 p<,00 Err.of std.estim.: ,041

		Stand. err.		Stand. err.		
	BETA	BETA	B	B	t(6)	p
Free. Exp			2,28	0,03	70,6	0
Class	-0,97	0,1	-0,06	0,01	-9,3	0





Discussion

The method of reactive experiment is useful in studying some aspects of eye-hand coordination. Through this method it is possible to create a cause and effect relationships and analyze different aspects of it. The most important seems the case were the stimulus evokes a particular motor reaction. A simplified scheme may be presented as follows: S? R? G. Stimulus (S), for example the light triggering the reaction and the motor reaction (R) evoked by the stimulus. The performance of the task is the goal (G) which terminates the experiment. This method allows only partial information on the complex relationships that occur in such tasks between the cognitive and motor aspects of human performance. During such research projects the objective is to evaluate the external factors determining the reaction and the motor performance. The quantitative index includes the speed of task performance evaluated in the time it takes to perform it. According to Przeweda (1981) reaction to environmental stimuli is most common for humans and is characterized by great dynamics in development in the early stages of life. These changes are caused by the biological processes of maturity in particular organs and systems as well as by the acquired experience. The considered schemes of reacting which according to recent concepts of human motor development are included in predispositions or functional traits have not been confronted with other data. This may be the consequence of concepts presented by Mleczko (1986, 1993) whose works on the development of simple reaction time and eye hand coordination are treated in Poland as classical. According to this author data obtained in different research projects may only have informative value. He states that it is possible only to compare particular traits of development between different populations since the validity and reliability is limited by different methods of selecting research material and by different evaluation procedures.

The above mentioned author conducted research on 3830 subjects between the age of 7 and 62 from Cracow. He concluded that a dynamic development of simple and complex reaction time in males occurs until the age of 17, besides the maturity spurt in which a stagnation period of this trait occurs. In females such a dynamic period of development lasted until the age of 16 (Mleczko 1986). The dynamics of development of this trait vary according to the social background of the tested subjects. The dynamics of development of polish children and youth from rural regions was different than those from the cities (Wolanski and Pyzuk 1973) and very similar to foreign rural populations (Ludwig and Hirtz 1980). In more recent, longitudinal research conducted on 8 year old children (314 children between the age of 7 and 14) the results were similar, indicating that in the life span development of these abilities, small sexual differences occur which are manifested by a earlier peak performance in females (Mleczko 1993).

On the basis of obtained results, which are in accordance to Mleczko's data, it is possible to state that the life span changes in relation to simple and complex reactions between the age of 7 and 14 are characterized by significant dynamics of development. It can thus be concluded that there is a significant influence of age on the performance of both movement schemes.

Analyzing the development of movement schemes, one must consider the fact that some movements are inborn and develop similarly in all humans in a particular time span and do not require significant learning (flexing and extending fingers). On the other hand, there are complex movements which are not conditioned genetically and require a long term learning process and experience. These movements develop separately in particular individuals at different stages of life and require learning and training. According to Tyszkowa (1977) such abilities are ontogenetically dependent. It is well know that the performance of motor reactions, their development and effectiveness is strictly related to the state of development of particular organs and the whole nervous system. This is especially true in performing highly complex activities which require the coordination of several or all senses and many different muscle groups. The central nervous system plays a key role in coordinating such activities, by not only analyzing the incoming external and internal stimuli but also by programming particular effectors for movement performance (Górska et all 2000). The maturity of the brain and whole nervous system create appropriate conditions for the development of sensor and motor activities.

Attempting to answer the second research question, it can be assumed that the described factors determining the speed of reaction in humans and especially the frontal lobe of the CNS, responsible for steering movements have not reached full development in the considered children, because dynamic changes occur in the movement schemes during successive years.

Conclusions

1. There is a significant relationship between age and the time performance of considered simple and complex movement schemes.
2. The dynamic development of the analyzed motor activities in children between the age of 7 and 14 may indicate that the biological process of maturation of particular organs and especially the CNS has not been completed.

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