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Latent Structure of Motor Abilities in Pre-School Children

Horvat Vatroslav
University of Zagreb, Zagreb, Croatia

The theoretical and practical knowledge which have so far been acquired through work with pre-school children pointed to the conclusion that the structures of the latent dimensions of the motor abilities differ greatly from such a structure, in pre-school children and adults alike. Establishing the latent structure of the motor abilities in pre-school children is a scientific challenge. In the course of a child's development, the structure of the motor abilities is constantly changing, within its latent dimensions as well as in the relation to other anthropological dimensions (Bala, Popović, & Jakšić, 2009). This research has been carried out on a sample of 230 6.5-year-old children. A battery of 15 composite tests for the evaluation of five hypothetical latent motor dimensions was used. Three tests were used for each dimension (coordination, flexibility, strength, agility and precision). Having carried out the factor analysis and oblimin rotation according to Guttman-Kaiser criterion, three latent dimensions were extracted. They were defined as: coordination with object manipulation, motor abilities general factor and flexibility. Altogether 47% of the variance of latent space was explained. The results of the factor analysis point to the conclusion that the latent space of motor abilities is still significantly undefined in pre-school children. This can be expected only at the later age.

Keywords: motor abilities, latent dimensions, children

Introduction

A kynesiologist/kindergarten teacher's primary task in working with children is a positive influence on the optimal growth and development of individual anthropological dimensions. A particularly sensitive period for the development is pre-school age. In order for this development to unfold as is appropriate, it needs to be particularly carefully planned and carried out by the kynesiologist. This primarily involves the stimulation of the development of all anthropological dimensions and their mutual integration. Among the anthropological dimensions which are influenced by the physical workout, the most important ones for the kynesiologists are the anthropometric characteristics, motor abilities and motor knowledge.

Studies of the motor abilities of pre-school children have started relatively early (Hicks, 1930). If motor activities are scarce or absent in the education of children during their development, they cannot be made up for in the later stages of development. A possibly positive influence of the motor stimuli on the child gradually weakens in the course of growing up and maturation. Insufficient number of motor experiences and opportunities for participation in motor activities can slow down motor as well as the intellectual development of a child (N. T. Kelly & B. J. Kelly, 1985; Humphrey, 1991).

Motor abilities can be defined as latent motor structures responsible for an unlimited number of manifest

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Horvat Vatroslav, Ph.D., Faculty of Teacher Education, University of Zagreb.

motor reactions and they can be measured and described (Mraković, 1992).

There have been a number of attempts at defining latent dimensions of motor abilities in pre-school children. The main problem of most studies carried out on children is the lack of adequate measuring instruments which can be used. The tests used to study motor abilities of adults are not appropriate for pre-school children. The practice has shown that a certain number of these tests, which had satisfactory metric characteristics, are not applicable on pre-school children in their manners of conduction as well as the targeted latent dimensions.

Another problem which emerges in the research of individual anthropological dimensions in children is the continuous change of the latent structure in the course of a child's growth and development. Before school start, children pass through two developmental periods. The first developmental period represents the time from the child's birth to the age of three, while the second period ends around the age of six. The research carried out up until now has shown a trend towards a gradual complicating of the latent structure of motor abilities in the course of growing up (Mraković, Findak, Metikoš, & Neljak, 1996; Katić, Dizdar, Viskić-Štalec, & Šumanović, 1997; Kosinac & Katić, 1999).

A problem noticed in the research of the motor abilities space is a great inconsistency of the results. The precondition for the scientifically correct definition of the latent structure of motor abilities in pre-school children is an appropriate measuring instrument. Several authors have suggested and checked in their studies a set of tests appropriated for pre-school children (Rajtmajer, 1993; Živčić, 1996; Videmšek, Štihec, & Kropej, 2003). The enlargement of the number of appropriate composite tests for the estimation of pre-school children's abilities is one of the key elements in the attempt to scientifically define the latent structure of the motor abilities in pre-school children. Research results in defining this structure (Rajtmajer, 1993; Pišot, 1999; Planinšec, 2002; Bala, 2009) have shown that latent dimensions of the motor abilities in children differ greatly from the dimensions of the adult population, in their quantitative as well as qualitative characteristics.

The aim of this research is to attempt at a scientific contribution to a better definition of the latent structure of motor abilities in children at the end of their second period of development.

Materials and Methods

Sample

Out of a population of Zagreb kindergarten children, a sample of 230 children was created. All children from the sample had to satisfy certain criteria in order to be included in the research. They had to be 6.5-year-old (± 6 months) at the time the research was carried out. At the time of the research, the children had to be completely healthy. For every participant included in the sample, a written consent of a parent/guardian was obtained in which they agreed to have their children included in the research. This has been carried out in accordance with the ethical codex prepared by the council for children, which is a counselling body of the Republic of Croatia.

Variables

The sample used to estimate the latent structure of children's motor abilities consisted of 15 tests. Three tests were used for each of the hypothetical latent dimensions (coordination, flexibility, strength, agility and precision). Each test was measured three times and then the average result was calculated (see Table 1).

Table 1
Sample of Variables

Test	Abbreviations	Measured capacity	Measuring unit
Pushing a ball around stands with hands	Kgr	Hand coordination	Seconds
Pushing a ball around stands with feet	Kgn	Leg coordination	Seconds
Walking backwards on all four	Khn	Coordination	Seconds
Twist with a bat	Fip	Shoulder flexibility	cm
Spread leg forward bend	Fsr	Leg flexibility	cm
Forward bend on a bench	Fpk	Flexibility	cm
Ten-meter run	S10	Strength explosive	Seconds
Standing long jump	Ssd	Strength explosive	cm
Body lifts up	Spt	Strength repetitive	No. of repetitions
Side steps	Aks	Agility	Seconds
Going around stands	Aoo	Agility	Seconds
Figure of eight with a bend	Aos	Agility	Seconds
Aiming at a target	Pgc	Precision	No. of hits
Aiming at a frame	Pgo	Precision	No. of hits
Aiming with a stick	Pcs	Precision	No. of hits

Data Analysis

For the purpose of this research, the SPSS (Statistical Package for the Social Sciences) 17.0 statistical program was used. For the purpose of establishing the latent structure of the motor characteristics, the explorative method of the factor analysis was used to establish: the correlation matrix of the manifest variables, the characteristic values of the correlation matrix (λ), the percentages of the contribution of each characteristic value to the total amount of the variance explained (λ%), the cumulative percentages of the contribution of each characteristic value to the total amount of the variance explained (cum%) and the communality of the manifest variables. After that, oblimin rotation of the original data according to the GK (Guttman-Kaiser) criterion was carried out. A matrix of the parallel projections of the manifest variables with oblimin factors (set matrix), a matrix of the correlation of the manifest variables with oblimin factors (structure matrix) and a matrix of correlations among the oblimin factors were obtained.

Results and Discussion

The latent structure was checked with factor analysis of the explorative type. From a greater number of manifest variables of motor abilities among which there is a different level of connection, by data condensation a lesser number of latent dimensions was obtained, which more or less explained such a connection.

Values of correlations among manifest variables of motor characteristics are presented in Table 2. When explaining the acquired values of individual correlations of the variables used in this research, one needs to pay attention to the "+" or "–" sign in front of the number for those variables in which lower results are in fact the better results (pushing a ball around stands with hands, pushing a ball around stands with feet, walking backwards on all four, twist with a bat, ten-meter run, side steps, going around stands and figure of eight with a bend). As opposed to the previous ones, in composite motor tests, spread leg forward bend, forward bend on a bench, standing long jump, body lifts up, aiming at a target, aiming at a frame and aiming with a stick, greater results are the better ones.

Table 2

Correlation Matrix of Manifest Morphological Variables

	kgr	kgn	khn	fip	fsr	fpk	s10	ssd	spt	aks	aoo	aos	pgc	pgo	pcs
kgr	1.00														
kgn	0.65	1													
khn	0.39	0.38	1												
fip	-0.01	-0.05	-0.10	1											
fsr	-0.05	0.01	0.04	0.11	1										
fpk	0.14	-0.01	0.15	-0.11	0.18	1									
s10	0.20	0.21	0.33	-0.16	-0.12	0.08	1								
ssd	-0.39	-0.37	-0.46	0.07	0.05	-0.16	-0.47	1							
spt	-0.31	-0.27	-0.19	-0.02	-0.06	-.05	-0.15	0.26	1						
aks	0.32	0.30	0.42	-0.15	-0.21	0.09	0.38	-0.36	-0.15	1					
aoo	0.28	0.29	0.37	-0.09	-0.24	0.06	0.33	-0.37	-0.16	0.45	1				
aos	0.39	0.37	0.48	-0.01	-0.08	0.15	0.29	-0.50	-0.20	0.47	0.54	1			
pgc	-0.22	-0.25	-0.21	0.13	0.07	0.14	-0.05	0.29	0.13	-0.12	-0.11	-0.13	1		
pgo	-0. 24	-0.18	-0.11	-0.04	0.02	-0.03	-0.14	0.31	0.10	-0.16	-0.03	-0.18	0.21	1	
pcs	-0.36	-0.29	-0.20	-0.02	0.00	-0.04	-0.04	0.27	0.17	-0.05	-0.15	-0.24	0.21	0.16	1

Notes. Correlations in bold $p < 0.01$; correlations in italics $p < 0.05$.

Values of the correlation coefficients vary from zero value among variables which are influenced by the mechanisms for movement structuring and mechanisms for synergetic regulation and the regulation of tonus (measures of body coordination and agility on one hand and measures of flexibility of certain body parts) and moderate (measures of body coordination and measures of aiming at a target and aiming precision). In the correlation, matrix and values of correlation coefficients among variables which are influenced by mechanisms for regulation of excitation intensity and mechanisms for structuring movement are also moderate.

Using factor analysis according the GK criterion, four main components have been defined which have explained 54% of the total variability of motor characteristics. Considering the fact that the main components obtained are relatively inconsistent, a model was chosen which kept an optimal number of three main components which could be defined in a more sensible way without significant information loss. In the latent structure with three main components, a total percentage of the explained variability was reduced to 47%. The values of the extracted main components are presented in Table 3. The percentage of the total variability is relatively low, yet understandable considering the sample of participants who participated in the survey as well as the values obtained in the correlation matrix. From the explained variability, one concludes that it would be scientifically justified and necessary to increase the number of the composite tests used to estimate latent space of the motor characteristics in pre-school children in the future research. It is suggested that that space could be better defined in such a way.

The first extracted main component uses up 28% of the total variance. The second main component uses up 10% of variance. The last extracted main component which is included in defining the latent space of the motor characteristics uses up 9% of the total variance. Such values are understandable considering the values of the communality which every variable shares with other variables in the latent space of the motor characteristics. The main components matrix and communality values of the individual composite tests of motor abilities are presented in Table 4.

Table 3

Particular Values (λ), Percentage of Explained Variance (λ%) and Cumulative Percentage of Explained Variance (cum%)

Factors	λ	λ%	cum%
1	4.21	28.04	28.04
2	1.52	10.11	38.16
3	1.30	8.66	46.82
4	1.07	7.12	53.94
5	0.99	6.63	60.57
6	0.89	5.93	66.50
7	0.83	5.52	72.03
8	0.77	5.17	77.19
9	0.71	4.75	81.94
10	0.60	3.98	85.92
11	0.54	3.62	89.54
12	0.48	3.20	92.74
13	0.42	2.83	95.57
14	0.35	2.34	97.91
15	0.31	2.09	100.00

Table 4

Matrix of the Main Components and Communalities of Individual Variables (com%)

	1	2	3	com%
kgr	0.69	-0.34	-0.01	0.60
kgn	0.66	-0.31	-0.10	0.54
khn	0.69	0.05	0.19	0.51
fip	-0.14	-0.36	0.06	0.16
fsr	-0.14	-0.46	0.61	0.60
fpk	0.17	0.05	0.75	0.60
s10	0.53	0.39	0.09	0.44
ssd	-0.74	0.01	-0.06	0.55
spt	-0.40	0.30	-0.10	0.26
aks	0.64	0.40	-0.02	0.57
aoo	0.63	0.39	-0.06	0.55
aos	0.73	0.14	0.12	0.56
pgc	-0.36	0.28	0.49	0.45
pgo	-0.34	0.30	0.14	0.23
pcs	-0.41	0.46	0.09	0.39

The main components extracted have in most composite tests explained a relatively moderate percentage of variance. Out of the applied variables, the greatest percentage of the explained variance have the following tests pushing a ball around stands with hands, spread leg forward bend and forward bend on a bench (60%) and the tests the values of which fit within 57% to 51% range (pushing a ball around stands with hands, walking backwards on all four, standing long jump, side steps, going around stands and figure of eight with a bend). The variables with somewhat lower values of the percentages of the explained variance are: ten-meter run, aiming at a target and aiming with a stick. These are found within 45% to 39% range. The lowest value of the communality is found in the composite tests: twist with a bat (16%), body lifts up (26%) and aiming at a frame

(23%). The cause for such low communalities can be a possible influence of error which could have occurred during measuring. This was noticed in the variables twist with a bat and body lifts up. At the composite test aiming at a frame, the reason for the low communality can be the correct understanding of the way the test was supposed to be carried out. The task was to hit a horizontally placed frame of a box. The hit was not accepted when the ball hit the ground before hitting the target and some children did not take this into consideration. Moreover, it is suggested that a certain influence on this composite test have some other anthropological characteristics of children as well as a relatively quick loss of concentration.

Also, the measurements of body lifts up have low values in explaining the variance which this variable shares with the applied set of composite tests. In this case, the cause could be found in the lack of intrinsic motivation mostly in the sample of girls. The course of measurement has shown that the boys were much more motivated to achieve better results on this test compared to the girls who had a visibly lower will for full engagement on the test. Considering the developmental characteristics of children of this age, the noted differences in the intrinsic motivation of the children with regard to their sex are understandable. Besides, one of the possible causes for such values of test results is the amount of mistakes which can occur in the estimation of the moment when the individual trials have finished. The children's task was to make as many successful lifts as possible in a ten-second period. This involved touching their knees with their shoulders at each lift. The possibility of the wrong estimation of the end of this task could have influenced the values of communality of this variable and the size of uniquity.

The other precision tests had somewhat lower communality values as expected. It is a well known fact that the percentage of error is significant in precision tests. The values were low in aiming at a frame (23%) and somewhat higher at aiming with a stick (39%) and aiming at a target (45%). In the variable aiming with a stick, a possible cause of low communality is the fact that it is "difficult" to carry out this motor task. One part of the children from the sample had great difficulties raising the stick with one hand and aiming at the target. The stronger children probably had somewhat greater chance of scoring better results. This is confirmed by the correlation of this variable with the variables for the estimation of strength. It is recommended that in the future research, this test is modified in such a way that the stick is lifted and aimed at the target with the use of both hands. Apart from the mentioned variable, aiming at a target was a composite test which children carried out gladly. However, it was probably the cause for the communality obtained in relatively bad metric characteristics which the variables for estimation of precision have shown in most studies carried out so far.

The number of the extracted components has confirmed the findings that the space of the latent dimensions of the morphological characteristics differs greatly from the latent structure of the adult population. The first main component has 28% of the explained variance. The highest projections had those composite tests constructed for estimation of coordination, agility and strength. It is well known that these composite tests are under the influence of the mechanisms for the structuring of movement and on a higher level of the mechanism for the regulation of movement and the mechanism for energetic regulation. It is obvious that the obtained structure confirms that the conclusions acquired in the studies of the motor characteristics carried out so far which have looked into the existence of the general motor abilities factor in children at the end of the second developmental period. Such a structure was suggested already in the correlation matrix of the manifest variables.

Composite tests, which are under influence of the mechanisms for the structuring of movement and the mechanisms for the synergetic regulation and tonus regulation, have moderate projections with the second main component. Besides them, there are variables with somewhat lower projections which are under the influence of mechanisms for the regulation of excitation intensity. Unfortunately, the projections of the variables with the second main component obtained do not allow for the possibility of the more sensible explanations for the pattern of the apparition of such a structure.

Tests of “spread leg forward bend” and “forward bend on a bench” as well as the variable “aiming at a target” have significant projections to the third main component. It is obvious from the main component matrix that the structure of the motor characteristics latent dimension could be defined in such a way that there is a general factor of motor abilities which was extracted in some other studies as well, while the rest was difficult to define sensibly. Obviously, among children at this age, there was no significant definition of the motor characteristics latent dimensions space.

The initial coordinate system of the three main extracted components of the motor abilities in children was transformed by the oblimin rotation in the cosine angle solution (see Table 5), the matrix of the parallel projections of the manifest variables with oblimin factors (see Table 6) and the matrix of correlation of manifest variables with oblimin factors. Finally, values of correlations between oblimin factors are presented in Table 7.

Table 5
Matrix of Parallel Projections of Manifest Variables With Oblimin Factors (Set Matrix)

	Coordination with object manipulation	General factor of motor abilities	Flexibility
kgr	0.70	0.17	0.08
kgn	0.68	0.17	-0.02
khn	0.35	0.49	0.23
fip	0.18	-0.38	0.09
fsr	0.13	-0.43	0.65
fpk	-0.10	0.18	0.75
s10	0.01	0.66	0.08
ssd	-0.46	-0.47	-0.12
spt	-0.46	-0.03	-0.16
aks	0.09	0.73	-0.02
aoo	0.10	0.71	-0.06
aos	0,32	0.58	0.15
pgc	-0.56	0.01	0.44
pgo	-0.48	0.02	0.08
pcs	-0.64	0.11	0.01

The variables “pushing a ball around stands with hands and feet” have high parallel projections to the first oblimin factor. The set of composite tests for the estimation of aiming at a target and aiming have somewhat lower, but still significant projections. The variables “standing long jump” and “body lifts up” have moderate values of parallel projections. In this extracted factor, the values of individual parallel projections have the same direction, although they have a different “+/-” sign in front. All tests for the estimation of precision have moderate parallel projections with the first oblimin factor. It is obvious that the parallel projections of the mentioned variables with the first oblimin factor are influenced by the mechanism for movement regulation and energetic regulation. Those variables which had high and significant parallel projections with the first extracted factor had high and significant correlations with the same factor in the structure matrix. The common characteristics of the tests which define this dimension are the manners of carrying out these motor tasks, as almost all require a piece of equipment (ball and stick). The only variables which do not require equipment to be carried out and measured are “standing long jump” and “body lifts up”. Those children, who have better developed repetitive strength of the stomach musculature and a higher level of explosive strength, have a better chance of achieving better results on these tests as the strength probably allows then better control of the body position and balance sustainment while the ball is being pushed with hands or feet, and in aiming at a target ad aiming. These variables are under the influence of the mechanism for movement structuring and mechanism for synergetic regulation and tonus regulation, and on a higher level under the influence of the mechanisms for movement regulation. The obtained values of the parallel projections as well as the correlations of these variables with the first factor point to the definition of this factor as body coordination with object manipulation.

All variables used to estimate the latent dimension of agility and the composite test “ten-meter run” have high parallel projections to the second factor. Besides, the variables “walking backward on all four” and “standing long jump” have the significant parallel projections with this oblimin factor. The variable “twist with a bat” has the lowest moderate projection to the first factor. This variable is situated on the opposite pole of this factor. The first variables are under the influence of the mechanism for movement structuring, while the others are under the influence of the mechanism for the regulation of the excitation intensity. On a higher level, these variables are under influence of the mechanism for movement regulation and the mechanism for energy regulation. From the values of the parallel projections, it is obvious that this factor can be defined as the “general factor of motor abilities”. This is confirmed by the values of the correlations of these variables with the other factor in the structure matrix, where they are mostly high or moderate (see Table 6).

Table 6

Correlation Matrix of the Manifest Variables With Oblimin Factors (Structure Matrix)

	Coordination with object manipulation	General factor of motor abilities	Flexibility
kgr	0.75	0.33	0.15
kgn	0.72	0.32	0.05
khn	0.48	0.57	0.28
fip	0.11	-0.34	0.09
fsr	0.10	-0.38	0.65
fpk	0.01	0.18	0.75
s10	0.16	0.66	0.10
ssd	-0.57	-0.58	-0.17
spt	-0.49	-0.13	-0.20
aks	0.25	0.75	0.01
aoo	0.25	0.73	-0.03
aos	0.47	0.66	0.20
pgc	-0.52	-0.10	0.38
pgo	-0.47	-0.08	0.04
pcs	-0.62	-0.03	-0.04

The third factor of motor abilities is best defined by the high parallel projections with composite tests which estimate the capability for carrying out the amplitude of movements, “spread leg forward bend” and “forward bend on a bench” and somewhat more moderate parallel projections, such as “aiming at the target”. It is interesting that the third variable for precision estimation had almost zero parallel projections with this factor.

A similar relation between this variable and other flexibility variables was achieved in the population of adults (Agrež, 1976). The other variables have almost zero parallel projections with this factor. Almost the same image was achieved in the correlation matrix of the manifest variables with the third factor. On the basis of the achieved values, it can be concluded that the third extracted oblimin factor has got the same structure in the set matrix as well as in the structure matrix. The achieved values of the parallel projections as well as the correlation of the manifest variables with the third factor allow one to conclude that this latent dimension could be defined as "flexibility".

The values of correlations among the extracted latent dimensions are presented in Table 7.

Table 7

Correlation Matrix Between Oblimin Factors

	Coordination with object manipulation	General factor of motor abilities	Flexibility
Coordination with object manipulation	1		
General factor of motor abilities	0.22	1	
Flexibility	0.10	0.03	1

Out of the values of the correlations between the extracted latent dimensions, it is visible that they are very low or almost at zero value. The highest obtained correlation is between the first and the second factor. As the first factor is body coordination with object manipulation and the second is the general factor of motor abilities, this correlation is understandable and expected. It is supposed that the children who achieve better results on composite tests for the estimation of coordination with object manipulation will achieve better results in the variables used for the estimation of the general factor of motor abilities. These two factors are positively directed, as the second factor is defined by the tests, the better values of which have the negative sign in front of the number. It is obvious that these factors actually share the common space.

Besides this connection, the absence of significant correlations of the third factor (flexibility) with the first two factors is noticeable. These correlations are almost zero. It is obvious that the manifest variables which define this factor behave as if they did not belong to the motor abilities' space. Some other studies have also obtained similar results on the behaviour of flexibility in the motor characteristics space in pre-school children as well as the adults (Agrež, 1976; Bala, Nićin, & Popović, 1997; Bala, Popović, & Jakšić, 2009).

From the results of the factor analysis, it can be concluded that the latent space of the motor characteristics in pre-school children is still greatly undefined. This is confirmed in the study carried out by Bala et al. (2009) about a possible trend of the changes in the latent structure of the motor abilities in children. This research was carried out on a sample of four- to eight- year-old children. On the basis of the results of this research, the author has concluded that the structure of the latent dimensions of motor abilities can be defined more significantly only after school start. There has been no significant factorisation of the motor abilities space in younger children.

The results obtained are another contribution in the attempt at better understanding of the latent space of the motor characteristics in pre-school children, which is an important precondition for carrying out of the high-quality organized kynesiological activities with pre-school children.

Conclusions

With regard to the results of the factor analysis of the group of tests used to estimate the motor abilities, which were the subject of this research, it can be concluded that three factors were obtained: coordination with object manipulation, general motor abilities factor and flexibility. It is obvious that the complete definition of the motor abilities' latent space has not yet been achieved. It is to be expected that this will occur later in life.

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