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## Criterion validation of the Scale of Psychomotor Development (SPMD) in developmental delay study of pre-school children

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### Abstract

Criterion validity and test-retest reliability of the Scale of Psychomotor Development (SPMD) was studied on groups of children of 4–6 years old. A conclusion about developmental delay or delayed speech development was used as a criterion of external validity. To examine the accuracy of the differential diagnostics of the three groups (the norm and two groups with the above diagnoses) a discriminant analysis was used. The results showed high accuracy in predicting the subject's belonging to the norm group or developmental delay group, and lower prediction accuracy for the group with delayed speech development in differentiation with the norm and developmental delay.

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### 1. Introduction

The Scale of Psychomotor Development (SPMD) was developed in 2001 to measure a wide range of psychomotor development parameters in children of 3 months to 7 years old, close to the normative group (with no diagnoses related to developmental delay or mental deficiency) [1].

The aim the present study was to analyse the sensitivity of the scale for the differential diagnostics in the study of preschool children with a temporary delay in the development of mental and speech processes. These groups of subjects included pupils of compensatory kindergartens with a medical diagnosis of F83 – Mixed specific developmental disorders. Their psychoeducational reports observed developmental delay of cerebro-organic genesis (DD) or the delayed speech development of the 2nd degree (DSD2). These findings were used as an

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external validity criterion for checking the SPMD criterion validity in the differentiation of three groups: Norm, DD, DSD2.

Another aim of the study was to expand the range of tools used for studying children from these groups. The relevance of the problem is determined by the spread of delayed cognitive development in preschool children. Delay in intellectual development as a result of organic disorders of the central nervous system ranges from 1.5 % to 10 % among children with disabilities [2]. The study by Volosovets T.V. registered a fivefold increase in the number of children with developmental delay of the cerebro-organic origin in Russia (1990 to 2003) [3]. The study of psychomotor development becomes an important differential diagnostic criterion for determining the learning potential of the child, normalisation of his/her activities. This requires tools for a detailed survey of the child's psychomotor development and longitudinal monitoring of the changes.

## 2. Method

The Scale of Psychomotor Development (SPMD) is an adaptive test in which the questions are selected individually depending on the calendar age of the child and the answers to the previous questions. The test questions are answered by a psychologist working with the child. The questions concern the child's behavioural characteristics, performance of some actions in everyday life or in a test situation. The questions are quite typical for development tests for children of the respective age. The key features of the test are related to data processing which is carried out by the test software. This software also contains stimulus materials, maintains a database, builds longitudinal study graphs of the child's development and performs other service functions.

Data processing is described in the manual in terms of fuzzy logic and membership function [4]. This article describes the processing procedure more succinctly in terms of a percentile rank often used in achievement tests. This description is provided in order to demonstrate test features and to prove the necessity of this study for verifying its psychometric properties.

Processing Stage 1 – conversion of an answer to a question to the raw score of the item. Every test item uses a categorical (dichotomous) response format and may have one of the two possible answers – “Yes” (the child can carry out control actions in everyday life, at play or following the instructions) or “No” (the child cannot). Each item is processed independently of the rest to make the test sustainable in case of data omission which often occurs when examining young children. For example, in a similar study of criterion validity EF battery 9 % of the children were unable to perform any task and many were unable to perform the entire test. That complicates the subsequent analysis of the data [5].

Processing Stage 2 - conversion of raw scores of each item into a normalised estimate of the item. It is carried out based on the previously collected normative data about the possibility of performing this action by healthy children.

Processing Stage 3 – generalisation of the normalised estimates in the items into the indicators on the scale. Selection of tasks for each age group is organised so as to obtain both positive and negative normalised estimates for each scale that subsequently allows achieving a balanced scale assessment, also ranging from -1 to 1, where 0 means that the results obtained do not deviate from those of the normative population. If the preliminary evaluation of the results (in the process of testing) shows a significant deviation from the normative results for the child's calendar age, an adaptive test mode allows you to present additional tasks for another calendar age. At various stages of designing the Scale of Psychomotor Development was tested for content and criterion validity but this concerned only the population close to normal [1, 4]. In the present study we tested criterion validity in another area of test application, namely, in the work with children who have a diagnosed deviation in mental development (DD, DSD2).

## 3. Participants

The study uses data from diagnosing 1.270 children aged 3–6 years obtained as a result of SPMD application by specialised teachers and psychologists engaged in the psycho-pedagogical support of children in regular and special pre-school educational institutions. Diagnosing was conducted as a part of a scheduled examination of children after receiving written permission from their parents. Out of 1.270 children 1.177 were part of the control group (without diagnosed diseases associated with delayed development of speech and cognitive functions), 58 children formed a DD group and 35 children a DSD2 group. Conclusions about the presence of DD or DSD2 were made outside the scope of this study by other specialists – representatives of counselling centres and commissions with the participation of neurologists, speech pathologists and psychiatrists. Thus, division of children into these groups acted in this study as an external criterion with respect to the results of the SPMD application. Available data about re-testing of 390 children 6 months after the initial testing was also used to evaluate test-retest reliability.

#### **4. Procedure**

The Scale of Psychomotor Development includes a wide range of scales with different structures at different age stages from 3 months to 7 years, including auxiliary scales used not so much for diagnosing as for planning the developing and correctional work with the child. This study used a short set of scales listed below. It is normally applied in mass screenings as well as when working with children with increased fatiguability and poor health. The list of SPMD scales used in the study: MG - Coordination of general movements, MV - Hand-eye coordination, MS - Fine motor coordination, IM - Mathematical ideas, IY - Understanding of spatial relationships, IS - Understanding of “part – whole” relationships, IL - Understanding of “similarity – difference” relationships, IG - Understanding of “general – particular” relationship, IR - Memory, IA - Attention, US - Speech development.

The following methods of data mathematical and statistical analysis were used: the Pearson correlation to assess test-retest reliability; the multivariate analysis of variance (MANOVA) with posterior paired comparisons of means to determine the differences between the groups; a discriminant analysis to study the accuracy of differential diagnosis of the groups. The discriminant analysis was performed 4 times to verify the prediction accuracy of the child’s belonging to one of the groups: 1) Norm, DD, DSD2; 2) Norm, DD; 3) Norm, DD+DSD2; 4) DD, DSD2. SPMD scales were used as discriminant variables. A stepwise discriminant variables selection method was used to ensure the best possible division of the groups [6]. Prediction accuracy was determined by employing the Cross-Validation method: In cross validation, each case is classified by the functions derived from all cases other than that case. The correctness of the parametric analysis method application is determined by an approximately normal distribution of all the scales: indices of skewness and kurtosis are significantly smaller [1]. Data processing was carried out using the IBM SPSS 22 software.

#### **5. Results**

##### *5.1. Test-Retest Reliability*

Correlations of repeated measurements for the age group of 3–4 years ranged from 0.358 to 0.589 (median 0.508), and for the age group of 5–6 years – from 0.429 to 0.832 (median 0.725). That is, the reliability of the scales for 3–4 year old children is lower than that for children of 5–6 years.

##### *5.2. Criterion Validity*

According to the results of the single factor MANOVA (factor – Group, 3 levels: Norm, DD, DSD2) the factor effect is statistically valid in relation to the totality of variables (Pillai’s Trace criterion,  $p < 0.00001$ ). The impact

of the factor Group explains 41.7 % of the total variance of variables. The effect of the factor Group is statistically valid with respect to each of the scales ( $p < 0.00001$ ). Posterior paired contrast of means (The Bonferroni Post Hoc Test) demonstrated statistically valid differences in each of the three pairs of means on each scale ( $p < 0.001$ ), except for the pair Norm – DSD2 on the scale IG ( $p = 0.082$ ). For each of the scales the highest indices were observed in the Norm group, the lowest – in the DD group and the indices in the group “DSD2” were higher than those for DD, but lower than the Norm.

Results of the discriminant analysis. The prediction accuracy of the child’s belonging to one of the groups: 1) to one of the three groups: Norm – 97 %; DD – 94.2 %; DSD2 – 38.2 %. 2) to one of the two groups: Norm – 95.6 %; DD – 96.1 %; 3) to one of the two groups: Norm – 92 %; DD+DSD2 – 84.7 %; 4) to one of the two groups: DD – 91.2 %; DSD2 – 62.9 %. Belonging to the groups Norm or DD is best predicted by a combination of scales (in the order of decreasing discriminatory power): MS, IR, IY, MG, IA, US, IM, IL (the indices are lower for the DD group). Belonging to the groups DD or DSD2 is predicted by a combination of scales (in the order of decreasing discriminatory power): MS, US, IS, IR (the indices are lower for the DD group).

## 6. Discussion

### 6.1. Test-Retest Reliability

In the analysis of test-retest reliability 6 months later the scales showed a generally low absolute level of reliability that is expected for the given sample (preschool children) and a long interval between the surveys (6 months). Improving test-retest reliability as the test subjects grow older is characteristic for the general abilities tests due to a better control of conditions of their implementation and deceleration of mental development pace in the field of the characteristics that may be subject to measurement or influence the test result [7]. That is, to receive a more accurate evaluation of test-retest reliability for pre-school children it is required to use a significantly shorter interval between measurements since significant changes may occur in just a few months. Considering these data it can be concluded that even these retest reliability level indicators which are significantly different from random ones are rather high for an interval of 6 months (very long even for adults), and allow a suggestion that if the interval is 1–2 months they would be significantly higher (we plan to check it in our next research).

### 6.2. Criterion Validity

In general the Scale of Psychomotor Development has shown high values of group factor influence (Norm, DD, DSD2) on the indices of all scales. Really high prediction accuracy of the child’s belonging to one of the groups was obtained for groups of Norm and DD (95.6 and 96.1 %, respectively), indicating a very high capacity of the test to differentiate these groups. The highest level was received for the following scales (in a descending order): MS (Fine motor coordination), IR (Memory), IY (Understanding of spatial relationships), MG (Coordination of general movements), IA (Attention), US (Speech development). In general it corresponds to the data on the clinical significance of psychomotor development scales obtained in the study “The Wechsler Preschool and Primary Scale of Intelligence” which pointed that only the overall IQ which is most closely related to the factors of visual-spatial coordination and memory, perception and speech, shows sufficiently high accuracy for the clinical use [8].

### 6.3. Limitations and Future Research

Prediction accuracy for the group DSD2 is rather low which may be related to the fact that delayed speech development is often accompanied by varying degrees of intelligence development lagging in children. The scale

“Speech development” in this test is not sufficient for studying the features of delayed speech development. To make the differential diagnosis valid and reliable it is necessary to include additional scales for a more detailed study of the speech pathology structure. In the future we plan to check the set of speech scales that are currently being developed in the application to the differential diagnosis of DSD2. Overall, test results are consistent with the original test application area and confirm the possibility of its application for diagnosing psychomotor development of preschool children with DSD2, but with limitations in terms of differentiation of DSD2 and DD.

## 7. Conclusion

The obtained psychometric indicators of SPMD test allow the conclusion that it can be used as an objective psychodiagnostic tool in assessing the probability of DD and solving the problems of the differential approach in distinguishing temporary delays in mental development of various geneses. The test has demonstrated its reliability in further study of development peculiarities in preschool children with DSD2, where for the purpose of defining the correctional strategies and content of development programs it is important to examine the status of various cognitive processes and determine the specificity of deviations in psychomotor development, and not just in speech.

When testing preschool and primary school children with DD in Russia the psychodiagnostic methods standardised on these groups are used extremely seldom. Apparently, only the tests and questionnaires for diagnosing communication features of these children were validated and standardised [9]. In this connection, verification of SPMD psychometric properties creates new opportunities for the differential diagnosis of cognitive development in children with one of the most common diagnoses “F83 – Mixed specific developmental disorder” (ICD-10) and opens up new prospects for defining the content of correction and development programs for preschool children with delayed intellectual and speech development. Successful criterion validation of the test is a necessary foundation for the development and practical application of a mathematical model of DD probability assessment with the help of the SDMP scale.

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