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Handedness: Manual Lateral Parameter – or the Result of the Researcher's Manipulation

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Abstract

The purpose of the research was to compare different methods of handedness assessment. Participants included 161 children between 4 and 7 years of age: 87 girls and 74 boys. The research incorporated typical methods used in investigations and assessment of lateral phenotype. All tests were repeated at least three times to assess their reliability in assessing children. Our findings reveal that different sets of assessments and scoring methods produced different results in determination of right- or left-handedness. Factor analysis identified three significant factors of handedness: social pressure, genetic mechanisms, and two-hand coordination. We conclude that it is necessary for assessment of handedness to use at least three tests associated with each of these factors.

Keywords: handedness, left-handedness, methods, lateral profile, children.

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1. Introduction

While handedness is an obvious phenomenon, it is hard to measure. Observable phenomenon attracts researchers because it seems to be easy to bind to some psychological parameters and to use as a predictor of psychological characteristics. Difficulty with measuring handedness is reflected in research that reported that groups of both right-handers and left-handers are heterogeneous ones [1-5]. This notion, however, is not new as authors over the past decades have introduced additional terms to describe people with different combinations of dominance in their left and right hands [6-9]. The term "ambidexterity" presupposes individuals who perform all tests equally with both hands. In reality, however, people classified as ambidextrous only perform a portion of tests with both hands equally, with the balance of tasks indicating heterogeneous predominant hands. The term "mixed-hander" is used to denote individuals who perform some tests with one predominant hand the other tests with another. It is unclear

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whether the same individuals would be classified as ambidextrous and mix-handers. Classification of handedness is determined based on performance on varied tasks with varying results [10-13]. For example, Faurie and Raymond [14] estimated handedness by correlating country-wide handedness with homicide rates and analysing in which hand a person holds a machete. Such correlational analyses do not provide evidence for causality.

The validity of questionnaires [15-16] in assessing handedness is questionable due to disparate result from tests performance under experimental conditions [9, 17]. For example, in our previous investigation, about 30% of parents did not know that their children were lefthanders and were very surprised to see that they themselves use left hands in performing some tests [9]. This is consistent with data observed by Grimshaw et al. [18], who found that magical ideation was associated with weaker hand preference as assessed with questionnaire, but was not correlated with handedness as assessed with the behavioural measure of asymmetry in hand skill.

A closer examination of questionnaire items can reveal some problems with the methodology. For example, one frequently asked question, “In which hand do you hold a tooth-brush?” can be answered differently, depending on the focus of the responder. This is the case, because a part of left-handed people takes a brush with the right hand, but then shift it to the left hand for brushing. Others brush their teeth from different sides with different hands. Likewise, the question regarding in which hand the person holds a knife during the meal, is also dependant on the environment as some people do not use a knife during the meal, and in some families all members hold it in the right hand, regardless of handedness. Similarly, the question in which hand the person holds a pen at writing is also problematic. In some cultures, social pressure is strong enough for all children at schools to be forced to hold pens in their right hands. In such cases, the converted left-handed student will be identified as right-handed [19-24].

Importantly, there are a number of handedness tests which cannot be conducted through questionnaires, but are essential for assessing qualitative performance with two hands (intermanual coordination). Hand clasping and arm folding are examples of such coordination [25]. In particular, A. Luria has shown that people with the sinister form of these tests showed similar recovery from traumatic left hemispheric aphasia as left-handers.

In addition to abovementioned measures of handedness, the laterality quotient (LQ) has been commonly used for these purposes. To calculate LQ, researchers apply questionnaire data to the formula LQ = [(R – L)/(R + L)] X 100. This formula precludes the use of the symmetrical variant. Nonetheless, many researchers use the formula and perform assessments using two hands equally. They use the LQ formula while artificially extending the research to groups of predominant laterality (both right and left), assuming symmetrical nature of the tests. Importantly, lots of literature identify the necessity to appreciate not just right or left performances, but symmetrical ones too [26]. We think that using questionnaires do not help us to capture data from which we can make valid inferences regarding handedness; we believe it is important to capture real performances and not people's notions about them. In order to make valid inferences regarding handedness based accepted definitions, it is necessary to compare various tests, while determining criteria for estimation of handedness based corresponding set of data. Such set is especially necessary for defining children's handedness, since prediction appraisals are especially significant for children between 4 and 7 years of age. In addition to data collection, it is important to compare different method of LQ calculation. In this respect, the objective of the present research was to compare the results of different methods of LQ calculation as well as the stability of different test performances by preschool children – the period when asymmetry forms.

2. Methodolog

In our research participated 161 preschool children from Saint-Petersburg: 87 girls and 74 boys of age group 4-7 years old (see Table 1).

Table 1: Children distribution by gender and age.

Age	boys	Girls	total
4.0-4.11	26	30	56
5.0-5.11	30	37	67
6.0-7.3	18	20	38

We administered tests for handedness estimation that were most commonly found in literature. Predominant hand determination was based on the following measures: (a) estimated dynamometry results (the hand pressing a carpal dynamometer DK-25 with greater force), (b) hand-clasping with their fingers interlaced (the hand with uppermost thumb was determined as the dominant), (c) arm folding (dominance was established based on which arm was the first lying on the chest), (d) shoulder test (after raising both hands with closed eyes, the higher hand is considered predominant), (e) applauding (the predominant hand is more active), (f) grabbing an object from «The Wonderful Sack» of small toys (the predominant hand picks up a toy), (g) the hand used at drawing, (h) a hand unscrewing a jar cover (the experimenter holds the jar), (i) circle and square drawing with closed eyes (the predominant hand draws smaller size, more exact forms with bigger pressure), and (j) a tapping-test. This, final assessment, used a two-sided 8,5X8,5 - sized form, with six squares on either side. The children were instructed to put the greatest possible number of dots in each square within 10 seconds (60 seconds per side). One side of the paper was reserved for the right hand while the other for the left. The mean number of dots per square was used as a measure of handedness.

Children were provided three opportunities for simultaneous demonstrations with their choice of hands recorded. For example, for hand-clasping trials, if a child clasped for the first time with the right hand, the second time with the right hand, and the third time with the left hand, the first letters of the corresponding words were recorded – RRL (right, right, left). For mathematical analyses of the results the numerical value 2 was given to each right index, 1 was given to the symmetric index (the child who did the test equally with each hand), and 0 was given to the left.

2.1. Analyses

Prognostic significance testing and factorial analysis of the resultant indicators were performed with the SPSS 11.5 statistical package for Windows. To calculate LQ, we did not use the commonly accepted formula LQ = [(R-L)/(R+L)]X100 (this method does not take into account symmetrical results). The following methods were compared.

Method 1

Mostly researchers apply the formula suggested by Bragina and Dobrohotova [27]: LQ = [(R-L) / (R+L+S)] X 100, where LQ is the laterality quotient; R is the total amount of the tests executed with the right hand; L is the total amount of the tests executed with the left hand; and S is the total amount of the tests executed with two hands simultaneously.

The uniqueness of this formula is that in numerator does not take into consideration the number of symmetrically executed tests. This leads artificially overrating the right indicator factor due to symmetrically executed tests. As a result, there is significant probability that the result can be skewed in cases when experimental samples include preschool children, a population that often performs many tests symmetrically.

Using this formula, children’s range of «handedness» based on their laterality quotient would be as follows: the left-handed would be in the range from -5 to -100;

mix-handed would be in the range from -5 to +5; right-handed would be in the range from +5 to +100 [28]. These possible ranges would produce a reduced number of children with symmetric handedness indicators because the range for dominant lateral indicators is higher than for the symmetric ones.

Method 2

According to the reasons described above, we have revised the formula: LQ = [R-L-S) / (R+L+S)] X 100; designations remain the same as in the formula proposed by N. Bragina and T. Dobrohotova.

It is obvious, that the result between the two formulas will differ dramatically whenever symmetric result are available. According to the research of Bishop [26], such results are necessary for obtaining objective data. In order to determine whether participating children were left-handed, right-handed or symmetric, we used two variants of this method. The first variant used the scale that is described above. However, in view of its obvious non-uniformity, the second variant used the second interval scale (on the basis of S. Stivens' measuring metric scale). Thus the children with factor range from -69,2 to -20,5 were considered left-handed, from -20,5 to +28,2 symmetric, and from +28,2 to +76,9 were considered right-handed. Application of the uniform scale is only possible when samples have normal distributions. We used the Kolmogorov-Smirnov test for normality and determined our sample to have a normal distribution ($p < 0{,}081$).

Method 3

Furthermore, to maximize objectivity, we propose a third method for determining handedness. For this method, we coded handedness by assigning 2 points to a right-handed performance, 1 point to a symmetric performance, and 0 points to a left-handed performance. Thus, in the event that a child performed a test with the right hand during each of the three trials, he or she would receive 6 points; alternatively, if all three trials were performed with the left hand, the child would receive 0 points. Other combinations of trial performance would yield intermediate scores. For calculation of overall handedness – we used the mean score. Accordingly, children with mean performance between 1.8 and 3.0 points were considered left-handed, from 3.1 to 4.3 – symmetric, and from 4.3 to 5.5 – right-handed. Dynamometry and tapping-test results were fixed in numerical expression and the mean of three trials for each hand was calculated.

Method 4

The fourth method for determining handedness predominance was based strictly on prevalence of performances with either the left or right hand [9]. If performances with the right side prevailed, the child was considered right-handed; if performances with the left side prevailed – left-handed. If there were performances were both right and left sides were included equally (for example, the left and right hand), and there were equal number of trials with left and right sides, then the handedness indicator was considered symmetric.

The fourth method for determining handedness underestimates the number of left-handed children, as only a few children carry out all tests with the steady use on only their left hand. Peters and Pang [8] demonstrated that most people carry out at least a portion of handedness tests with two hands or only with their right. In practice, however, this method is the simplest to use in comparison with the other abovementioned methods. Therefore, if the inaccuracy of this method of calculating handedness is inconclusive, it can be recommended to practitioners.

3. Results

Figure 1 illustrates the distribution of the children on handedness parameter estimated in the four ways described in the above section. It is obvious, that the number of left-handed, right-handed and symmetric children, estimated in different ways, differs not by percents, but by factors greater than two. For example, the symmetric group, as measured using two variants of the second method, differs by a whole order of magnitude. Thus, it is obvious, that, by manipulating the analytical method, it is possible to receive any planned result.

In addition to choosing a calculation method, it is also possible to choose particular sets of tests, each of which could determine a different number of children preferring left, symmetric or right execution (Table 2). From this table, it is evident that if the experimenter uses the set with tests 1, 2, 5, 6, and 7, the result will shift sharply to the right. Alternatively, using tests 1, 2, and 3 will shift results to the left, while using tests 3, 4, 8, along with tapping and dynamometry will produce results that indicate that most of the sample is symmetric. These results are consistent with research where one

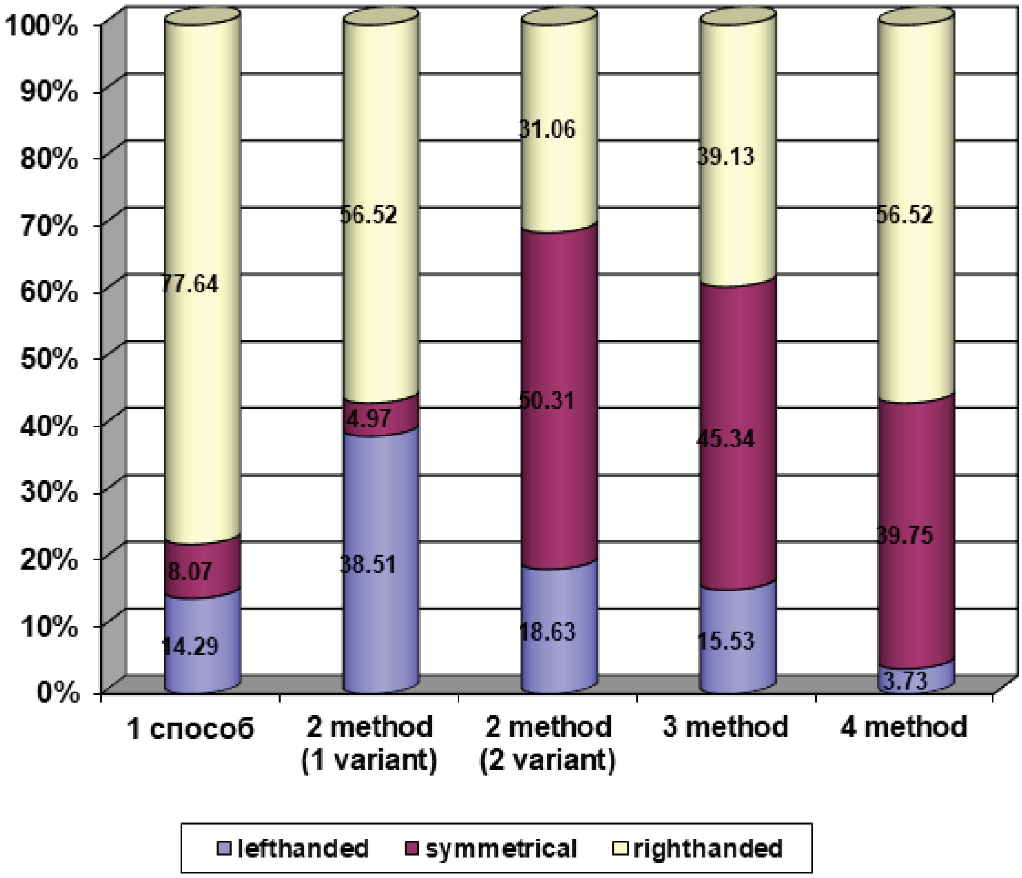

Figure 1: The distribution of children on handedness parameter estimated in various way.

method of data analyses produces nearly zero left-handed participants while another produces a sharply higher number [9-11].

Table 2: Predominance of the left, right and symmetric scores on tests of preschool children's handedness (n = 161).

Test		Left	Symmetrical	Right
1.	Hand clasping	53.4	0.6	45.9
2.	Arm folding	39.7	9.9	50.3
3.	Shoulder test	36.0	31.7	32.3
4.	Applauding	9.3	81.4	9.3
5.	Circle and square drawing	29.2	5.6	65.2
6.	Taking an object	25.5	0	74.5
7.	Drawing and writing	6.8	0	93.2
8.	Unscrewing a lid	5.6	39.7	54.7

It is important to notice that the tests investigated differ in stability of execution by preschool children (Table 3). Each test was repeated three times. Stability was calculated as a percent of similarly repeated performances (from 3) by each child.

Thereafter, results were averaged for all children. Table 3 indicates that the third and eighth tests are extremely unstable, whereas tests 1, 2, 4 and 7 are stable.

Table 3: Stability of test performance by preschool children.

Test		Stability (%)
1.	Hand-clasping	96.9
2.	Arm folding	87.6
3.	Shoulder test	38.5
4.	Applauding	86.3
5.	Circle and square drawing	62.7
6.	Hand the person takes an object with	59.0
7.	Hand used at drawing and writing.	95.6
8.	Cover unscrewing	27.3

For the further substantiation of the methods used, we conducted a factor analysis (Maximum Likelihood method) of the different tests of determining handedness (we used 4 methods of calculation and made 4 factor analyses). In all cases, except one (the 4th method), analyses indicate a three-factorial solution (Table 4). The one outstanding case produced a four-factorial solution, with one of the factors including only a small weight. The first factor included the test – "hand used at drawing," the second – "applauding," and the third – "arm folding." Earlier research on off handedness of adult boxers Nikolaenko and colleagues [29] also reported a three-factorial solution: the first factor included tests having high level of social pressure, the second factor included genetically associated tests, and the third factor included tests associated with intermanual connections.

Table 4: The parameters of Factor analysis (Maximum Likelihood method) for three methods used.

Type of method	χ^2	Df	P	Cumulative %
1	13.191	18	.780	38.7
2 (the second variant)	9.142	18	.956	37.5
3	17.747	18	.472	33.6

Early detection of latent signs of left-handedness in children will allow caretakers to treat children more cautiously, being careful not to retrain them to perform actions with their right hands. Such retraining sometimes happens imperceptibly and can cause emotional damage and neurotic symptoms that are difficult to cure [30-32].

4. Discussion

Thus, our findings indicate that by manipulating LQ calculation methods and choosing particular set of handedness tests, it is possible to get any variation of left-handedness and right-handedness distribution in a population. At the same time, it is necessary to remember that handedness is an incomplete parameter that is defined by a complex of genetic, social, and intermanual factors. These factors are substantiated by findings from this study as well as described by Nikolaenko and colleagues [20]. Since the current and previous research support a three-factor model, we conclude that at least three tests should be used in determining the dominant hand. Moreover, since it is desirable that tests determine both advantage of hands and their equality in operation, we recommend the use of at least six tests for handedness. When quick assessments of handedness are required, as is the case for paediatricians, we recommend using the arm-folding test. For this assessment, research indicates that the dominant hand is not the hand which lies on top, but the hand which lays down on the breast first, as depictions of Napoleon, one of the best known left-handed people, in numerous portraits. The other two handedness assessments could be observation of with which hand the person takes an object as well as any test estimating the intermanual connection. It is important to note that whenever an assessment of handedness uses learned movement, left-handedness could be hidden behind socially approved movements involuntarily influencing the child. In addition to choosing tests of handedness, a researcher has a choice of LQ calculation method.

5. Conclusions

Our findings suggest that it is better to use the third method of this research for LQ calculation (see above). Handedness could be the result of the researcher's manipulation, if researchers do not take into account the methods by which they explore handedness and methods that they use to count the results.

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