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Developmental norms for the Gardner Steadiness Test and the Purdue Pegboard: a study with children of a metropolitan school in Brazil

G.N.O. Brito[1,2]
and T.R. Santos-Morales[1]

[1]Laboratório de Neuropsicologia Clínica, Setor de Neurociências, Departamento de Pediatria, Instituto Fernandes Figueira, FIOCRUZ, Rio de Janeiro, RJ, Brasil
[2]Laboratório de Neuropsicologia Clínica, Setor de Neurociências, Universidade Federal Fluminense, Niterói, RJ, Brasil

Correspondence
G.N.O. Brito
Caixa Postal 100846
24001-970 Niterói, RJ
Brasil
E-mail: ccsgnob@vm.uff.br

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Abstract

Norms for the Gardner Steadiness Test and the Purdue Pegboard were developed for the neuropsychological assessment of children in the metropolitan area of Rio de Janeiro. A computer-generated unbiased sample of 346 children with a mean age of 9.4 years (SD = 2.76), who were attending a large normal public school in this urban area, was the subject of this study. Two boys were removed from the study, one for refusing to participate and the other due to severe strabismus. Therefore, the final sample contained 344 children (173 boys and 171 girls). Sex and age of the child and hand preferred for writing, but not ethnic membership or social class, had significant effects on performance in the Gardner Steadiness Test and the Purdue Pegboard. Girls outperformed boys. Older children performed better than younger children. However, the predictive relationship between age of the child and neuropsychological performance included linear and curvilinear components. Comparison of the present results to data gathered in the United States revealed that the performance of this group of Brazilian children is equivalent to that of US children after Bonferroni's correction of the alpha level of significance. It is concluded that sex and age of the child and hand preferred for writing should be taken into account when using the normative data for the two instruments evaluated in the present study. Furthermore, the relevance of neurobehavioral antidotes for the obliteration of some of the probable neuropsychological effects of cultural deprivation in Brazilian public school children is hypothesized.

Key words
- Neuropsychology
- Assessment instruments
- Norms
- Development
- Cross-cultural differences
- Manual differences
- Sex differences
- Brazil
- Metropolitan children

Introduction

Research in child neuropsychology in Brazil is hindered by the lack of appropriate normative information for neurobehavioral assessment instruments. As emphasized by Brito and colleagues (1), even major books on psychological tests published in this country (e.g., 2) do not provide normative data for most instruments therein reviewed. Even when such data exist, methodological shortcomings such as, for example, insufficient description of the demographic characteristics of the participants and the use of rather crude statistical procedures render the data of limited value for use in the Brazilian setting (cf. 1). The need for adequate locally derived normative data for instruments used in the neuropsychological assessment of children cannot be overemphasized (1).

One of the purposes of our research program is the development of adequate normative data for neuropsychological instruments used in the assessment of children and adults in Brazil. Our previous efforts in this direction have made several neurobehavioral assessment instruments available for use in this country: the Conners Abbreviated Teacher Rating Scale (3,4), the Composite Teacher Rating Scale (5,6), the Edinburgh Handedness Inventory (7-10), the Attention Deficit Hyperactivity Disorder (ADHD) (DSM-IIIR) Teacher Rating Scale (11), the Bender Gestalt Test (1,12), the Benton Right-Left Discrimination Test, Motor Persistence Tests, the Color Span Test, and WISC-R's Digit Span Test (1). The clinical applications and relevance of these instruments for research in child neuropsychology in Brazil have been described by Brito et al. (13).

The Gardner Steadiness Test (14) and the Purdue Pegboard (15) were examined in the present study because performance on both instruments has been reported to be frequently impaired in developmentally disabled children and brain-damaged adults (for reviews, see 14,16,17).

As emphasized by Gardner (14), the Steadiness Test was not designed to be a simple test for the presence of developmental disabilities involving hyperactivity and attentional deficits since it also measures motor persistence and motor coordination. Additionally, abnormal movements such as resting tremors and choreiform movements, and tension and anxiety may affect performance. However, the results derived from this test in conjunction with data obtained with other assessment instruments and the clinical history of the child may allow the examiner to conclude which neurobehavioral function is probably impaired. Along this line, Gardner (14) reported the usefulness of the Steadiness Test for monitoring drug treatment of ADHD children with psychostimulants. Furthermore, he demonstrated that psychostimulant-induced improvement in the performance of this test usually corresponds with parent description of improved behavior. Moreover, performance in this instrument also proved useful for adjusting drug dosage level when the child is being maintained on medication.

The Purdue Pegboard was originally developed to evaluate manual dexterity for the selection of employees for industrial jobs (15), but has also been used in neuropsychological assessment to provide information as to the location of cerebral damage (16,17). Gardner (14) considers that the Purdue Pegboard provides an excellent test of fine motor coordination in children with neurologically based developmental disabilities, whereas, according to Spreen and Strauss (17), this instrument is used mainly to measure finger and hand dexterity. Moderate test-retest reliabilities (15,17) and significant practice effects over several weekly sessions (16) have been reported for the Purdue Pegboard. Furthermore, according to Lezak (16), a brain lesion is probable when the performance discrepancy between the two hands is at least three points. This cutoff criterion, however, is considered to be controversial by other investigators (17). Performance in this test is determined by additional (and multiple) factors, besides fine motor coordination and finger/hand dexterity, including attention, motor persistence and the presence of abnormal movements such as resting tremors and choreiform movements. Tension and anxiety may also affect performance in the Purdue Pegboard. Furthermore, supramodal executive functions play a major role in the performance of this instrument (16).

In the present paper, we describe developmental norms for the Gardner Steadiness Test (14) and the Purdue Pegboard (15) applied to Brazilian children attending a large normal public school located in the metropolitan area of Rio de Janeiro. However, the scope of these tests was expanded with the addition of procedures not included in the standard administration of both instruments. The objective of the addition of these procedures was to derive several different measures of performance with each hand in order to ascertain performance differences between the preferred and the non-preferred hands better than presently possible. As described above, performance differences between hands might have important clinical implications for neuropsychological assessment and rehabilitation (see 16).

Material and Methods

Subjects

A computer-generated unbiased sample of 346 children was the subject of this study. The children had a mean age of 9.4 years (standard deviation = 2.76) and were drawn from a large normal public school in the greater Rio de Janeiro area (Niterói) with over 2,000 registered children in preschool, elementary and junior high school classes. As emphasized in previous publications (1,11,12), we selected the only normal school in this metropolitan area for our research program dealing with the development of normative data for instruments used in the neuropsychological assessment of children not only due to its large number of children but, more importantly, because it attracts children from all ethnic groups and social strata, albeit mostly from lower social classes, with place of residence in communities distributed throughout the city of Niterói and adjoining municipalities (São Gonçalo, Itaboraí and Maricá, RJ, Brazil). Although the children were not subjected to a psychiatric interview, they were screened for the presence of minor physical disabilities, motor and vocal tics, speech disorders, and other behavioral deviances (e.g., nail biting, stereotypes) during their two-session participation in the study by the use of the Physical Disability and Behavior Checklist described in a previous publication (13). However, only children with impairment deemed capable of interfering with performance in the Gardner Steadiness Test and the Purdue Pegboard, such as visuomotor impairment or severe motor tics, were excluded from the study. One boy who refused to be tested and another boy who presented a severe form of strabismus considered capable of interfering with visuomotor performance were excluded from the study. Therefore, the final sample contained 344 children (173 boys and 171 girls). The social class distribution of children in the present sample, according to Hollingshead and Redlich (18), was: I (0.6%, N = 2), II (2.6%, N = 9), III (9.9%, N = 34), IV (34.6%, N = 119) and V (51.2%, N = 176). Given the small number of children in social classes I and II, their data were combined with children in social class III for statistical analysis. Parents of four children did not provide the information requested to assign social class. One hundred and forty-eight children (43.0%) were Caucasian, 129 (37.5%) were of African ancestry and 67 (19.5%) were of a multiple-race group (see 19 for a discussion on race/ethnicity). For a comparative analysis of racial/color categorization in US and Brazilian censuses, the reader is referred to Nobles (20). Additionally, as described previously (11), the proportion of girls in the school increases with age due to a substantial dropout rate for boys, which is common in the Brazilian school system. Fifty-three (15.5%) children had failed in at least one grade in school. The sample included 35 (10.2%) children, 21 boys (mean age = 9.6 years, SD = 2.4) and 14 girls (mean age = 9.1 years, SD = 2.8), who preferred to write with the left hand, a frequency distribution consistent with data reported elsewhere (9,10). Thirty-three (9.5%) children in need of neurological, psychological or speech therapy, according to their teachers, were included in the normative sample. Therefore, it is presumed that the unbiased sample of participants drawn from a large pool of children in attendance of the normal school selected for the present study is representative of the population of public school children in the metropolitan area of Rio de Janeiro.

Neuropsychological battery

The neuropsychological battery used in the present study was administered during two sessions (one session a day) during the academic years of 1999 and 2000 and consisted of the tests listed below in the order administered. Children were tested individually in a quiet and air-conditioned room of the school.

The first session included the following tests:

Edinburgh Handedness Inventory (21). The procedures for the administration of the Edinburgh Handedness Inventory in children were as described (9,10). The Edinburgh Handedness Inventory was administered to the participants of the present study in order to investigate the relationships between manual preference, as assessed by the inventory, and manual specialization, as assessed by the two instruments described below. Analysis of these data is currently being conducted and will be the subject of a separate report. For the present study, however, the item of the inventory related to the hand preferred for writing was used to classify children as right- or left-handed.

Gardner Steadiness Test. The procedures for this test were reported by Gardner (14). Initially, the examiner demonstrates how to hold a stylus in a hole mounted on a metal board without making contact with the metal, while standing in front of the board. Also, the examiner demonstrates how a sound is produced when an error is made, i.e., when contact between the stylus and the hole is made. The length of the stylus, the diameter of the hole and the distance between the stylus tip and the handle point where the child grips are all standardized (14). Two digital clocks are used, one to measure the duration of the trial and the other to measure touch time during the trial. A counter collects the number of contacts made between the stylus and the metal. In order to be counted the contact has to last at least 100 ms. In the original administration, three trials of 60 s were administered only with the hand the child preferred to use in the test. In the present study, however, similar data were also collected with the non-preferred hand. Trials for each hand were administered alternately. Total number of contacts and total touch time across three trials were used for data analysis.

The second session consisted of the following test:

Purdue Pegboard. Procedures for this test were as described by Tiffin (15). Briefly, the child is instructed to practice to take pegs with the hand he or she prefers to use from the cup on the same side as the preferred hand and place them as rapidly as he or she can in the row of holes on the same side. After practice with a few pegs, the child is told to try to place as many pegs as possible with the preferred hand. The same procedure is followed with the non-preferred hand. The child is given one trial with each hand and the number of pegs placed is recorded. The trial lasts 30 s measured with a stopwatch. After these two trials, the child is requested to place as many pegs as possible with both hands over a 30-s period and the number of pairs of pegs placed is recorded. Here, the procedures used in the present study depart from the standard method in the sense that the child is requested to perform two additional tasks before the last task of the standard procedure. The first task consists of three trials with each hand alternately. In each trial, the child is asked to place ten pegs with either the preferred or the non-preferred hand as rapidly as he or she possibly can and the time taken to perform the task is recorded with a stopwatch. The second task was a modification of the task described by Annett (22). Again, three trials are administered with the child alternatively using the preferred and non-preferred hand. In each trial, the child is requested to move ten pegs from the left to the right row of holes if his or her preferred hand is the right hand and move them back to the left row with the non-preferred (left) hand. The procedure is reversed if the child's preferred hand is the left hand. Time to perform the transfer of the pegs is recorded with a stopwatch. After completion of these two tasks, the last task of the standard procedure is administered. In this task, the child is requested to build "assemblies" of a peg, a washer, a collar and another washer. The examiner instructs the child that the fastest way to form the "assemblies" is to alternate hands. Only one row of holes is used and the single trial duration is 60 s. The total number of items (pegs, washers and collars) assembled in the allotted time is recorded.

Statistical analysis

Statistical procedures available in the Statistical Analysis System package (23) were used for data analysis and followed the same principles as described in a previous report (1). Briefly, the data referring to the Gardner Steadiness Test and the Purdue Pegboard were initially subjected to multivariate analysis of variance (MANOVA) in order to control the experimentwise error rate. Sex, age, hand used for writing, ethnic group, social class and need for treatment were the independent variables. The Gardner Steadiness Test provided four dependent (neuropsychological) variables, each representing totals across the three trials administered for each hand, i.e., number of contacts and touch time. The Purdue Pegboard provided eight dependent (neuropsychological) variables: number of pegs placed with each hand, number of pairs of pegs placed with both hands, total time to place ten pegs with each hand across three trials, total time to transfer ten pegs with each hand across three trials and total number of items assembled in the "assembly" modality of the test. A significant MANOVA was followed by univariate ANOVAs for each dependent variable with age and sex as the independent variables. When the ANOVA was significant, *post hoc* Scheffé's tests were performed. Additionally, polynomial regression analyses were also performed to determine trends in performance with age. Moreover, the performance of Rio de Janeiro children was compared to that of their US counterparts by bilateral *t*-tests across sex and age groups with (and without) Bonferroni correction for error rates. In order to compare the performance of Brazilian and US children, however, the age of Brazilian children was entered into the analysis in yearly intervals exactly as presented by Gardner (14) in his normative studies of the Steadiness Test and the Purdue Pegboard in US children.

Results

MANOVAs and ANOVAs, where applicable, of data on the effects of ethnic group, social class and need for treatment on the neuropsychological variables derived from the Gardner Steadiness Test and the Purdue Pegboard revealed no significant statistical effects. Therefore, there will be no further mention of ethnic group, social class and need for treatment in the presentation of the results.

Hand used for writing, as expected, had a significant multivariate effect on performance in the Gardner Steadiness Test and the Purdue Pegboard, i.e., performance with the left hand was significantly better than performance with the right hand in children who preferred to write with the left hand, and the inverse was also true. Multiple paired *t*-tests with Bonferroni's correction for the alpha level of significance confirmed that the performance of the left hand was significantly better than the performance of the right hand for each of the variables derived from the Gardner Steadiness Test and the Purdue Pegboard (with the exclusion of performance with both hands and the assembly modality) in children who preferred to write with the left hand. Likewise, the performance of the right hand was significantly better than the performance of the left hand for each of the variables derived from those two tests in children who preferred to write with the right hand.

Hand used for writing, however, had no significant multivariate effect when the neuropsychological variables entered into the analysis were those related to performance of the preferred or non-preferred hand on the two tests described in the present study. In the case of the Gardner Steadiness Test, these variables were total number of contacts and total touch time with the left or right hand for children who preferred to write with the left or right hand, respectively, and total number of contacts and total touch time with the right or left hand for children who preferred to write with the left or right hand, respectively. For the Purdue Pegboard, the variables entered into the multivariate analysis were number of pegs placed with the left or right hand, total time to place ten pegs with the left or right hand, and total time to transfer ten pegs with the left or right hand for children who preferred to write with the left or right hand, respectively, and number of pegs placed with the right or left hand, total time to place ten pegs with the right or left hand, and total time to transfer ten pegs with the right or left hand for children who preferred to write with the left or right hand, respectively. Performance with both hands and in the assembly modality were also included in the analysis. The lack of a significant multivariate effect for hand used for writing on the variables just described was confirmed by multiple *t*-tests for independent samples which did not reveal a significant effect for any of the pairwise comparisons included in the multivariate analysis.

Taken together, the results described above demonstrate that the performance of the left hand was better than that of the right hand in children who preferred to write with the left hand and the inverse was also true. Furthermore, these results clearly show that there were no differences in performance between the left hand of children who preferred to write with the left hand and the right hand of children who preferred to write with the right hand. Likewise, there were no differences in performance between the right hand of children who preferred to write with the left hand and the left hand of children who preferred to write with the right hand. Moreover, the performance of children who preferred to write with the left hand was equivalent to that of children who preferred to write with the right hand in the two bimanual tasks of the Purdue Pegboard, i.e., both hands and the assembly modality. These results allowed us to combine the data for the performance of the left hand of children who preferred to write with the left hand with that of the right hand of children who preferred to write with the right hand as preferred-hand performance and similarly to combine the data for the performance of the right hand of children who preferred to write with the left hand with that of the left hand of children who preferred to write with the right hand as non-preferred-hand performance. Therefore, the remainder of the statistical analysis and the normative data presented below will deal with performance of the hand preferred and non-preferred for writing in lieu of performance of the left and right hand.

Gardner Steadiness Test

A MANOVA of the data for performance

in the Gardner Steadiness Test revealed significant effects of sex (F = 7.87, d.f. = 4,307, P = 0.0001) and age (F = 6.06, d.f. = 64,1204, P = 0.0001). Univariate ANOVAs showed significant sex and age effects for each of the variables derived from this test: total number of contacts with the preferred hand (sex: F = 31.16, d.f. = 1,310, P = 0.0001; age: F = 20.78, d.f. = 16,310, P = 0.0001), total number of contacts with the non-preferred hand (sex: F = 23.25, d.f. = 1,310, P = 0.0001; age: F = 17.35, d.f. = 16,310, P = 0.0001), total touch time with the preferred hand (sex: F = 8.46, d.f. = 1,310, P = 0.0039; age: F = 17.21, d.f. = 16,310, P = 0.0001), and total touch time with the non-preferred hand (sex: F = 12.11, d.f. = 1,310, P = 0.0006; age: F = 19.71, d.f. = 16,310, P = 0.0001). Girls had significantly lower scores (i.e., better performance) than boys. Additionally, *post hoc* analysis of the data showed that older children had better performance than younger children for each of the variables described above. However, polynomial regression analyses indicated not only statistically significant (all P = 0.0001) linear, but also quadratic age trends for each of the variables derived from the Gardner Steadiness Test. Therefore, the predictive relationship between age of the child and neuropsychological performance includes both linear and curvilinear components, as illustrated in Figure 1.

As expected, total number of contacts and total touch time with both the preferred and non-preferred hands correlated signifi-

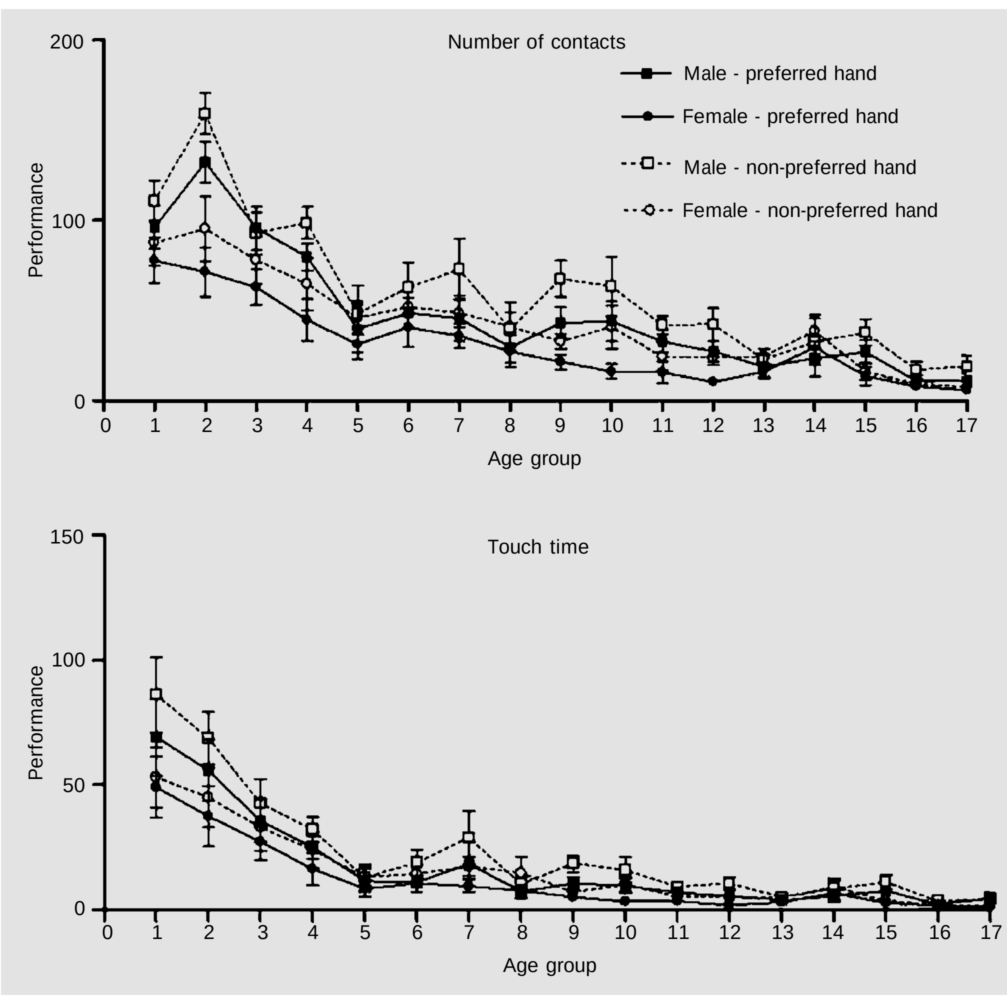

Figure 1. Performance in the Gardner Steadiness Test as a function of age groups from 1 (5.0-5.5) through 17 (14.0-15.11) exactly as shown in the appendices. The upper panel shows number of contacts and the lower panel shows touch time (s) for male and female children performing the test with their preferred and non-preferred hands.

cantly (r = 0.77, P = 0.0001 and r = 0.79, P = 0.0001, respectively).

Appendix 1 shows the normative results for the variables derived from the Gardner Steadiness Test for boys and girls across age. Data are presented separately for the preferred and non-preferred hands.

Comparison of our data with those reported by Gardner (14) revealed that Brazilian boys performed significantly worse than US boys only in the 5-0 to 5-11 age range. In addition, Brazilian girls performed significantly better in the 10-0 to 10-11 age range, but significantly worse in the 11-0 to 11-11 age range in comparison with US girls. Performance differences between Brazilian and US children were, nevertheless, eliminated after the application of Bonferroni's correction for the alpha level of significance. (Brazilian-US children comparison data are available from the first author).

Purdue Pegboard

A MANOVA of the data for the performance of the Purdue Pegboard revealed significant effects of sex (F = 3.88, d.f. = 8,303, P = 0.0002) and age (F = 6.62, d.f. = 128,2197, P = 0.0001). Univariate ANOVAs showed significant sex and age effects for each of the variables derived from this instrument, except for total time to transfer ten pegs with the non-preferred hand across three trials, which showed a significant age, but not sex, effect: number of pegs placed with the preferred hand (sex: F = 16.53, d.f. = 1,310, P = 0.0001; age: F = 41.29, d.f. = 16,310, P = 0.0001), number of pegs placed with the non-preferred hand (sex: F = 15.36, d.f. = 1,310, P = 0.0001; age: F = 39.36, d.f. = 16,310, P = 0.0001), number of pairs of pegs placed with both hands (sex: F = 3.94, d.f. = 1,310, P = 0.0480; age: F = 34.16, d.f. = 16,310, P = 0.0001), total time to place ten pegs with the preferred hand across three trials (sex: F = 11.24, d.f. = 1,310, P = 0.0009; age: F = 61.91, d.f. = 16,310, P = 0.0001), total time to place ten pegs with the non-preferred hand across three trials (sex: F = 7.48, d.f. = 1,310, P = 0.0066; age: F = 47.07, d.f. = 16,310, P = 0.0001), total time to transfer ten pegs with the preferred hand across three trials (sex: F = 5.00, d.f. = 1,310, P = 0.0261; age: F = 61.13, d.f. = 16,310, P = 0.0001), total time to transfer ten pegs with the non-preferred hand across three trials (sex: F = 1.38, d.f. = 1,310, P = N.S.; age: F = 52.72, d.f. = 16,310, P = 0.0001) and the total number of items assembled in the "assembly" modality of the test (sex: F = 16.14, d.f. = 1,310, P = 0.0001; age: F = 49.37, d.f. = 16,310, P = 0.0001). Except for total time to transfer ten pegs with the non-preferred hand across three trials, for which there was no significant effect of sex, the data demonstrated that girls had significantly better scores than boys on each of the variables described above. Additionally, *post hoc* analysis of the data showed that the older the child the better the performance in each of the variables derived from the Purdue Pegboard. However, as demonstrated for the Gardner Steadiness Test, polynomial regression analyses revealed statistically significant (all P = 0.0001) linear and quadratic age trends for each of the variables derived from the Purdue Pegboard. Therefore, the predictive relationship between age of the child and neuropsychological performance in both instruments includes linear and curvilinear components.

Appendix 2 shows the normative results for the variables derived from the Purdue Pegboard for boys and girls across age. Data are reported separately for the preferred and non-preferred hands, both hands and the assembly modality.

Multiple *t*-tests of the differences in performance in the Purdue Pegboard for US and Brazilian children across sex and age showed a few significant differences (alpha level of 0.05 for each comparison). Briefly, performance with the preferred hand was better for US boys and girls in three and two age groups, respectively, in comparison with

Brazilian children. Likewise, US boys and girls demonstrated better performance with the non-preferred hand in six and three age groups, respectively. Additionally, performance with both hands was better for US boys and girls in four and three age groups, respectively. However, Brazilian boys and girls showed better performance in the more complex assembly modality in six and five age groups, respectively. Bonferroni's correction for the alpha level of significance eliminated each of the performance differences between US and Brazilian children determined by multiple *t*-tests. (Brazilian-US children comparison data are available from the first author).

Performance differences between hands

A MANOVA of the between-hand (non-preferred minus preferred) performance difference scores for total number of contacts and total touch time (Gardner Steadiness Test) and number of pegs placed individually with each hand, total time to place ten pegs and total time to transfer ten pegs (Purdue Pegboard) revealed a significant age effect (F = 1.87, d.f. = 80,1477, P = 0.0001). Sex, however, had no significant multivariate effect on between-hand differential performance, i.e., the performance differences between the non-preferred and the preferred hand were equivalent in boys and girls. Appendix 3 shows the normative results for the between-hand performance difference scores across age for variables derived from the Gardner Steadiness Test and the Purdue Pegboard.

Discussion

The results demonstrate that ethnic group, social class and need for treatment (according to the teacher) had no effect on performance in the Gardner Steadiness Test and the Purdue Pegboard. As expected, hand preference for writing had a significant multivariate effect on performance and therefore has to be taken into account in the derivation of the normative data for these two neuropsychological assessment instruments. Additionally, girls outperformed boys and older children performed the Gardner Steadiness Test and the Purdue Pegboard better than younger children. The predictive relationship between age of the child and performance included both linear and curvilinear components. The performance differences between the preferred and the non-preferred hands in the Gardner Steadiness Test and the Purdue Pegboard demonstrated a significant age, but not sex, effect.

Moreover, comparison of the data herein presented to those obtained in the US showed a few significant differences between the two groups of children which were, nevertheless, eliminated after application of Bonferroni's correction for the alpha level of significance.

The effects of race on neuropsychological performance are considered to be confounded with socioeconomic differences and so are still largely controversial (see 16). However, the lack of effect of ethnic group on neuropsychological test performance found in the present study is in agreement with previous findings from our group (1,12). Therefore, it would appear that ethnic group has no bearing on test performance of children residing in the greater Rio de Janeiro area. In addition, the lack of effect of social class on neuropsychological test performance also reported in the present study is consistent with previous data from our group (1,12). Before we conclude that social class is unimportant for the neuropsychological performance of children residing in the metropolitan area of Rio de Janeiro, it should be noted that indices of socioeconomic status are usually reported to be related to neuropsychological performance (16,17). Therefore, the present results seem to be inconsistent with the available evidence. In our previous papers (1,12), the lack of effect of paternal occupation, an index of social class, on neuropsychological performance was attributed to the fact that such information was missing for a substantial number of the children in the sample. However, in the present report, data for social class were missing for only four children in the sample and so the lack of effect of socioeconomic status on performance in the Gardner Steadiness Test and the Purdue Pegboard cannot be explained by limitations in data. It is, of course, plausible that the reduced number of children in the upper social classes in our sample may have limited our ability to detect a significant effect of social class on the performance in the two instruments. This remains to be determined in future studies.

The significant effect of age on performance in the Gardner Steadiness Test and the Purdue Pegboard reported in the present study is consistent with data reported by other investigators (14,17). Additionally, our data show that the predictive relationship between age and neuropsychological performance includes both linear and curvilinear components. Furthermore, age had a significant effect on the between-hand performance difference scores in both tests. Therefore, the age of the child should be considered when using the normative data herein presented. Moreover, the effect of age on neuropsychomotor performance, as reported in the present study, is in agreement with a recent model of the role of the brain in human cognitive development (24) and a neuropsychological theory of motor skill learning (25). In addition, it has been reported that age has a significant effect on the performance in other instruments used in the assessment of motor function (26). Lastly, it is well known that the primate motor system has a prolonged developmental trajectory (for a review, see 27).

As reported in the present study and in previous publications from our group (1,12), and consistent with data from other investigators (e.g., 16), there seems to be a differential rate of neuropsychological development for boys and girls in the sense that girls usually outperform boys in most assessment instruments. On a molecular level, it may be suggested that the better neuropsychological performance of girls is related to developmental differences between the sexes in basic mechanisms of neuronal plasticity in the brain (see 28). Furthermore, differences in neuropsychological performance between boys and girls may depend on the extent of recruitment of populations of cortical neurons likely to be selectively activated during the planning and execution of a particular behavioral task (e.g., 29). It can be surmised that between-sex differences in the development of neuropsychological functions depend on epigenetic factors (e.g., hormones) impinging upon the brain during neural development.

Although the performance of Brazilian and US children in the Gardner Steadiness Test and the Purdue Pegboard showed a few differences related to the sex and age of the child, these differences were eliminated by statistical correction procedures for the alpha level of significance. Therefore, we conclude that there are no performance differences between the two groups of children for the two tasks described in the present study. This conclusion is not in agreement with the evidence previously obtained by our group which indicated that US children performed better than Brazilian children in several neuropsychological instruments such as the Bender Test, right-left discrimination, digit span, color span and the human-figure drawing (1,12). Possibly, the complexity of the cognitive and executive requirements for the performance of these latter instruments is higher than that required for the performance of the Gardner Steadiness Test and the Purdue Pegboard (but see 30). Inasmuch as the instruments used in the present report measure mostly primary abilities (31) such as activity, attention and motor behavior, the data gathered in our two previous studies (1,12), taken together with the results herein described, seem to provide further support for the hypothesis that the limited extent of formal academic instruction in Brazilian metropolitan public schools may lead to specific underdevelopment of secondary abilities (31) or scientific concepts (32), as proposed by Brito and colleagues (1) and consistent with recent ideas formulated by Michel (33) and Gottlieb (34). Therefore, we hypothesize that neurobehavioral antidotes along the lines advanced by Hunt (35) almost half a century ago might eliminate at least some of the neuropsychological effects of cultural deprivation found in Brazilian metropolitan public school children (1).

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Appendix 1. Performance in the Gardner Steadiness Test for boys and girls across age.

Age		Number of contacts			
		Preferred hand		Non-preferred hand	
		Male	Female	Male	Female
5.0-5.5	Means ± SD	96.0 ± 39.9	77.7 ± 39.7	110.7 ± 38.7	87.4 ± 40.7
	N	11	10	11	10
	95% CI	69.1-122.8	49.2-106.1	84.7-136.7	58.2-116.5
5.6-5.11	Means ± SD	132.2 ± 34.2	71.4 ± 42.6	159.1 ± 34.2	95.2 ± 57.2
	N	9	10	9	10
	95% CI	105.8-158.5	40.8-101.9	132.8-185.4	54.2-136.1
6.0-6.5	Means ± SD	95.7 ± 38.1	62.9 ± 31.3	92.9 ± 36.8	77.9 ± 42.6
	N	10	10	10	10
	95% CI	68.4-122.9	40.5-85.2	66.5-119.2	47.4-108.3
6.6-6.11	Means ± SD	79.7 ± 23.8	44.7 ± 36.8	98.5 ± 28.0	64.8 ± 45.9
	N	10	10	10	10
	95% CI	62.6-96.7	18.3-71.0	78.4-118.5	31.9-97.6
7.0-7.5	Means ± SD	39.7 ± 37.7	31.3 ± 27.2	48.0 ± 44.6	45.8 ± 29.5
	N	8	10	8	10
	95% CI	8.1-71.3	11.7-50.8	10.6-85.3	24.6-66.9
7.6-7.11	Means ± SD	48.4 ± 29.2	40.5 ± 33.2	62.6 ± 48.0	51.9 ± 35.3
	N	12	10	12	10
	95% CI	29.8-66.9	16.6-64.3	32.1-93.1	26.5-77.2
8.0-8.5	Means ± SD	45.6 ± 40.7	35.9 ± 21.7	72.7 ± 53.6	48.5 ± 25.7
	N	10	10	10	10
	95% CI	16.4-74.7	20.3-51.4	34.3-111.0	30.0-66.9
8.6-8.11	Means ± SD	29.5 ± 27.7	27.2 ± 29.5	39.5 ± 28.9	40.9 ± 44.6
	N	10	11	10	11
	95% CI	9.6-49.3	7.4-47.1	18.7-60.2	10.9-70.9
9.0-9.5	Means ± SD	43.1 ± 27.0	21.4 ± 13.4	67.5 ± 31.8	32.8 ± 13.5
	N	10	10	10	10
	95% CI	23.7-62.4	11.7-31.0	44.7-90.2	23.0-42.5
9.6-9.11	Means ± SD	43.9 ± 36.8	16.0 ± 11.4	63.2 ± 54.4	40.7 ± 33.8
	N	11	8	11	8
	95% CI	19.1-68.6	6.4-25.5	26.6-99.8	12.4-69.0
10.0-10.5	Means ± SD	32.7 ± 20.0	15.6 ± 18.9	41.7 ± 15.6	24.3 ± 25.4
	N	10	10	10	10
	95% CI	18.3-47.0	2.0-29.1	30.4-52.9	6.0-42.5
10.5-10.11	Means ± SD	27.2 ± 17.2	10.3 ± 8.0	42.2 ± 28.3	23.8 ± 13.4
	N	10	10	10	10
	95% CI	14.8-39.5	4.5-16.0	21.8-62.5	14.1-33.4
11.0-11.5	Means ± SD	18.7 ± 21.0	16.0 ± 9.1	22.8 ± 18.5	24.4 ± 13.7
	N	10	10	10	10
	95% CI	3.6-33.7	9.4-22.5	9.5-36.0	14.5-34.2
11.6-11.11	Means ± SD	23.4 ± 30.9	29.6 ± 21.5	32.4 ± 41.2	38.5 ± 29.4
	N	10	10	10	10
	95% CI	1.2-45.5	14.1-45.0	2.9-61.8	17.4-59.5
12.0-12.11	Means ± SD	26.9 ± 21.3	13.4 ± 16.9	37.6 ± 23.3	16.0 ± 15.2
	N	10	11	10	11
	95% CI	11.6-42.1	2.0-24.8	20.9-54.2	5.8-26.3
13.0-13.11	Means ± SD	10.8 ± 11.3	7.7 ± 5.7	16.9 ± 15.0	9.1 ± 5.8
	N	11	10	11	10
	95% CI	3.1-18.4	3.6-11.7	6.8-26.9	4.9-13.2
14.0-15.11	Means ± SD	11.2 ± 13.1	5.4 ± 5.2	18.9 ± 21.1	7.6 ± 6.1
	N	11	11	11	11
	95% CI	2.4-20.0	1.8-9.0	4.6-33.1	3.5-11.7

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Appendix 1. Continued.

Age		Touch time (s)			
		Preferred hand		Non-preferred hand	
		Male	Female	Male	Female
5.0-5.5	Means ± SD	69.1 ± 51.3	49.1 ± 39.0	86.1 ± 50.1	52.9 ± 38.0
	N	11	10	11	10
	95% CI	34.6-103.7	21.1-77.0	52.4-119.7	25.7-80.1
5.6-5.11	Means ± SD	55.7 ± 37.1	37.3 ± 38.4	68.7 ± 31.5	44.9 ± 37.8
	N	9	10	9	10
	95% CI	27.2-84.2	9.8-64.8	44.4-92.9	17.8-72.0
6.0-6.5	Means ± SD	35.5 ± 26.7	27.2 ± 23.3	42.5 ± 29.8	33.0 ± 30.0
	N	10	10	10	10
	95% CI	16.3-54.6	10.5-43.9	21.1-63.9	11.5-54.5
6.6-6.11	Means ± SD	25.0 ± 13.8	16.2 ± 19.7	32.0 ± 15.7	23.8 ± 23.2
	N	10	10	10	10
	95% CI	15.1-34.9	2.1-30.3	20.7-43.2	7.2-40.5
7.0-7.5	Means ± SD	11.5 ± 13.0	8.4 ± 9.2	12.8 ± 14.5	12.9 ± 11.2
	N	8	10	8	10
	95% CI	0.5-22.4	1.8-15.0	0.6-24.9	4.9-20.9
7.6-7.11	Means ± SD	11.1 ± 7.8	10.5 ± 10.2	18.7 ± 18.0	14.3 ± 12.0
	N	12	10	12	10
	95% CI	6.1-16.1	3.2-17.8	7.2-30.2	5.7-22.9
8.0-8.5	Means ± SD	18.2 ± 27.7	9.3 ± 7.7	28.7 ± 34.2	17.2 ± 12.4
	N	10	10	10	10
	95% CI	0.0-38.1	3.8-14.9	4.2-53.2	8.3-26.1
8.6-8.11	Means ± SD	7.3 ± 8.2	7.6 ± 10.9	10.2 ± 8.6	14.7 ± 21.0
	N	10	11	10	11
	95% CI	1.4-13.1	0.3-14.9	4.0-16.3	0.5-28.8
9.0-9.5	Means ± SD	10.6 ± 7.8	5.0 ± 4.3	18.4 ± 10.9	6.9 ± 3.4
	N	10	10	10	10
	95% CI	5.0-16.2	1.9-8.1	10.6-26.2	4.4-9.4
9.6-9.11	Means ± SD	9.5 ± 9.1	3.3 ± 2.3	15.9 ± 17.2	10.0 ± 8.7
	N	11	8	11	8
	95% CI	3.4-15.7	1.3-5.2	4.3-27.5	2.6-17.3
10.0-10.5	Means ± SD	6.9 ± 4.2	3.4 ± 4.6	9.1 ± 3.3	5.1 ± 6.0
	N	10	10	10	10
	95% CI	3.8-9.9	0.0-6.7	6.7-11.5	0.8-9.5
10.5-10.11	Means ± SD	5.6 ± 3.8	1.9 ± 1.4	10.5 ± 7.5	5.1 ± 3.7
	N	10	10	10	10
	95% CI	2.8-8.3	0.9-2.9	5.1-15.9	2.5-7.8
11.0-11.5	Means ± SD	3.8 ± 5.7	3.1 ± 2.4	5.0 ± 5.4	4.6 ± 3.2
	N	10	10	10	10
	95% CI	0.0-7.9	1.3-4.8	1.1-8.9	2.3-7.0
11.6-11.11	Means ± SD	5.4 ± 8.4	6.6 ± 5.7	8.3 ± 13.1	9.1 ± 7.9
	N	10	10	10	10
	95% CI	0.0-11.5	2.5-10.7	0.0-17.7	3.4-14.7
12.0-12.11	Means ± SD	7.5 ± 6.7	2.7 ± 3.9	11.0 ± 9.2	3.6 ± 3.9
	N	10	11	10	11
	95% CI	2.7-12.3	0.1-5.3	4.4-17.6	0.9-6.2
13.0-13.11	Means ± SD	2.2 ± 2.4	1.4 ± 1.1	3.2 ± 3.0	1.8 ± 1.3
	N	11	10	11	10
	95% CI	0.5-3.8	0.6-2.2	1.2-5.3	0.8-2.8
14.0-15.11	Means ± SD	4.5 ± 8.4	0.9 ± 0.9	4.2 ± 5.0	1.3 ± 0.9
	N	11	11	11	11
	95% CI	0.0-10.1	0.3-1.6	0.8-7.7	0.7-2.0

Data are reported as means ± SD and the 95% confidence intervals (95% CI) are given below. N, number of children.

Appendix 2. Performance in the Purdue Pegboard for boys and girls across age.

Age		Preferred hand		Non-preferred hand	
		Male	Female	Male	Female
5.0-5.5	Means ± SD	8.7 ± 1.0	9.4 ± 2.0	8.0 ± 1.5	8.5 ± 1.5
	N	11	10	11	10
	95% CI	8.0-9.4	7.9-10.8	6.9-9.0	7.4-9.5
5.6-5.11	Means ± SD	7.5 ± 1.1	9.0 ± 1.5	7.2 ± 0.9	7.5 ± 1.5
	N	9	10	9	10
	95% CI	6.6-8.4	7.8-10.1	6.4-7.9	6.4-8.5
6.0-6.5	Means ± SD	9.8 ± 1.4	10.3 ± 0.9	9.0 ± 1.6	8.6 ± 1.3
	N	10	10	10	10
	95% CI	8.7-10.8	9.6-10.9	7.7-10.2	7.6-9.5
6.6-6.11	Means ± SD	10.8 ± 1.2	10.8 ± 1.5	9.0 ± 1.2	10.2 ± 0.9
	N	10	10	10	10
	95% CI	9.9-11.6	9.6-11.9	8.1-9.8	9.5-10.8
7.0-7.5	Means ± SD	11.2 ± 1.4	11.7 ± 1.4	9.5 ± 1.3	10.6 ± 2.0
	N	8	10	8	10
	95% CI	10.0-12.4	10.6-12.7	8.4-10.5	9.1-12.0
7.6-7.11	Means ± SD	12.1 ± 1.4	11.9 ± 1.6	10.5 ± 1.3	10.3 ± 1.7
	N	12	10	12	10
	95% CI	11.2-13.0	10.7-13.0	9.6-11.3	9.0-11.5
8.0-8.5	Means ± SD	12.3 ± 1.2	13.5 ± 1.2	10.5 ± 1.1	11.5 ± 1.2
	N	10	10	10	10
	95% CI	11.4-13.1	12.5-14.4	9.6-11.3	10.5-12.4
8.6-8.11	Means ± SD	12.2 ± 1.8	13.8 ± 1.2	11.3 ± 2.2	12.2 ± 1.4
	N	10	11	10	11
	95% CI	10.9-13.4	12.9-14.6	9.6-12.9	11.2-13.2
9.0-9.5	Means ± SD	12.3 ± 1.4	13.4 ± 2.0	11.5 ± 1.5	11.8 ± 1.6
	N	10	10	10	10
	95% CI	11.2-13.3	11.9-14.8	10.3-12.6	10.6-12.9
9.6-9.11	Means ± SD	13.0 ± 1.3	12.6 ± 1.3	11.5 ± 0.8	11.7 ± 1.3
	N	11	8	11	8
	95% CI	12.1-14.0	11.5-13.7	10.9-12.0	10.5-12.9
10.0-10.5	Means ± SD	13.1 ± 1.9	14.3 ± 1.1	12.4 ± 1.7	12.8 ± 1.1
	N	10	10	10	10
	95% CI	11.7-14.4	13.4-15.1	11.1-13.6	11.9-13.6
10.5-10.11	Means ± SD	14.0 ± 1.3	14.4 ± 1.1	11.9 ± 1.1	12.9 ± 1.5
	N	10	10	10	10
	95% CI	13.0-14.9	13.5-15.2	11.0-12.7	11.7-14.0
11.0-11.5	Means ± SD	13.6 ± 1.1	13.7 ± 1.5	13.0 ± 1.1	13.6 ± 1.8
	N	10	10	10	10
	95% CI	12.7-14.4	12.5-14.8	12.1-13.8	12.2-14.9
11.6-11.11	Means ± SD	14.5 ± 1.3	15.2 ± 1.7	12.7 ± 1.1	12.9 ± 0.7
	N	10	10	10	10
	95% CI	13.5-15.4	13.9-16.4	11.8-13.5	12.3-13.4
12.0-12.11	Means ± SD	13.7 ± 1.4	15.1 ± 2.4	12.4 ± 2.3	14.6 ± 1.0
	N	10	11	10	11
	95% CI	12.6-14.7	13.5-16.8	10.7-14.0	13.9-15.3
13.0-13.11	Means ± SD	15.7 ± 1.7	15.7 ± 1.1	13.9 ± 1.2	14.3 ± 1.5
	N	11	10	11	10
	95% CI	14.5-16.9	14.8-16.5	13.0-14.7	13.1-15.4
14.0-15.11	Means ± SD	15.0 ± 1.7	16.3 ± 1.6	13.8 ± 1.1	14.6 ± 1.6
	N	11	11	11	11
	95% CI	13.9-16.2	15.2-17.4	13.0-14.6	13.5-15.7

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Appendix 2. Continued.

Age		Both hands		Assembly	
		Male	Female	Male	Female
5.0-5.5	Means ± SD	6.0 ± 1.5	5.8 ± 1.8	12.0 ± 4.0	14.9 ± 3.1
	N	11	10	11	10
	95% CI	5.0-7.1	4.5-7.0	9.2-14.7	12.6-17.1
5.6-5.11	Means ± SD	6.2 ± 1.3	6.4 ± 1.1	13.5 ± 3.6	14.4 ± 4.7
	N	9	10	9	10
	95% CI	5.2-7.2	5.5-7.2	10.7-16.3	11.0-17.7
6.0-6.5	Means ± SD	7.3 ± 1.4	6.8 ± 1.2	17.9 ± 3.6	17.6 ± 4.1
	N	10	10	10	10
	95% CI	6.2-8.3	5.9-7.6	15.2-20.5	14.6-20.5
6.6-6.11	Means ± SD	7.6 ± 1.2	8.0 ± 0.8	17.0 ± 4.6	23.0 ± 7.3
	N	10	10	10	10
	95% CI	6.6-8.5	7.4-8.5	13.6-20.3	17.7-28.2
7.0-7.5	Means ± SD	8.2 ± 1.6	8.8 ± 1.7	21.8 ± 6.2	26.8 ± 5.6
	N	8	10	8	10
	95% CI	6.8-9.6	7.5-10.0	16.6-27.1	22.7-30.8
7.6-7.11	Means ± SD	9.3 ± 1.6	8.6 ± 1.3	24.3 ± 5.0	24.4 ± 5.1
	N	12	10	12	10
	95% CI	8.3-10.3	7.6-9.5	21.1-27.5	20.7-28.0
8.0-8.5	Means ± SD	8.2 ± 1.6	8.9 ± 1.1	22.5 ± 4.6	27.1 ± 3.0
	N	10	10	10	10
	95% CI	6.9-9.4	8.0-9.7	19.1-25.8	24.9-29.2
8.6-8.11	Means ± SD	9.8 ± 0.9	10.3 ± 1.7	27.3 ± 3.4	31.7 ± 3.5
	N	10	11	10	11
	95% CI	9.1-10.4	9.1-11.5	24.7-29.8	29.3-34.1
9.0-9.5	Means ± SD	9.7 ± 0.6	9.9 ± 1.6	24.6 ± 6.5	27.4 ± 5.1
	N	10	10	10	10
	95% CI	9.2-10.1	8.7-11.0	19.9-29.2	23.7-31.0
9.6-9.11	Means ± SD	9.5 ± 1.2	10.5 ± 1.9	28.9 ± 3.8	30.5 ± 5.1
	N	11	8	11	8
	95% CI	8.6-10.4	8.8-12.1	26.3-31.4	26.1-34.8
10.0-10.5	Means ± SD	10.6 ± 1.7	10.3 ± 1.6	32.5 ± 5.8	32.6 ± 5.2
	N	10	10	10	10
	95% CI	9.3-11.8	9.1-11.4	28.2-36.7	28.8-36.3
10.5-10.11	Means ± SD	10.5 ± 1.4	10.7 ± 1.7	32.1 ± 4.4	32.2 ± 3.5
	N	10	10	10	10
	95% CI	9.4-11.5	9.4-11.9	28.9-35.2	29.6-34.7
11.0-11.5	Means ± SD	10.2 ± 1.0	11.3 ± 1.4	31.1 ± 4.5	34.1 ± 4.7
	N	10	10	10	10
	95% CI	9.4-10.9	10.2-12.3	27.8-34.3	30.7-37.4
11.6-11.11	Means ± SD	10.7 ± 1.9	11.3 ± 1.4	30.1 ± 4.9	34.6 ± 6.2
	N	10	10	10	10
	95% CI	9.3-12.0	10.2-12.3	26.5-33.6	30.1-39.0
12.0-12.11	Means ± SD	10.9 ± 1.9	12.0 ± 1.5	30.3 ± 6.3	35.1 ± 7.4
	N	10	11	10	11
	95% CI	9.5-12.2	11.0-13.1	25.7-34.8	30.2-40.1
13.0-13.11	Means ± SD	11.8 ± 1.6	12.1 ± 0.8	38.9 ± 4.3	38.7 ± 3.5
	N	11	10	11	10
	95% CI	10.7-12.8	11.4-12.7	36.0-41.8	36.1-41.2
14.0-15.11	Means ± SD	12.3 ± 1.3	12.7 ± 1.7	40.6 ± 4.5	37.0 ± 5.4
	N	11	11	11	11
	95% CI	11.4-13.2	11.5-13.9	37.6-43.6	33.3-40.6

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Appendix 2. Continued.

Age		Time to place 10 pegs (s)			
		Preferred hand		Non-preferred hand	
		Male	Female	Male	Female
5.0-5.5	Means ± SD	97.9 ± 19.5	89.3 ± 16.6	110.1 ± 25.2	101.0 ± 18.4
	N	11	10	11	10
	95% CI	84.8-111.0	77.4-101.2	93.1-127.0	87.8-114.1
5.6-5.11	Means ± SD	106.0 ± 13.5	98.4 ± 15.3	112.4 ± 9.9	104.2 ± 15.9
	N	9	10	9	10
	95% CI	95.6-116.4	87.4-109.4	104.8-120.1	92.8-115.6
6.0-6.5	Means ± SD	86.6 ± 8.5	82.4 ± 10.8	96.5 ± 17.9	96.5 ± 13.7
	N	10	10	10	10
	95% CI	80.5-92.8	74.6-90.1	83.7-109.4	86.6-106.3
6.6-6.11	Means ± SD	75.6 ± 7.8	70.3 ± 6.6	89.6 ± 9.3	84.7 ± 13.4
	N	10	10	10	10
	95% CI	70.0-81.2	65.5-75.1	82.9-96.3	75.0-94.3
7.0-7.5	Means ± SD	71.5 ± 7.3	67.9 ± 6.9	84.9 ± 7.6	79.0 ± 8.6
	N	8	10	8	10
	95% CI	65.3-77.6	62.9-72.9	78.5-91.3	72.8-85.2
7.6-7.11	Means ± SD	66.7 ± 9.6	67.9 ± 11.4	76.4 ± 10.6	78.1 ± 11.6
	N	12	10	12	10
	95% CI	60.6-72.9	59.7-76.1	69.6-83.2	69.7-86.4
8.0-8.5	Means ± SD	66.6 ± 8.2	60.5 ± 5.4	77.2 ± 12.2	71.3 ± 11.3
	N	10	10	10	10
	95% CI	60.7-72.5	56.6-64.4	68.4-86.0	63.2-79.4
8.6-8.11	Means ± SD	62.6 ± 6.4	57.0 ± 4.9	69.3 ± 8.2	62.9 ± 7.1
	N	10	11	10	11
	95% CI	58.0-67.3	53.6-60.4	63.4-75.2	58.1-67.7
9.0-9.5	Means ± SD	65.5 ± 5.9	61.4 ± 9.9	72.7 ± 6.6	72.1 ± 11.1
	N	10	10	10	10
	95% CI	61.2-69.7	54.3-68.5	67.9-77.4	64.1-80.1
9.6-9.11	Means ± SD	61.5 ± 5.5	60.5 ± 10.7	71.2 ± 5.8	67.9 ± 9.4
	N	11	8	11	8
	95% CI	57.8-65.2	51.5-69.4	67.3-75.1	60.1-75.8
10.0-10.5	Means ± SD	57.4 ± 6.4	56.6 ± 4.0	63.5 ± 6.5	63.4 ± 5.9
	N	10	10	10	10
	95% CI	52.8-62.0	53.7-59.4	58.8-68.2	59.2-67.7
10.5-10.11	Means ± SD	57.3 ± 5.9	57.3 ± 6.1	67.4 ± 7.4	68.1 ± 9.2
	N	10	10	10	10
	95% CI	53.0-61.5	52.9-61.7	62.1-72.8	61.4-74.7
11.0-11.5	Means ± SD	58.4 ± 5.2	53.2 ± 3.9	64.5 ± 5.7	61.8 ± 4.8
	N	10	10	10	10
	95% CI	54.6-62.1	50.4-56.0	60.3-68.6	58.4-65.3
11.6-11.11	Means ± SD	56.1 ± 7.4	54.1 ± 4.8	65.8 ± 10.6	62.9 ± 7.1
	N	10	10	10	10
	95% CI	50.8-61.4	50.7-57.6	58.3-73.4	57.8-68.1
12.0-12.11	Means ± SD	51.1 ± 7.2	50.4 ± 6.6	60.3 ± 9.4	56.3 ± 5.4
	N	10	11	10	11
	95% CI	45.9-56.3	46.0-54.9	53.6-67.0	52.6-59.9
13.0-13.11	Means ± SD	47.6 ± 4.0	50.8 ± 4.3	57.3 ± 5.4	57.7 ± 3.8
	N	11	10	11	10
	95% CI	44.9-50.3	47.7-53.9	53.6-61.0	54.9-60.4
14.0-15.11	Means ± SD	50.3 ± 4.9	47.3 ± 5.5	55.9 ± 4.1	53.4 ± 7.1
	N	11	11	11	11
	95% CI	47.0-53.6	43.6-51.1	53.1-58.6	48.6-58.3

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Appendix 2. Continued.

Age		Time to transfer 10 pegs (s)			
		Preferred hand		Non-preferred hand	
		Male	Female	Male	Female
5.0-5.5	Means ± SD	59.2 ± 9.3	54.0 ± 9.9	68.5 ± 13.6	62.1 ± 12.5
	N	11	10	11	10
	95% CI	52.9-65.4	46.9-61.1	59.4-77.7	53.2-71.1
5.6-5.11	Means ± SD	61.4 ± 7.2	58.0 ± 8.1	68.7 ± 9.1	65.1 ± 14.4
	N	9	10	9	10
	95% CI	55.8-67.0	52.2-63.8	61.6-75.8	54.7-75.5
6.0-6.5	Means ± SD	50.0 ± 5.3	54.0 ± 7.5	57.6 ± 7.7	58.1 ± 6.9
	N	10	10	10	10
	95% CI	46.2-53.9	48.6-59.4	52.1-63.1	53.1-63.1
6.6-6.11	Means ± SD	46.1 ± 4.9	43.1 ± 4.3	54.8 ± 6.1	50.0 ± 7.4
	N	10	10	10	10
	95% CI	42.5-49.7	39.9-46.2	50.4-59.3	44.7-55.3
7.0-7.5	Means ± SD	43.6 ± 5.8	42.1 ± 4.7	48.5 ± 2.7	47.0 ± 4.0
	N	8	10	8	10
	95% CI	38.7-48.5	38.7-45.5	46.2-50.9	44.1-49.9
7.6-7.11	Means ± SD	40.0 ± 5.0	41.6 ± 4.1	45.3 ± 5.1	47.7 ± 7.0
	N	12	10	12	10
	95% CI	36.8-43.2	38.6-44.6	42.0-48.6	42.6-52.8
8.0-8.5	Means ± SD	39.2 ± 4.7	38.3 ± 5.3	43.1 ± 5.7	44.5 ± 7.3
	N	10	10	10	10
	95% CI	35.8-42.6	34.5-42.2	39.0-47.2	39.3-49.7
8.6-8.11	Means ± SD	37.5 ± 3.3	34.0 ± 2.0	41.0 ± 5.6	40.7 ± 2.7
	N	10	11	10	11
	95% CI	35.1-39.9	32.7-35.4	37.0-45.1	38.8-42.5
9.0-9.5	Means ± SD	42.1 ± 5.8	37.8 ± 5.3	45.0 ± 6.2	42.8 ± 4.6
	N	10	10	10	10
	95% CI	37.9-46.3	33.9-41.6	40.6-49.5	39.5-46.1
9.6-9.11	Means ± SD	37.7 ± 2.4	37.6 ± 7.8	41.7 ± 3.8	42.9 ± 6.4
	N	11	8	11	8
	95% CI	36.1-39.3	31.0-44.1	39.1-44.3	37.5-48.2
10.0-10.5	Means ± SD	34.9 ± 4.9	33.3 ± 1.9	39.2 ± 4.3	38.7 ± 3.6
	N	10	10	10	10
	95% CI	31.4-38.4	31.9-34.7	36.1-42.2	36.1-41.4
10.6-10.11	Means ± SD	34.2 ± 4.1	34.7 ± 3.6	40.5 ± 3.6	39.3 ± 4.5
	N	10	10	10	10
	95% CI	31.2-37.2	32.0-37.3	37.8-43.1	36.0-42.5
11.0-11.5	Means ± SD	33.7 ± 4.0	31.1 ± 1.9	36.3 ± 5.1	35.7 ± 3.1
	N	10	10	10	10
	95% CI	30.7-36.6	29.7-32.5	32.7-40.0	33.5-37.9
11.6-11.11	Means ± SD	32.1 ± 4.7	33.1 ± 5.8	35.7 ± 3.8	38.5 ± 5.8
	N	10	10	10	10
	95% CI	28.7-35.5	28.9-37.3	32.9-38.5	34.4-42.7
12.0-12.11	Means ± SD	33.1 ± 4.4	30.6 ± 3.5	37.1 ± 4.9	33.1 ± 2.7
	N	10	11	10	11
	95% CI	30.0-36.3	28.2-32.9	33.6-40.6	31.2-35.0
13.0-13.11	Means ± SD	28.9 ± 1.3	31.2 ± 2.9	32.2 ± 2.5	33.4 ± 3.3
	N	11	10	11	10
	95% CI	28.0-29.8	29.0-33.3	30.5-33.9	31.0-35.8
14.0-15.11	Means ± SD	30.1 ± 5.2	27.8 ± 2.6	32.3 ± 4.0	34.2 ± 4.5
	N	11	11	11	11
	95% CI	26.5-33.6	26.0-29.7	29.6-35.0	31.1-37.2

Data are reported as means ± SD and the 95% confidence intervals (95% CI) are given below. N, number of children.

Appendix 3. Between-hand performance differences in the Gardner Steadiness Test and the Purdue Pegboard across age.

Age	N	Gardner Steadiness Test		Purdue Pegboard		
		Number of contacts	Touch time (s)	Number of pegs placed	Time to place 10 pegs (s)	Time to transfer 10 pegs (s)
5.0-5.5	21	12.3 ± 20.5	10.6 ± 16.9	0.8 ± 1.2	11.9 ± 14.3	8.7 ± 9.3
		2.9-21.7	2.9-18.3	0.2-1.3	5.3-18.4	4.5-13.0
5.6-5.11	19	25.2 ± 26.9	10.1 ± 16.6	0.9 ± 1.2	6.0 ± 13.3	7.2 ± 8.2
		12.2-38.2	2.0-18.1	0.3-1.5	0.0-12.5	3.2-11.1
6.0-6.5	20	6.1 ± 26.5	6.4 ± 14.8	1.2 ± 1.4	11.9 ± 11.5	5.8 ± 4.0
		0.0-18.5	0.0-13.3	0.5-1.9	6.6-17.3	3.9-7.7
6.6-6.11	20	19.4 ± 20.3	7.3 ± 7.0	1.2 ± 1.1	14.1 ± 7.9	7.8 ± 4.2
		9.9-28.9	4.0-10.5	0.6-1.7	10.4-17.8	5.8-9.8
7.0-7.5	18	11.7 ± 16.0	3.0 ± 8.1	1.3 ± 2.5	12.1 ± 7.4	4.9 ± 4.0
		3.7-19.7	0.0-7.1	0.1-2.6	8.4-15.8	2.9-6.9
7.6-7.11	22	12.9 ± 24.3	5.9 ± 9.1	1.6 ± 1.5	9.9 ± 7.0	5.6 ± 4.8
		2.1-23.7	1.8-9.9	0.9-2.3	6.7-13.0	3.5-7.7
8.0-8.5	20	19.8 ± 20.3	9.1 ± 8.7	1.9 ± 1.5	10.6 ± 8.4	5.0 ± 5.6
		10.3-29.3	5.1-13.2	1.1-2.6	6.7-14.6	2.4-7.6
8.6-8.11	21	11.9 ± 19.0	5.0 ± 8.8	1.2 ± 1.4	6.2 ± 6.6	5.1 ± 4.1
		3.2-20.5	1.0-9.1	0.5-1.8	3.2-9.2	3.2-7.0
9.0-9.5	20	17.9 ± 16.7	4.8 ± 5.8	1.2 ± 1.3	8.9 ± 5.9	3.9 ± 4.3
		10.0-25.7	2.1-7.6	0.5-1.8	6.1-11.7	1.9-6.0
9.6-9.11	19	21.6 ± 24.4	6.5 ± 8.0	1.2 ± 1.4	8.7 ± 6.8	4.5 ± 3.8
		9.8-33.4	2.6-10.4	0.5-1.9	5.4-12.0	2.6-6.3
10.0-10.5	20	8.8 ± 12.1	2.0 ± 2.7	1.1 ± 1.2	6.4 ± 4.7	4.8 ± 2.9
		3.1-14.5	0.7-3.3	0.5-1.6	4.2-8.7	3.5-6.2
10.6-10.11	20	14.2 ± 14.4	4.0 ± 4.3	1.8 ± 1.5	10.4 ± 6.7	5.4 ± 3.7
		7.4-21.0	2.0-6.1	1.0-2.5	7.3-13.6	3.6-7.2
11.0-11.5	20	6.2 ± 12.8	1.3 ± 3.1	0.3 ± 1.5	7.3 ± 5.0	3.6 ± 2.9
		0.2-12.2	0.0-2.8	0.0-1.0	4.9-9.7	2.2-5.0
11.6-11.11	20	8.9 ± 11.4	2.6 ± 4.1	2.0 ± 1.2	9.2 ± 7.0	4.5 ± 2.8
		3.5-14.3	0.6-4.5	1.4-2.6	5.9-12.5	3.1-5.8
12.0-12.11	21	6.4 ± 8.7	2.1 ± 2.9	0.9 ± 1.6	7.4 ± 5.3	3.2 ± 2.7
		2.4-10.4	0.7-3.4	0.1-1.6	5.0-9.8	1.9-4.4
13.0-13.11	21	3.8 ± 7.0	0.7 ± 1.4	1.6 ± 1.4	8.3 ± 3.5	2.8 ± 2.4
		0.6-7.0	0.0-1.4	0.9-2.2	6.7-9.9	1.6-3.9
14.0-15.11	22	4.9 ± 9.4	0.0 ± 5.2	1.5 ± 1.5	5.8 ± 4.4	4.2 ± 4.3
		0.6-9.1	0.0-2.4	0.8-2.1	3.8-7.7	2.3-6.2

Data are reported as means ± SD and the 95% confidence intervals are given below. Except for number of pegs placed, the variables included in the table represent the difference in performance between the non-preferred and the preferred hand. N, number of children.