Psychology
2013. Vol.4, No.10A, 29-33
Published Online October 2013 in SciRes (http://www.scirp.org/journal/psych)
http://dx.doi.org/10.4236/psych.2013.410A006

The Effects of Hand Preference on Attention

Sergio L. Schmidt[1], Eunice do Nascimento Simões[1], Guilherme J. Schmidt[2], Ana Lucia Novais Carvalho[3]
[1]State University of Rio de Janeiro, Rio de Janeiro, Brazil
[2]Institute of Neurology Deolindo Couto, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil
[3]Fluminense Federal University, Niteroi, Brazil
Email: slschmidt@terra.com.br

Received August 3rd, 2013; revised September 5th, 2013; accepted September 26th, 2013

Handedness is associated with cerebral hemispheric differences. Normal patterns of brain asymmetries are needed for the neural processing of attention. In order to identify ADHD (Attention Deficit Hyperactive Disorder) children, the use of checklists allows a greater level of accuracy. Here, we will review our data on this subject. Our first study investigated the psychometric properties of a scale developed to assess attention disorders. Our second study investigated the relationship between handedness and attention disorders using the factors derived from the scale. Our third study included the use of a continuous visual test of attention (CVAT) and examined the relationship between handedness and CVAT variables. For the first and second study, 239 students were included. From this sample, 42 students were selected to participate in the third study. Forty-five teachers rated the children. Four factors were extracted: hyperactivity/impulsivity (explained variance = 36.3%); inattention (11.4%); social isolation (5.2%) and self-confidence (explained variance = 3.3%). Sixty-eight children were included in the ADHD group. We found a higher number of consistent left-handers in the ADHD group as compared to the normal group and a significant effect of handedness on factor hyperactivity/impulsivity. This indicated that left-handers showed greater problems in the hyperactivity-impulsivity domain as compared to right-handers. Considering the data derived from CVAT, a significant handedness effect was found only for the variable commission errors. Left-handers with attention problems showed the greatest number of errors and normal dextrals the lowest number of errors. Normal left-handers made significantly more errors than normal dextrals. Commission error is a parameter that is commonly viewed as a measure of impulsivity. Our data show that hyperactivity/impulsivity is related to handedness, because left-handers present more problems in impulsive behavior than right-handers and suggest that consistent left-handed subjects show greater probability to develop ADHD as compared to right-handed subjects.

Keywords: ADHD; Handedness; Laterality

Introduction

The presence of primary disorder of inattention and/or hyperactivity/impulsivity is a diagnostic criterion for Attention Deficit Hyperactive Disorder (ADHD), which is the most common childhood psychiatric disorder, affecting 5% of the school population. According to the Diagnostic and Statistical Manual of Mental Disorders-5th Edition (2013), these behavioral changes must be present in more than one venue frequented by children, and their behavior at home and at school are commonly rated through by parents and teacher. As suggested by Mares, McLuckie, Schwartz & Saini (2007) and Tripp, Schaughency & Clarke (2006), it is essential to collect data from these two sources, considering that parents and teachers emphasize different aspects during the evaluation. Such differences are commonly described in the literature (for example: Mitsis, McKay, Shultz, Newcorn, & Halperin, 2000). Cho et al. (2011), in a recent study that aimed to compare data obtained from scale for teachers and parents in the assessment of cognitive performance in children, confirmed these data. These authors find that teachers are more skilled in assessing hyperactive/impulsive behavior, which facilitates the identification of children with low cognitive performance. Such a facility by professionals is probably related to the fact that teachers know about child development and deal with a large number of children. This finding does not exclude the need for data collection though filling out scales by parents. The study makes clear that parents and teachers point out different but important aspects on child behavior.

Previous studies have shown that psychologists who rely only on their clinical judgment may experience difficulties in identifying children with behavioral problems (Barkely, 1990; Schmidt, Snyder, Rouget, & Gray, 2000). The use of checklists completed by teachers or parents allows a greater level of accuracy, even when considering the limitations of the instruments (Greenhill, 1998; Schatz, Ballantyne & Trauner, 2001; Ulloa, Narváez, Arroyo, del Bosque, & de la Peña, 2009). Studies have demonstrated that, in some cases, behavior rating scales are even more effective in classifying children with learning and cognitive disorders than traditional psychological

tests (Dewey, Crawford, & Kaplan, 2003). The results demonstrated that the scale was more efficiently in classifying children with ADHD than the psychometric measures alone. Still on the use of scales, an American research with 401 pediatricians and family practice physicians, in a prospective cohort study of 22.059 children from 4 to 14 years, showed that 53.5% of them used school reports to diagnose attentional or hyperactivity problems (Carey, 1999).

Our first study describes a scale developed by us to assess hyperactive/impulsive behavior and inattention to be filled by teachers. This study was performed to provide information about the psychometric properties of this scale, including the analysis of its reliability and validity, which was essential characteristics of an instrument that is to be used clinically (Glascoe, Martin, & Humphrey, 1990; Meisels, 1989).

Our second study will provide some information about handedness which is an important issue that psychologists must take into account in their assessments. Language lateralization is associated with handedness in children. In fact, there is an atypical language lateralization in left-handed children similar to that reported in adults (Szaflarski et al., 2012). The finding that handedness may be associated with structural and functional differences has led many researchers to study a possible relationship between handedness and neuropsychiatric diseases. Several studies have demonstrated that among children with learning disabilities, such as dyslexia, autism, and developmental coordination disorder, left-handedness is more common than in the general population (Cairney et al., 2008; Eglinton & Annett, 1994; Goez & Zelnik, 2008). Abnormal brain connectivity has recently been reported in Obsessive Compulsive Disorder (Di Paola et al., 2012). Regarding ADHD, the conclusions are not clear. Rodriguez and Waldenström (2008) studied the possible relationship between handedness and mental health in a sample of 1714 children. They found a higher than expected proportion of left-handedness in children with impulsive and/or hyperactivity behavior. Although Rodriguez and Waldenström (2008) reported handedness in a large sample, its assessment was done by means of a questionnaire answered by the mothers. Several studies (Mitsis, Mckay, Schulz, Newcorn, & Halperin, 2000; Schmidt, Snyder, Roget, & Gray, 2000) have shown that data derived from parents' reports must be interpreted with caution. In contrast, Reid and Norvilitis (2000) directly observed the hand used by the children, a procedure known to be much more reliable than parents' report. They concluded that ADHD was not exclusively related to the prevalence of non-right-handedness. However, the sample size was too small, especially regarding the expected number of left-handers. More recently, Rodriguez et al. (2010) demonstrated that mixed-handedness was associated to increased risk for language difficulties and ADHD in late adolescence. From the above mentioned studies, we concluded that the relationship between handedness and attention disorder was still controversial. Therefore, we investigated this controversial relationship using direct observation of handedness.

Our third study included the use of a continuous performance test (CPT) developed by one of us. The CPTs are usually used to objectively assess attention (DuPaul, Anastopaulos, Shelton, Guevremont, & Metevia, 1992). Rosvold et al. (1956) demonstrated that CPTs were highly sensitive to brain damage or dysfunction. In particular, the CPTs have been shown to differentiate ADHD from normal groups (Epstein et al., 2003). Several variables may be derived from the CPTs, including errors of omission and commission, mean hit reaction time (RT), mean hit RT standard error, and signal detection measures (Epstein et al., 2003). The interpretation of each CPT parameter (Conners, Epstein, Angold, & Klaric, 2003; Riccio, Cohen, Hynd, & Keith, 1996; Tinius, 2003) has largely been based upon clinical assumptions and the face validity of each measure (e.g. omission errors measure inattention, commission errors measure impulsivity). In general, the parameters can be divided into three types: inhibition of response, inattention to stimuli, and stability of processing time (Epstein et al., 2003; Riccio et al., 2002). Functional neuroimaging studies are consistent with models of sustained attention that involve the interaction of cortical (frontal, temporal, parietal) and subcortical (limbic, basal ganglia) structures (Riccio et al., 2002). An extensive neural network is activated during the execution of the task that includes the frontal, cingulate, parietal, temporal, and occipital cortices; the cerebellum and the basal ganglia (Honey et al., 2005). Moreover, significant differences between the left and the right hemisphere have also been reported (Riccio et al., 2002). In particular, ventral frontal region and parietal lobe activation were greater in the right hemisphere (Honey et al., 2005). Asymmetry favoring the activation of the right hemisphere is reported by many researches (Riccio et al., 2002). These studies support the view that execution of the CPT is associated with cerebral asymmetric activation. Therefore, our third study attempted to examine a possible relationship between handedness and CPT variables in normal and ADHD children. We should mention that handedness will be measured by direct observation and attention problems will be assessed by a valid teacher scale for attention disorders (Carvalho, Manhães, & Schmidt, 2012).

Methods

Participants

A total of 239 students participated in the first and the second study (validity of a teacher scale and relationship between handedness and factors derived from the scale, respectively). The sample consisted of 120 boys (mean age = 9.17 years, SD = 2.51 years, minimum = 5 years, maximum = 18 years) and 119 girls (mean age = 9.11 years, SD = 2.76 years, minimum = 6 years, maximum = 17 years), from elementary schools.

From this sample, a total of 42 students were selected to participate in the third study. The sample consisted of 25 boys (mean age = 10.88 years, SD = 4.08 years, minimum = 5 years, maximum = 18 years) and 17 girls (mean age = 10.31 years, SD = 3.68 years, minimum = 6 years, maximum = 15 years). There was no difference regarding male and female age ($t = -0.44$; $df = 40$; $p > 0.40$). The selection was designed to pair handedness matched by age, gender, and behavioral observations.

Forty-five teachers rated the children. The teacher selected to rate a particular child was the one that spent most of the time with the child.

The child's participation in the research was voluntary. Parents and school principals signed informed consents regarding the voluntary participation of the children in the research. The participation of the teachers was also voluntary. These studies were approved by all local Ethics Committees.

Scale

The scale is composed of 58 questions with information about behavior in the classroom, peer group, and disruptive

behavior. These questions are rated on an oral assessment scale ranging from 1 to 3 reflecting problem prevalence (1 = not true; 2 = somewhat or sometimes true; 3 = very true or often true). The internal consistency of the 58 scorable items scale was evaluated using Cronbach's alpha. Alpha is a correlation coefficient and ranges in value from −1 to 1. If Cronbach's alpha drops below 0.7, the hypothesis of internal reliability cannot be accepted (Barret & Kline, 1981; Cattell, 1966). To evaluate how each individual item affects the reliability of the scale, alpha was calculated removing each of the items of the scale.

Raw data from the questionnaire were factor analyzed. To find the simplest possible factor structure, an orthogonal varimax rotation that maximizes the variance of the squared loadings for each factor was used. Only factors that account for variances greater than 1 (eigenvalue greater than 1) were included. With regard to the factor loadings, we considered only the most highly correlated variables (greater than 0.50) for each factor.

Evaluation of Hand Preference

Hand preference was assessed by direct observation of three tasks: 1) hand to write; 2) hand to take a sheet of paper on the table; 3) hand to open a lid of a bottle. The choice of the three tasks derived from a previous empirical study of handedness in 1600 subjects (Schmidt & Höfke, 1989).The observer that rated the children was blind with respect to the presence or absence of behavioural problems. Then, each child was classified as right-consistent, left-consistent, or non-consistent. To be consistent, the child had to perform the three tasks with the same hand.

Continuous Visual Attention Test (CVAT)

The CVAT computer program was developed by Schmidt and Manhães (2001) and approved for clinical use. The subjects are required to press the space bar of a microcomputer when a specific visual target stimulus appears. The test starts with instructions and a practice session. The respondents press the space bar for the correct target as fast as they can. There are 6 blocks, with 3 sub-blocks each of 20 trials (two figures presented, whether targets or not). For each block, the sub-blocks have different inter stimulus time intervals (ISI): 1, 2, or 4 seconds. The order of the ISIs varies between blocks. Each stimulus is displayed for 250 milliseconds. The total test takes 15 minutes to complete. The types of measures include: omission errors (OE), commission errors (CE), reaction time of correct responses (RTC), and variability of reaction time (VRT). This standardized test has a number of advantages over other tests, especially in relation to the norms of the variables derived from the test. Recently the CVAT was applied as an activation tool in a functional neuroimaging study (Schmidt et al. 2008).

Results

First Study: Validity of a Teacher Scale for Attention Problems

The checklist presented high internal reliability as indicated by Cronbach's alpha coefficients ($\alpha = 0.96$). Elimination of any of the items from the scale caused little change in α. Four factors were extracted: Factor 1—Hyperactivity/Impulsivity (explained variance = 36.3%); Factor 2—Inattention (explained variance = 11.4%); Factor 3—Social isolation (explained variance = 5.2%); Factor 4—Self-confidence (explained variance = 3.3%)

Second Study: Handedness and Attention Problems

Sixty-eight children (28% of the total sample) were included in the behavioral/attention problem group. The comparison group included 171 children. The two groups did not differ with regard to age ($t = 0.99$; $df = 159$; $p = 0.32$). In contrast, the number of males was found to be greater in the ADHD group as compared to the comparison group (qui-square = 42.956; df = 1; $p < 0.001$).

There was not any significant association (qui-square = 0.558; df = 1; $p = 0.27$) between the presence of behavioral problems and the number of right-consistent and non-right-handers (left consistent and non-consistent children). However, when the analysis was done considering only right-consistent and left-consistent children, the association reached significant levels (qui-square = 4.664; df = 1; $p = 0.03$). This result can be explained by the higher number of consistent left-handers in the ADHD group as compared to the comparison group. Therefore all subsequent analyses were done considering only right and left consistent children. The ANOVAS on the indices for each factor showed a significant effect of handedness on F1 ($F = 5.449$; $df = 1/159$; $p = 0.02$), but not on the other factors: F2 ($F = 0.996$; $df = 1/159$; $p = 0.32$); F3 ($F = 0.731$; $df = 1/159$; $p = 0.39$); F4 ($F = 2.639$; $df = 1/159$; $p = 0.11$). These data indicated that left-handers show greater problems in the impulsive-hyperactivity domain as compared to right-handers.

Third Study: Visual CPT and Handedness

Forty-two participants were matched for the analysis of the Continuos Performance Tests. Anova (s) on the standardized scores indicated a significant effect of attention problems on performance in the following parameters of the CVAT (OE: $F = 8.09$; $df = 1/24$; $p = 0.009$; CE: $F = 5.46$; $df = 1/24$; $p = 0.03$; VRT: $F = 4.80$; $df = 1/24$; $p = 0.04$). No significant difference between the control and the ADHD groups was found for the reaction time. A significant handedness effect was found only for the variable CE ($F = 4.85$; $df = 1/24$; $p = 0.04$). In both visual and audio continuos tests, left-handers with attention problems showed the greatest number of errors and normal dextrals the lowest number of errors. Fourteen participants were matched for the analysis of a Continuous Auditory Attention Test. Anova (s) on the standardized scores indicated a tendency for a significant effect of attention problems on the performance of the CAAT, indicating that the presence of attention problems worsens the performance of the audio CPT as seen in the visual one.

Discussion

The first study indicates that the components of the scale can be viewed as an internally reliable instrument for obtaining quantified information from teachers. Empirical analysis demonstrates that there is no internal discrepancy in the item content of the checklist. High internal consistency is a prerequisite of validity (Guilford, 1956; Nunnally, 1978). Arrindel and Endle (1985) claimed that stable factors required the sample to be approximately 20 times larger than the number of factors. Ac-

cording to these authors, variable-subject ratio is not important compared to the ratio of sample size to factors. Therefore, only if reliable factors are to be considered, a conservative approach requires that the number of factors in the study never be greater than 11. As the study shows four factors, the hypothesis that the factors are reliable is confirmed. In support of the hypothesis of construct validity, the number of items of each checklist could be expressed by a smaller number of factors, which are psychologically meaningful.

The second study shows that the number of boys suffering from ADHD is higher than the number of girls. The same result has been reported by many other researches (e.g., Gershon, 2002; Quinn, 2008; Stefanatos & Baron, 2007). Moreover, the data show that hyperactivity/impulsivity is related to handedness, because left-handers present more problems in impulsive behaviour than right-handers. A similar finding was reported by Rodriguez and Waldenström (2008). The number of left-handers is higher than expected in the ADHD problems group. Our study assesses handedness by direct observation of the children, which lends much more credence to the handedness data. Furthermore, the assessment of behavioural problems was done by means of a culturally adapted checklist (Carvalho, Manhães, & Schmidt, 2012). Therefore, our results suggest that the influence of consistency of hand use in attention disorders seems to be a stable finding that is not restricted to western countries.

The handedness effect was confirmed by the data derived from the CVAT study. Our results show that the presence of attention problems has a significant effect on the performance of the visual CPT. All parameters of the CPT were affected by the presence of attention problems, except reaction time. A handedness effect was restricted to one parameter, i.e. commission errors. Left-handers with attention problems show greater impairment in commission errors as compared to right-handers. Commission error is a parameter that is commonly viewed as a measure of impulsivity. Moreover, when the normal group was analyzed separately, the handedness effect still remained for the commission errors. This may indicate that even in normal children, consistent left-handers are more impulsive than consistent right-handers.

The influence of handedness on attention can be interpreted in the context of the asymmetry of the neurobiological substrates of attention. The neural processing of attention is known to be asymmetrical (e.g., Rolfe, Hausmann & Waldie, 2006; Schmidt et al., 2008) and left-handers are thought to have less marked hemispheric asymmetries than dextrals (Bishop, 1990; Schmidt, Oliveira, Krahe, & Filgueiras, 2000). In particular, subjects suffering from ADHD were found to show alteration in the normal pattern of asymmetries in the basal ganglia and frontal lobes (Castellanos et al., 2002; Swanson et al., 2007). Therefore, our data suggest that consistent left-handed subjects show greater probability to develop ADHD as compared to right-handed subjects since a significant number of them do not present the normal patterns of brain asymmetries that are needed for the neural processing of attention.

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