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No deficits at the point of hemispheric indecision

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Abstract

This study attempted to replicate a recent finding by Crow et al. [Neuropsychologia 36 (1998) 1275] showing that about equal skill of right and left hand (i.e. hemispheric indecision) is associated with deficits in cognitive and scholastic achievement. The present study assessed hemispheric indecision by using Annett's [Left, Right, Hand and Brain: The Right Shift Theory, Lawrence Erlbaum, London, 1985] peg moving test and by assessing the consistency of hand preference at school entrance. Non-verbal intelligence, reading and spelling accuracy were assessed about three years later. The sample consisted of 530 boys. Contrary to Crow et al., children with about equal hand skill did not show deficits in non-verbal intelligence, reading and spelling. Also, there were no deficits when inconsistent hand preference was taken as indication of hemispheric indecision. The findings cast doubt on the hemispheric indecision hypothesis and speak specifically against Orton's [Reading, Writing and Speech Problems in Children, Norton, New York, 1937] position, revived by Crow et al., that delayed or absent hemispheric dominance may lead to difficulties with the acquisition of reading and spelling.

Keywords: Lateralization; Handedness; Dyslexia

1. Introduction

In a recent article of this journal, Crow et al. [2] presented data from the UK National Child Development Study on the relationship between relative hand skill and cognitive ability. This study included near about 13,000 11-year-old children. The main finding was that about equal skill of right and left hand was associated with a deficit in two reasoning tests (verbal and non-verbal) and with deficits in two scholastic achievement tests (reading comprehension and mathematical ability). About equal hand skill was interpreted as indication of delayed cerebral lateralization and this anomalous brain development was seen as cause for the cognitive and scholastic achievement deficits. This interpretation in the case of reading difficulties is similar to the well-known one of Orton [6].

The present study was inspired by Crow et al. [2] and focused specifically on the relationship between relative hand skill and deficits in reading and spelling. We used data from a longitudinal study of 530 German-speaking boys who were tested at school entrance with a battery of tests intended to identify precursors of reading and spelling difficulties. This battery included the peg moving test of Annett [1] to assess relative hand skill. Hand preference was also checked. Longitudinal follow-up testing at the end of Grade 1 included a non-verbal intelligence test and at the end of Grade 3 reading and spelling was extensively assessed. This database allowed to re-examine the main finding of Crow et al. in a longitudinal context.

Our children were learning to read and spell German. German is easier to read than English, because the relations between the letters and sounds are more consistent. Therefore, the main problem of poorly reading German children is impaired fluency and not a high error rate [7]. With respect to spellings, German is difficult, and in the same way, as English requires orthographic memory representations because relations between sounds and letters are rather inconsistent, e.g. instead of "Bär" (spoken in the same way as "bear") children may write "Ber", "Behr" or "Beer" as phonetically acceptable, but orthographically incorrect spellings.

2. Method

2.1. Participants and overview over procedure

Participants were 530 boys from 31 schools and 74 classrooms in the city of Salzburg and neighboring communities. By including only boys in the sample, we expected to find more children with marked reading or spelling difficulties.

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Children's age at school entrance ranged from 5.10 to 8.1 ($M = 6.9$, S.D. $= 0.5$). Children in Austria start school after their sixth birthday. In kindergarten, children are not confronted with school-type activities. Particularly, there is no reading preparation involving letters. The individual testing for precursors of reading difficulties, including hand skill and hand preference, took place in the first 2 months of Grade 1 in a quiet room in the school. At the end of Grade 1 an abbreviated version of the Primary Test of Cognitive Skills [3] was presented as a classroom test. Only three non-verbal scales (spatial sequences, spatial integration and spatial concepts) were used. The three scales were standardized and summed, and the resulting variable was standardized as an IQ scale ($M = 100$, S.D. $= 15$).

In the last months of Grade 3, the reading and spelling performance of the sample was assessed. Reading was individually tested with three subtests of a standardized reading tests developed in our laboratory [4]. For each subtest children had to read aloud a page of reading material (a short text, a list of high-frequency words and a list of long as well as complex compound words). The instructions stressed on speed and accuracy. Reading errors for these subtests are largely absent in Grade 3 so that reading speed was used as measure. Because the reading time scores for the three subtests exhibited correlations around 0.90, a single reading rate score (syllables per minute) was formed. The standardized classroom spelling test required the correct spelling of a total of 49 words, dictated with sentence context. The reliability of the spelling test is around 0.90 (parallel test method).

2.2. Relative hand skill

The peg moving test was identical to that of Annett [1]. The only difference was that instead of three, only two trials per hand were done. The child's task was to move 10 pegs from one line of holes in a wooden frame into the holes of the line closer to the child as quickly as possible. Pegs had to be moved one by one. For the right hand, the task started from the utmost right hole and for the left hand, task started from the utmost left hole. If a peg dropped, the trial was repeated at some later point. Use of the right and the left hand alternated from trial to trial. Time per trial was measured. Correlations between the two trials of each hand were 0.69 and 0.76 for right and left hand, respectively, and thus, showed sufficient reliability of each hand skill measured. The two time scores for the each hand were averaged resulting in means of 13.8 s (S.D. $= 1.8$) and 14.8 s (S.D. $= 1.9$) for the right and the left hand, respectively. Annett had reported very similar means for 7-year-old children: right hand: 14.0 s (S.D. $= 1.5$) and left hand: 15.1 s (S.D. $= 2.0$). The percentage of children with a shorter time for the right than for the left hand (right hand advantage) was 79%.

2.3. Hand preference

Hand preference was assessed by presenting five objects and asking children to demonstrate a related action for each: pencil (drawing), scissors (cutting), spoon (eating), tooth brush (teeth brushing) and ball (throwing). Number of actions performed with the right hand was taken as preference score. A very large majority of 441 children (i.e. 83%) performed all actions with their right hand, only 30 children (i.e. 5.6%) performed all actions with their left hand and rest of the 59 children were not fully consistent in their hand preference. The consistent right handers moved the pegs faster with the right than with the left hand (right: 13.6 s, left: 15.0 s), whereas the consistent left handers showed the opposite skill difference (right: 15.1 s, left: 13.9 s). For right hand peg moving the right handers were reliable faster than the left handers, whereas for left hand peg moving the opposite was the case, $ts(1, 469) = 4.8$ and 3.1, respectively, $P < 0.005$.

3. Results

To examine the predictive relationship between relative hand skill at school entrance and later assessed cognitive and scholastic achievements, we divided the total sample into 10 groups of about equal sizes (*N*s between 49 and 54) based on relative hand skill. This is similar to the analyses of Crow et al. [2] who had divided their much larger sample into 20 groups. Of critical importance is the group with about equal skill for right and left hand. This group in Fig. 1 is labelled "0" because it was selected in such a way that the differences between left hand time and right hand time were close to 0. Actually, the difference scores (left minus right) for this group ranged from -0.30 to $+0.30$ s. The two groups labelled "-1" and "-2" in Fig. 1 exhibit an increasing advantage of the left hand over the right hand, i.e. the left minus right time difference is negative. The seven groups labelled "1–7" exhibit an increasing right hand advantage, i.e. the left minus right time difference is positive. From Crow et al.'s finding one would expect that there should be a dip in cognitive and academic performance at group 0 and both the increasing left hand advantage (groups -1 and -2) and the increasing right hand advantage (groups $+1$ and $+2$) should be associated with increasingly higher cognitive and academic performance levels.

Contrary to this expectation, Fig. 1 shows no dip in performance at the point of hemispheric indecision, that is for group 0. Fig. 1 gives boxplots which not only present the central tendency of the scores, but also provide information about the distribution of scores in each group. Boxplots have to be read in the following way. The bottom of the box corresponds to percentile 25, the line within the box is the median (percentile 50) and the ceiling represents percentile 75. The line extensions above and below the boxes represent the spread of the scores above percentile 75 and below percentile 25.

From the boxplots in Fig. 1 it is obvious that the group with about equal hand skill (group 0) exhibited no deficits relative to the neighboring groups. Two observations are

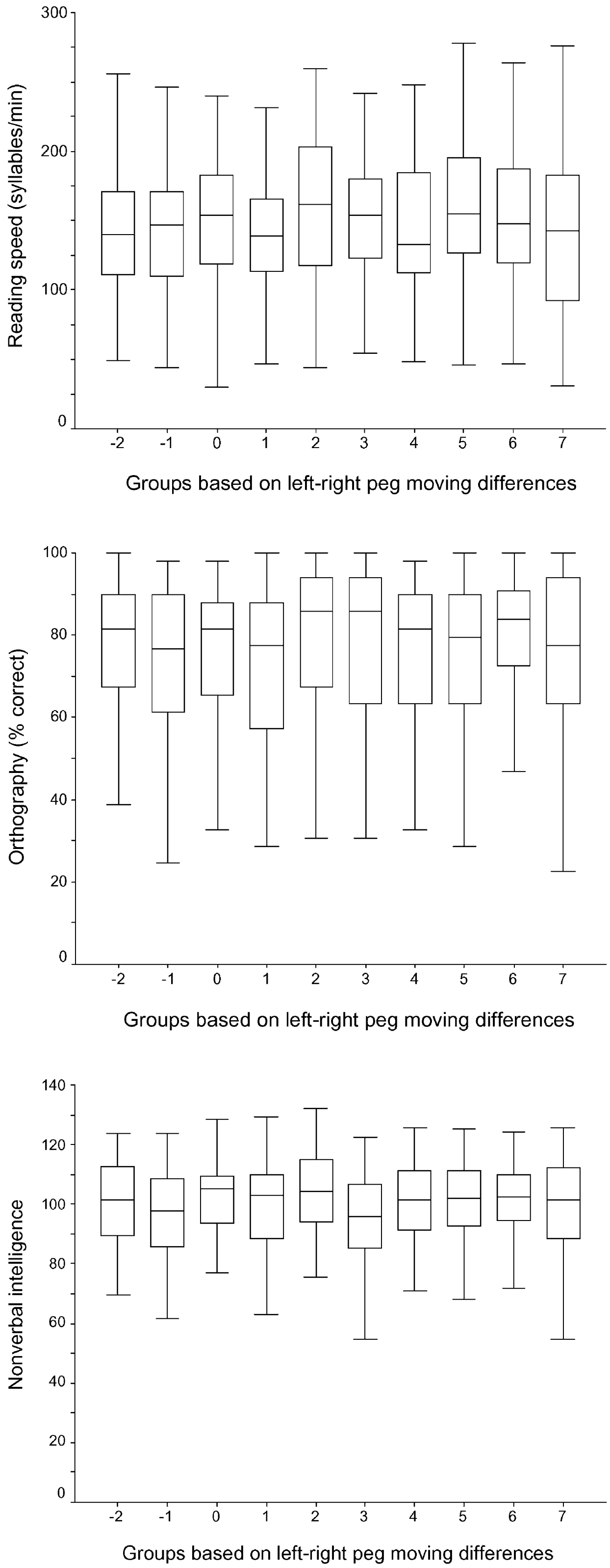

Fig. 1. Boxplots (see text) representing performance on the reading and spelling test and the non-verbal intelligence test for 10 groups based on relative hand skill differences. Group 0 shows about equal hand skill, groups with negative numbers show increasingly better left than right hand skill, groups with positive numbers show increasingly better right than left hand skill.

important. The medians for reading speed, spelling and non-verbal intelligence of group 0 (represented by the lines within the boxes) are slightly higher than the medians of the adjacent groups. The second observation of importance is that group 0 (about equal hand skill) did not include more children than the neighboring groups with very low and very high test scores. This would have been evident from larger box sizes and longer line extensions for group 0. To test the hemispheric indecision hypothesis with the groupings of Fig. 1, we combined the children with a left hand skill advantage (groups −1 and −2, $N = 99$) and also children with a moderate right hand skill advantage (groups +1 and +2, $N = 107$). The expectation from Crow et al. is that these two groups should exhibit higher cognitive and academic achievement levels than the group with hemispheric indecision (i.e. group 0, $N = 52$). This expectation was tested by a multivariate analysis of variance with reading, spelling and IQ as dependent measures. The variance explained by the group factor was very small, Hotelling's trace = 0.03, $F(6, 504) = 1.31$, $P > 0.20$. Hotelling's trace corresponds to the proportion of variance explained by the group effect. Inspection of the means showed a pattern similar to the medians of Fig. 1. Of importance is that contrary to Crow et al., the group with about equal hand skill for all three measures showed slightly better performance than the groups with unequal hand skill.

A more fine-grained examination of the hemispheric indecision hypothesis was done by correlational analyses. From the hypothesis it follows that the smaller the skill difference between the two hands (indicating more hemispheric indecision), the lower should be the reading and spelling scores and the intelligence scores. Inversely, an increase in the skill difference between the two hands (indicating more hemispheric specialization) should be accompanied by higher achievement scores. This formulation of the hypothesis takes into account differences in relative hand skill that may be masked by the rather coarse groupings shown in Fig. 1. In contrast to these expected positive correlations, there was essentially no correlation between the relative hand skill and reading, spelling and IQ with r's ($N = 530$) = 0.01, −0.01 and 0.05, respectively. These correlations did not change substantially, when instead of the total sample, we used only children forming the groups from −2 to +3 in Fig. 1. The reason for this is that in the Crow et al. study the dip in cognitive performance resulted only from the groups adjacent to the left and the right of the critical one in Fig. 1. The correlation coefficients between hand skill difference and reading, spelling and IQ in this subsample ($N = 313$) were 0.08, 0.08 and 0.06, respectively, and in no case reliable ($P > 0.05$, one-sided).

A further examination of the hemispheric indecision hypothesis was based not on relative hand skill but on hand preference data. We assumed hemispheric indecision when a child did not use the same hand (left or right) for all the five actions of the hand preference assessment. This indecision was shown by 59 children. In contrast, 441 performed all actions with their right and further 30 performed all actions with their left hand. These three groups were used in a multivariate analysis of variance with reading, spelling and IQ as dependent measures. Again, the group factor explained hardly any varicance, Hotteling's $T = 0.01$, $F(6, 1046) = 0.99$, $P > 0.40$. To illustrate, the mean IQ scores were 99, 101 and 100 for left handers, inconsistent hand users and right handers, respectively.

4. Discussion

The present findings are incompatible with the hypothesis that a failure or a delay to establish hemispheric dominance leads to deficits in intellectual functioning and in reading and spelling acquisition. In particular, we could not find the dip in cognitive and academic performance at the point of hemispheric indecision that was found by Crow et al. and that gave support to the hemispheric indecision hypothesis. Contrary to this, children with about equal hand skill at school entrance did not show the slightest indication of any deficit in reading fluency, spelling and non-verbal intelligence. Correlational analyses also found no hint for an association between relative hand skill and reading, spelling and non-verbal intelligence scores on the other. This lack of association was also obvious when hemispheric indecision was measured by inconsistent hand preference and not by about equal hand skill.

The failure to replicate the Crow et al. finding is troubling and difficult to understand. Of course, there are methodological differences between the studies. Our study included only boys because of our focus on early identification of children with later difficulties in learning to read and write and because of the higher prevalence of such learning difficulties in boys. This difference should be unproblematic, because Crow et al. found the negative effect of hemispheric indecision being even slightly stronger in boys than in girls. A further difference is that relative hand skill in our study was assessed at the age of about 7 years compared to an age of 11 years in the Crow et al. study. This may be of importance in relation to the different assessments of relative hand skill. A possible concern about the Crow et al. task is the similarity to writing that is explicitly acknowledged by Crow et al. The task was: "checking an array of squares on a printed sheet, the number of squares checked with each hand in a minute being recorded" ([2], p. 1276). The problem could be that children with more writing experience may exhibit a stronger hand skill difference. If this is correct, then little hand skill difference may result from lesser writing experience and this may be caused by the same factors (irregular school attendance, avoidance of school-related tasks and general learning difficulties) that may also cause poor performance on the scholastic achievement and the cognitive tests. The peg moving test, certainly when applied before school as in the present work, is immune to such an interpretation.

However, the use of the peg moving test may also be criticized. McManus [5] has previously pointed out that the hand skill measure used by Crow et al. provides a much clearer differentiation of hand skill differences than does Annett's peg moving test. This is correct. However, as pointed out, the sharper differentiation of the Crow et al. task may occur for the wrong reason (i.e. sensitivity to different amounts of writing experience). Even if one accepts that the peg moving test is less sensitive than the Crow et al. test to brain lateralization, then present findings are still troubling for the hemispheric indecision hypothesis. Even a rough measure of hemispheric indecision should allow to detect a negative effect in a sample of more than 500 children, if hemispheric indecision is a potent negative influence on cognition and learning. The problem is that there was no hint of such a deficit, and actually there was a tendency to the opposite.

Nevertheless, concerns about the validity of the peg moving test and of the writing-type test of Crow et al. as measures of hemispheric indecision have to be explored, before a conclusion about the hemispheric indecision hypothesis can be reached. We would like to add that an interesting hypothesis should certainly not be given up after a single negative finding. The present finding may only serve as a warning against prematurely accepting the hypothesis as correct.

Acknowledgements

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