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Manual performance as predictor of literacy acquisition: A study from kindergarten to Grade 1

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ABSTRACT

Many studies have shown phonological awareness to be a predictor of reading and spelling acquisition, but arguments that motor performance and manual laterality may also be predictors of literacy are much more controversial. We examined the links between manual performance, degree of laterality (absolute difference between the two hands) and literacy in a group of 73 pupils with typical development observed at the end of kindergarten and in the middle of Grade 1. Phonological awareness and hand skill were assessed in kindergarten. Reading comprehension, reading, spelling and graphomotor skills were assessed in Grade 1. Phonological awareness was confirmed to be a strong predictor for reading and spelling. Higher performance levels in reading and spelling were found to be associated with a weaker degree of laterality and with faster peg-moving by the non-dominant hand. These results support the hypothesis that manual motor skills have an impact on spelling and reading acquisition.

1. Introduction

The hypothesis that manual asymmetry and cognitive abilities are related dates back a long time in psychology. A disproportionately large number of left- or non-right handers was observed in people with an intellectual disability at the beginning of the last century (Gordon, 1921) and was later confirmed for known (e.g. Bishop, 1990a; Carlier et al., 2011) or unknown etiologies (Papadatou-Pastou & Tomprou, 2015). The putative relationship between laterality and cognitive ability in typically developing people then stood as an interesting path to investigate. Handedness is one of the most striking forms of asymmetry and is found across the world, even though the percentage of left-handers may differ from one culture to another (Bryden, 1982; Perelle & Ehrman, 1994; Scharoun & Bryden, 2014). There is an ongoing debate on the cognitive advantages or disadvantages for left- or right-handedness. Many studies have focused on general cognitive ability (e.g. Nicholls, Chapman, Loetscher, & Grimshaw, 2010; see Papadatou-Pastou & Tomprou, 2015 for a meta-analysis), or on more specific skills such as verbal and spatial skills (Somers, Shields, Boks, Kahn, & Sommer, 2015) but few studies have focused on reading skills (Annett & Manning, 1990; Palmer & Corballis, 1996).

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Our study was designed to investigate the influence of two complementary aspects of motor behavior – manual performance for each of the two hands and level of between-hand asymmetry – on literacy acquisition in typically developing children, controlling for phonological skills. Previous studies have reported handedness as a discontinuous trait (left- vs. right-handers, and sometimes left- vs. mixed-handers), which has low sensitivity when screening for individual differences. For the present study, we chose to assess hand performance (hand skill), giving the possibility of using continuous traits and regardless of the direction of laterality.

The main predictor of literacy acquisition is clearly phonological awareness (i.e. the ability to perceive, identify and manipulate sounds of spoken language). The link between phonological awareness, as measured in kindergarten, and reading and spelling skills, as measured subsequently, has been recognized for a number of years now (see Melby-Lervåg, Lyster, & Hulme, 2012, for a meta-analysis), and the effect on reading has been confirmed via assessments up to the age of 14 (Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009). This link may be universal, as researchers have observed it in many different languages [e.g. in French (Casalis, Deacon, & Pacton, 2011), in Dutch (de Graaff, Hasselman, Verhoeven, & Bosman, 2011), and in non-Roman alphabet languages such as Chinese (Ziegler, Tan, Perry, & Montant, 2000)]. Furthermore, some studies have reported the link between letter knowledge (name and sound) and reading acquisition (Leppänen, Aunola, Niemi, & Nurmi, 2008; Shatil, Share, & Levin, 2000), including findings for different languages, showing that letter knowledge helps children grasp the alphabetic principle (in English, McBride-Chang, 1999; in Hebrew, Levin, Shatil-Carmon, & Asif-Rave, 2006; in French, Labat, Ecalle, & Magnan, 2010; in Portuguese, Cardoso-Martins, Mesquita, & Ehri, 2011).

In addition to these phonological predictors, it has been found that motor and graphomotor skills can be related to literacy acquisition, and some studies have hypothesized that there is a relation between literacy acquisition and fine motor abilities. Delayed fine motor skill acquisition was indeed found to correlate with language impairment among kindergarten-age children (Adi-Japha, Strulovich-Schwarz, & Julius, 2011). There is also a comorbidity between dyslexia and dyspraxia (Kirby & Sugden, 2007). Haslum and Miles (2007) showed, in a sample of 12,950 10-year-old students, that 51.7% of severely dyslexic participants (2% of the total) presented motor difficulties. In typical children, a positive link was observed between handwriting performance and the ability to learn to read (Gentaz, Colé, & Bara, 2003). Berninger et al. (2006) found that early training in handwriting (with orthographic and/or motor activities) improved not only handwriting skills but also word reading. Such training is more effective with handwriting than with typing, showing that practice in writing letters by hand helps children recognize them (Longcamp, Zerbato-Poudou, & Velay, 2005). This difference between handwriting and typing may be attributable to activation of cerebral zones involved in motor activity when recognizing letters. Functional MRI scanning of four- to five-year-old children showed that after writing by hand, the "reading circuit" was activated during letter perception, but this was not the case after single-key typing or tracing (James & Engelhardt, 2012). The authors concluded that the experience of handwriting might facilitate reading acquisition in children.

Handwriting, by definition, is a one-hand activity performed by the dominant hand (i.e. a lateralized motor experience involving the same brain lateralization as for letter recognition). Functional MRI studies have shown that the same region of the brain is activated for letter recognition and writing letters by hand: the left ventral premotor cortex for right-handed persons, and the right ventral premotor cortex for left-handed persons (Longcamp, Anton, Roth, & Velay, 2005). The phenomenon of manual asymmetry raises the question of the different roles of the dominant and non-dominant hands in cognitive development and, in the present case, in literacy acquisition. Data on the magnitude of the difference between the two hands suggest that it may be the weakness of the non-dominant hand rather than the strength of the dominant hand that is relevant. Bishop (1984, 1990b) and Hill and Bishop (1998) focused on the role of the non-dominant hand when investigating left-handedness associated with clumsiness, finding, for example, that children with poor non-dominant hand scores made more mispronunciations in sentence repetition tasks (Bishop, 1990b). Corriveau and Goswami (2009) assessed hand dominance using a peg-moving task – the task consists of transferring 10 dowelling pegs from the furthest row of 10 holes to the nearest row of 10 holes as fast as possible. They observed that children with specific language impairment had lower performance levels with their non-dominant hand compared to age-matched children, but found no significant difference for dominant hand performance. In addition, non-dominant hand performance explained a significant part of the variance of one of the two phonological tasks (phoneme deletion, but not for reading and spelling scores). This finding supports the hypothesis of a link between the performance of the non-dominant hand and some language skills.

Annett's theory of handedness is based on asymmetry in manual activities, and one of the key assumptions was that being moderately right-handed (moderate-to-weak difference between the right hand and left hand) could maximize cognitive advantages, in particular for phonological processes (Annett, 1985; Smythe and Annett, 2006). Crow, unlike Annett, worked on the hypothesis that weakly lateralized children would be poorer readers (Crow, Crow, Done, & Leask, 1998). The data supported the hypothesis of Crow et al., as participants with the lowest scores on the cognitive tasks recorded equal hand skills (i.e. were not lateralized). Mayringer and Wimmer (2002) failed to replicate the results of Crow's team and found no association between relative hand skill scores (left-hand minus right-hand difference) and reading and spelling; their study did not support Annett's hypothesis either. In contrast, Nettle (2003), using a multiple regression model, observed that average cognitive ability increased monotonically with increasing strength of laterality (i.e. larger difference between the right and left hand). Unfortunately Nettle (2003) did not include any data on literacy acquisition. The inconsistency between these authors' findings may be explained, at least partially, by the different cognitive and laterality tasks used and differences in the characteristics of the participants (age, sex and proportion of left-handers). Thus, the debate on the impact of the non-dominant hand and relative hand skill on literacy acquisition continues.