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Influence of Manual Preference on the Line-Bisection Performance in 3-6 Years Old Children

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Abstract

One hundred and seventy-eight children (range 3,4 – 6,7 years old), who were classified as either right-handed, left-handed, or mixed-handed, performed line-bisection task twice – with the left and the right hand, respectively. The results showed that at the group level, all three handedness groups demonstrated a leftward bias when bisect with the left hand and a rightward bias when bisect with the right hand, but to varying degrees, with the right-handed group exhibiting significantly the biggest leftward error with the left hand and the smallest rightward error with the right hand. In addition, although the highest percentage of children in all three handedness groups showed symmetrical neglect, the incidence of right pseudoneglect was significantly higher in the right-handed group and vice versa – the incidence of left neglect was higher in the two non-right-handed groups. The pattern of the results suggested less lateralized visual spatial attention in left-handed 3,4 – 6,7 years old than in right-handed their peers.

Keywords: line-bisection task, preschool age, handedness.

1. Introduction

Handedness refers to hemispheric asymmetry for hand movement control and to the preferred use of one hand over the other for performing manual activities (Annett, 2002; Hellige, 1993). Approximately 90% of humans are right-handed and the rest 10% are left-handed (Springer & Deutsch, 1990).

A widely shared view is that handedness is related to cerebral lateralization, and especially to language lateralization (Asenova, 2018; Hellige, 1993; McManus, 2002; Ocklenburg et al., 2014). While the relation of handedness to language lateralization has been extensively studied for a long time, the relation of handedness to other functions, including spatial functions, has received far less attention.

The typical pattern of hemispheric lateralization of function is the left hemispheric dominance for language and the right hemispheric dominance for spatial processing and spatial attention (Hécaen & Sauguet, 1971; Hellige, 1993; O'Regan & Serrien, 2018; Zago et al., 2016), with right-sided lateralization of spatial processing tending to be less consistent than left-sided lateralization of language processing (O'Regan & Serrien, 2018). However, it is well documented that a small proportion of people, mainly left-handed, display different patterns of lateralization of language and spatial functions (Hécaen & Sauguet, 1971; O'Regan & Serrien, 2018).

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- Preschoolers (3-6 years old) demonstrate a group-level symmetrical neglect in the performance of a manual line-bisection task.
- Manual preference influences visuomotor bisection in typically developing 3-6 years old.
- The incidence of right pseudoneglect is highest among right-handed preschoolers and lowest among left-handed preschoolers.
- The incidence of left pseudoneglect is higher among non-right-handed preschoolers than among right-handed preschoolers.

With regard to the relationship between handedness and language lateralization, Knecht et al. (2000) reported an atypical right-hemispheric language lateralization in 4% in consistent right-handed subjects and in 27% in consistent left-handed subjects, and Mazoyer et al. (2014) reported a strongly atypical right-hemispheric language lateralization in 7% of left-handers. Based on a fMRI study's results of a sample of children aged 5 to 18 years, Szaflarski et al. (2012) reported that 15% of left-handed children demonstrated atypical language lateralization in the frontal regions and 33% showed atypical language lateralization in the temporo-parietal regions.

With regard to the relationship between handedness and spatial lateralization, there are few studies and inconsistent evidence, probably due to weaker lateralization of spatial processing asymmetries as compared to language processing asymmetries (Bryden, Munhall & Allard, 1983; O'Regan & Serrien, 2018).

Line-bisection and landmark tasks are widely used behavioral methods for studying visual spatial attention (Jewell & McCourt, 2000). Right hemisphere dominance for these processes causes typical patterns of performance of the two tasks in adults: slight systematic overestimation of the left half of pre-bisected lines in the landmark task performance and leftward bias of the subjective midpoint in line-bisection task performance regardless of the hand used – a phenomenon that is called "right pseudoneglect" (Asenova, 2014; Bowers & Heilman, 1980; Ciçek et al., 2009; Jewell & McCourt, 2000).

Numerous studies have provided evidence that the manual (motor) component of a paper-and-pencil version of a line bisection task influences the performance (Bradshaw et al., 1987; Dellatolas et al., 1996; Jewell & McCourt, 2000; Ochando & Zago, 2018). This component of the task is expressed through two effects: the effect of the hand used to bisect and the effect of the subject's handedness (for a review, see Jewell and McCourt, 2000; Hausmann et al., 2003). While in adults the effect of the hand which is used to bisect is manifested in slightly greater magnitude of left-sided bias from the real center when bisection is done with the left hand as compared to the right hand, in children it is manifested with different direction of deviation in bisection with both left and right hand: leftward bias with the left hand and rightward bias with the right hand (for a literature review see Jewell & McCourt, 2000).

Few studies have investigated the effect of handedness on the performance of line-bisection task. Scarisbrick and co-workers (1987) and Luh (1995) reported similar patterns of the results studying normal adults, namely, right-pseudoneglect in both left- and right-handed groups, with greater deviation with the left hand in left-handers than in right-handers. Ochando and Zago (2018) found well pronounced hand-used asymmetry observed for each spatial position of the lines in right-handers, and only for left-displaced lines in left-handers. Examining the effect of successfully switched left hand writing on line-bisection performance, Asenova (2014) found that switching of hand writing, not handedness, is a factor that modulates both the direction and the magnitude of bisection error, but probably its effects are dependent on the subject's sex. The researcher observed right pseudoneglect in the right-handed group and the ordinary left-handed group, but symmetrical neglect in the converted left-handed group.

The results of even fewer studies on the issue among children are also inconsistent. For example, Bradshaw et al. (1987) and Dellatolas et al. (1996) found that while right-handed children exhibited right pseudoneglect, left-handed children exhibited symmetrical neglect. Van Vugt et al. (2000) also reported a significant impact of handedness on line-bisection performance, with left-handed children bisecting substantially to the left in comparison to right-handed children. Asenova and Andonova-Tsvetanova (2019) did not find any differences between right- and left-handed children regarding line-bisection performance patterns.

Therefore, handedness emerges as a factor whose influence on the patterns of cerebral lateralization of visuospatial attentional function needs to be thoroughly explored. The limited information on the lateralization of spatial attention in children, and especially its determination from handedness as a subject-related factor, motivated the present study. Its main purpose was to investigate the potential influence of handedness on the development of asymmetry in visual spatial attention in typically developing preschoolers, using a paper-and-pencil version of a line bisection task.

2. Method

2.1 *Subjects*

A total of 178 children (84 boys and 94 girls, ranged 3,4 – 6,7 years old) participated voluntarily in the study with their parents' and the schools' administration consent. At the time of sampling all children attended all-day preschool classes. According to the information provided by children' teachers all were typically developing children and Greek native speakers.

2.2 *Assessment of handedness*

Handedness of participants was assessed by a performance test including the following 10 manual activities: striking a match, throwing a ball, combing, taking an object, waving goodbye, zipping/unzipping, putting glasses in a spectacle, threading a needle, picking up a glass of water, unscrewing a lid. Each activity was scored as left = -1 or right = +1. This test has been repeatedly used by Asenova in her research on functional lateralization (Asenova, 2004, 2013, 2014, 2018; Asenova & Andonova-Tsvetanova, 2019; Assenova & Vladimirova, 2006).

A Quotient of manual asymmetry (Q_{MA}) was calculated individually for each child, using the formula: $[(R – L) / (R + L)] \times 100$, where R is the number of activities performed with the right hand and L is the number of activities performed with the left hand. Children who scored between -70 and +70 were classified as mixed-handed, those who scored between +71 and +100 were classified as right-handed and those who scored between -71 and -100 were classified as left-handed. Therefore, children who scored between -71 and –100 were classified as mixed-handed. These cut-off points have been established by Dragovic (2004) depending on statistical criteria.

2.3 *Line-bisection task*

The line-bisection task is widely used in research of visual spatial attention and its lateralization. The task used in the present study was applied in previous research (Asenova, 2013; Asenova & Andonova-Tsvetanova, 2019; Hausmann et al., 2003; Patston et al., 2006). It includes 17 horizontal black lines 1 mm wide on a white sheet of paper (21×30 cm). Line length ranges from 100 to 260mm. Seven lines are presented in the middle of the sheet, five are aligned to the left and five lines are aligned to the right of the sheet. A child was given a fine black pen and was instructed by the experimenter to place a mark at the center of each line. The experimenter covered each bisected line, to prevent possible effect of the child's previous choice on the subsequent bisections.

Each child performed the task twice, once with the right hand and once with the left hand. There was no time limitation to complete the task.

The percentage of deviation for each line was calculated using the following formula: (measured mean from the left – the real mean)/real mean) x 100. After that, the average percentage of deviation for the left and the right hand separately was calculated. The negative values reflected a leftward bias and the positive values reflected a rightward bias of the real center (Scarisbrick et al., 1987).

3. Results

One-Way ANOVA was performed separately for right and left hand with the aim to investigate the effects of children' handedness on line-bisection performance. Homogeneity of variances was checked using Levene's Test of Equality of Error Variances. Mean deviation scores for the left and the right hand (MDlh and MDrh) were entered separately as a dependent variable, with children' handedness as a fixed factor.

Results of the One-Way ANOVA performed for the left (MDlh) and the right hand (MDrh) are presented in Table 1 and Table 2, respectively.

Table 1. Results of the One-Way ANOVA performed for the left hand (MDlh) of the handedness groups

Handedness group	N	Mean	Std. Deviation	Std. Error
Right-handers	90	-4.25	3.09	.325
Mixed-handers	81	-2.29	4.91	.545
Left-handers	7	-0.30	5.18	1.958
F; *Sig*	$F_{/2, 175/}$= 6.725; *Sig*.=.002			

As seen in Table 1, although all three handedness groups demonstrated leftward bias of the subjective midpoint from the real center of the lines when bisected with the left hand, the magnitude of the deviation was significantly different between groups: the deviation was largest in the group of right-handed children and smallest in the group of left-handed children ($F_{/2,175/}$=6.725; sig=.002).

Results from the Post Hoc Multiple Comparisons showed significant differences between the group of right-handers and the group of mixed-handers (Sig.=.002) and between the group of right-handers and the group of left-handers (Sig.=.015). The difference between the two non-right-handedness groups was slight and insignificant (Sig.=.219).

Table 2. Results of the One-Way ANOVA performed for the right hand (MDrh) of the handedness groups

Handedness group	N	Mean	SD	Std. error
Right-handers	90	0.71	3.82	.403
Mixed-handers	81	2.17	3.64	.404
Left-handers	7	1.48	3.27	1.239
F; *Sig*	$F_{/2, 175/}$=3.256; *Sig*.=.041			

As seen in Table 2, although all three handedness groups demonstrated rightward bias of the subjective midpoint from the real center of the lines when bisected with the right hand, the magnitude of the deviation was significantly different between the groups: this time the bias was smallest in the group of right-handed children and largest in the group of mixed-handed children ($F_{/2, 175/}$=3.256; Sig=.041).

Results from the Post Hoc Multiple Comparisons showed significant differences between the right-handed group and the mixed-handed group (Sig.=.012), but insignificant differences between the right-handed group and the left-handed group (Sig.=.603). Also insignificant was the difference between the two non-right-handed groups (Sig.=.636). Therefore, as it is illustrated in Figure 1, at the group level, all three handedness groups exhibited leftward bias when bisecting with the left hand and rightward bias when bisecting with the right hand, i.e., all three groups demonstrated symmetrical neglect.

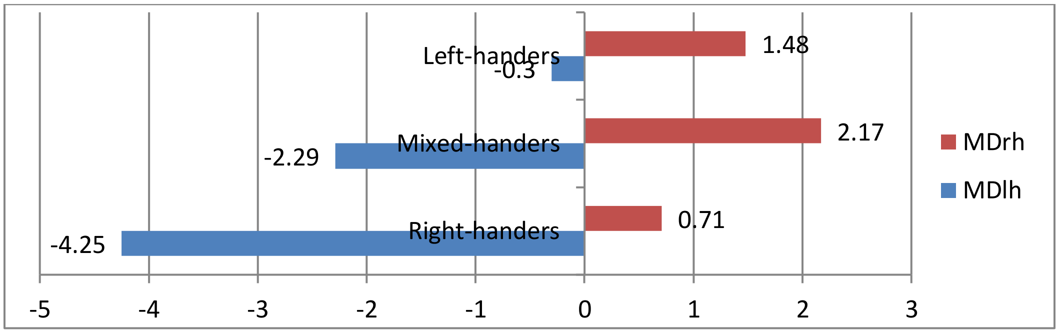

Figure 1. Mean Percentage of Deviation scores from the true center for the left hand (MDlh) and the right hand (MDrh) of the handedness groups

Results of the Chi-squire test revealed statistically significant between-group differences in the frequency of different types of neglect in handedness groups (see Table 3).

Table 3. Distribution of participants in the handedness groups according to the demonstrated type of neglect

Handedness groups	Type of neglect							
	RPsN		LN		SN		RevSN	
	N	%	N	%	N	%	N	%
Right-handers	33	36.7	3	3.3	52	57.8	2	2.2
Mixed-handers	18	22.2	20	24.7	39	48.1	4	4.9
Left-handers	1	14.3	2	28.6	3	42.9	1	14.3
Pearson Chi-Square	$\chi^2_{\|6\|}$=22.213, *p*=.001							
Cramer's *V*	.353							

RPsN – Right pseudoneglect (left bias with both hands);
LN – Left pseudoneglect (right bias with both hands);
SN – Symmetrical neglect (left bias with the left hand and right bias with the right hand);
RevSN – Reversed symmetrical neglect (right bias with the left hand and left bias with the right hand).

As shown, although the highest percentage of participants in all handedness groups demonstrated symmetrical neglect, the frequency of this type of neglect was significantly highest in the right-handed group and lowest one in the left-handed group ($\chi^2_{|6|}$=22.213, *p*=.001; Cramer's *V*=.353). Moreover, the percentage of children who exhibited right pseudoneglect was highest in the right-handed group and lowest in the left-handed group, and in contrast – the percentage of children who exhibited left pseudoneglect was highest in the two non-right-handed' group and lowest in the right-handed group.

4. Discussion

The focus of the present study was to examine the effect of handedness on the pattern of asymmetry of visual spatial attention assessed on the basis of performance of line-bisection task. The results revealed that all three handedness groups demonstrated a group-level leftward bias when bisecting with the left hand and a rightward bias when bisecting with the right hand, but to varying degrees, with the right-handed group exhibiting the biggest leftward error with the left hand and the smallest rightward error with the right hand. In addition, although the highest percentage of children in all handedness groups showed symmetrical neglect, the incidence of right pseudoneglect (the mature pattern of the task performance) was significantly higher in the right-handed group than in the non-right-handed groups and vice versa – the incidence of left neglect was higher in the two non-right-handed groups in comparison to the right-handed group.

The results of the present study are in agreement with the results of Asenova and Andonova-Tsvetanova (2019), who reported a slightly less lateralized visual spatial attention in left-handed 6–7-year-old than in their right-handed peers, as well as with the results of Karev (1999) who studied directionality in right, mixed and left-handed children and found that right handers were the most and left handers were the least left directed. They are also consistent with the results of Dellatolas et al. (1996) who studied typically developing 4–5 years old children and 10-12 years old children and found an obvious shift of the right hand with age from rightward to leftward bias in line-bisection, but more pronounced in right-handers than in left-handers.

Taken together, the findings of the present study support the suggestion that manual preference influences visuomotor bisection in typically developing preschoolers (Asenova & Andonova-Tsvetanova, 2019; Dellatolas et al., 1996). Moreover, the results of the two non-right-handedness groups could indicate a development of an atypical pattern of lateralization of spatial attention in a large proportion of these children with weaker lateralization patterns or left-lateralized dominance.

The main limitations of the study are the small size of the left-handed group and non-matched size of handedness groups. Replications with larger samples with equal representation of right-, mixed- and left-handed participants are needed to assure the validity of the current study' findings.

5. Conclusions

In conclusion, the present study found that 3-6 years old children exhibit a group-level symmetrical neglect when performing a paper-and-pencil version of a line bisection task, but to a different degree when the children's handedness is taken into account. These findings suggest that handedness influences the trajectory of lateralization of visual spatial attention in preschool age. Moreover, a significantly higher incidence of left pseudoneglect during the performance of line-bisection task (right bias with both hands) among mixed- and left-handers could suggests a higher risk of development of an atypical pattern of lateralization of spatial attention in a large proportion of these children with weaker lateralization patterns or left-lateralized dominance.

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The author declares no competing interests.

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