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Note

Mirror writing of digits and (capital) letters in the typically developing child

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ABSTRACT

Typically developing 5- to 6-year-old children often reverse some digits (e.g., ε for 3) or single (capital) letters (e.g., Я for R) when they are required to write them under dictation. A theoretical approach to this phenomenon, based on an implicit right writing rule and that postulates an influence of the preceding writing, was tested in an experimental study of 300 children aged 5–6 years. The data support the implicit right writing rule and show the considerable influence of the preceding writing. For example, 73% of the children who correctly wrote the letter C mirror wrote an immediately following digit 3, whereas only 10% of the children who mirror wrote the letter C also mirror wrote an immediately following digit 3.

1. Introduction

Teachers and parents know that almost all children have a tendency to reverse the writing of some single letters (e.g., Я for R) or digits (e.g., ε for 3) when they begin learning to write between 4 and 6 years of age. Because this spontaneous behavior seems lost in normal adults, it is intriguing to ask which process is responsible for such mirror writings.

The motor-based "directional apraxia" hypothesis (Della Sala and Cubelli, 2007) and the visual-based "neuronal recycling" hypothesis (Dehaene, 2007) share the assumption that there is a period in development when children know how to compose the letters and digits but they do not know whether an individual letter or digit, for example, the digit 3, should face left (3) or right (ε). Two recent empirical results (Fischer, 2010a, 2010b) offer some clues on how 5- to 6-year-old children choose one of the two directions (left or right).

Fischer (2010a) showed that frequencies of mirror writing were different for different digits. For example, the digit 3 was reversed in 45.60% of cases, whereas the digit 4 was only reversed in 16.22% of cases. Fischer's research also suggests that the preceding digit may trigger a form of motor priming (or a visuomotor priming when the digits are written adjacently) which influences the direction of the subsequent digit.

Further, Fischer (2010b) reported that children mostly reversed two capital letters – J and Z – and that these reversals were frequent. Fischer interpreted these findings as the result of children developing an implicit rule for writing capitals according to which capitals have distinctive features on the right or face right. Children may learn such an "implicit right

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writing rule" because the great majority of the asymmetrical letters have a vertical line on the left side and their distinctive feature on the right (B, D, E, F, K, L N, P, and R), face right[1] (C and G), or have a tail on the right (Q). The implicit right writing rule indicates the correct direction for the capitals listed above, but it does not do so for the letter J. For the letter S, which does not clearly face right or left, and the letter Z, which has a diagonal line and not a vertical line, the rule is not relevant.

These two hypothesized mechanisms for bootstrapping[2] the direction of writing – an implicit right writing rule for capitals and visuomotor priming from the preceding writing for digits – generated two different hypotheses.

According to the *global hypothesis*, since the implicit right writing rule gives the correct writing direction for 12 of the 15 asymmetrical capitals, the 12 capitals B, C, D, E, F, G, K, L, N, P, Q, and R should benefit from activation of the rule. Moreover, also the correct writing of 6 should be induced by the activated rule. While the effect on the digits 4 and 5 is unclear, then no mirror writing was hypothesized for these digits, the activated rule should promote mirror writing for 1, 2, 3, 7, 9, and J. Because the rule is not relevant for S and Z, the choice of direction for these two letters should be made by chance. Hence, the global hypothesis states that, as a group, the capital letters B, C, D, E, F, G, K, L, N, P, Q, R and the digits 6, 4, and 5, should be mirror written less frequently than the group of remaining asymmetrical characters.

The *local hypothesis*, combining the implicit right writing rule and visuomotor priming from the preceding writing, predicts that digit 3 will be mirror written more frequently after a correct writing of C or E, than after a mirror writing of C or E, respectively. For the letter J, it predicts more mirror writings after a mirror writing of 7 than after a correct writing of 7, and more mirror writings after a correct writing of 6 than after a mirror writing of 6. Therefore, mirror writing of J (1) should occur least frequently after a correct writing of 7 or after a mirror writing of 6, (2) should be at an intermediate level when J is at the beginning of a series, and (3) should occur most frequently after a mirror writing of 7 or after a correct writing of 6. Analyses of the writing of 3 after B were exploratory because of the hidden 3 in B.

2. Method

2.1. Participants

The participants were 300 children (144 girls and 156 boys) from 18 preschool classes of the French "Ecole Maternelle".

[1] A character with no vertical line faces right when its main concavity is turned towards the right. Under this definition, the digit 6 faces right, and the digits 2, 3, and 9 face left. In France, the digit 1 is written with a short, left-facing downward stroke at the top of the vertical line that forms the body of the digit; therefore, it also contradicts the implicit right writing rule.

[2] To "bootstrap" means "to help oneself, often through improvised means". Direct observation suggests that children choose the direction of writing on their own, with no outside help, and that they use a self-initiating process. Therefore, it could be said that children bootstrap the direction of their writing (see http://www.thefreedictionary.com/bootstrap).

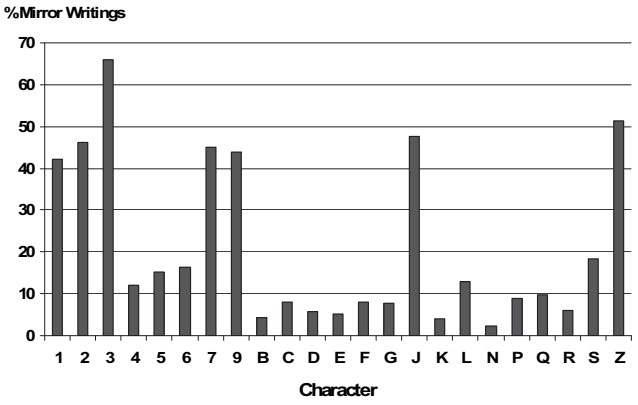

Fig. 1 – Percentage of mirror writings as a function of the character being written.

Thirty-nine other children were excluded because they did not produce any (horizontal) mirror writings or did not produce at least 50% relevant writings. The mean age was 5.715 years (SD = .35; range: 5.00–6.35). Thirty-three children wrote with their left hand and 267 wrote with their right hand. Participants were tested in groups of three or four, and the groups were randomly allocated to one of six experimental conditions (50 children in each condition): the children in the six experimental conditions did not differ in their mean age [$F(5,294) = .24$, $p > .94$] or in the ratio of girls to boys [$\chi^2(5) = .32$, $p > .99$]. All standard administrative authorizations and ethical rules for such experiments in schools were respected.

2.2. Material

The children had to write, under dictation and from memory, the 11 digits or letters of a series, in 11 aligned squares (one character per square). The sides of the squares measured 2.2 cm. Three series were used:

s1: P, 4, C, 3, 1, 7, J, L, 9, Z, G;
s2: J, 0, Z, 5, K, F, 9, B, 3, N, Q;
s3: R, E, 3, D, 8, 6, J, S, 2, 9, Z.

2.3. Procedure

The experimenter encouraged the children to write the digits and capital letters on the strip of paper, moving from left to

Table 1 – Mirror writings of the digit 3 as a function of the preceding writing.

Writing of 3	Following					
	A writing of C		A writing of E		A writing of B	
	Correct	Mirror	Correct	Mirror	Correct	Mirror
Correct	67	18	83	14	80	10
Mirror	181	2	190	1	152	1