Cogn Process (2009) 10:101–104
DOI 10.1007/s10339-008-0233-z

LETTER TO THE EDITOR

# Mirror writing in pre-school children: a pilot study

**Roberto Cubelli · Sergio Della Sala**

Received: 23 February 2008 / Revised: 13 September 2008 / Accepted: 29 September 2008 / Published online: 16 October 2008


**Abstract** Mirror writing refers to the production of individual letters, whole words or sentences in reverse direction. Unintentional mirror writing has been observed in young children learning to write and interpreted as the manifestation of different cognitive impairments. We report on mirror writing instances in a sample of 108 pre-school children. Results showed MW to be age-related but independent from handedness and left-right discrimination abilities. We propose an account of mirror writing as reflecting dissociation between acquired motor programmes for letter shape composition and unspecified spatial direction of hand movements. Before learning to write, the child's directional cognitive system is assumed to be dichotomous, thus inducing the production of randomly oriented asymmetrical letters.

**Keywords** Mirror writing · Children learning to write

## Introduction

Various species of animals, including monkeys, rats, pigeons and octopi, experience considerable difficulties in discriminating mirror-reversed stimuli (Ettlinger and Elithorn 1962; Lashley 1938; Mello 1965; Sutherland 1957). Humans are no exceptions (e.g., Davidoff and Warrington 2001). Humans also show mirror reversal in object manipulation (Feinberg and Jones 1985; Wade and Hart 1991) and in reading and writing (Gates and Bennett 1933; Hildreth 1934). Mirror writing (MW) is the topic of this paper.

It is common experience of every parent to walk in a nursery and notice that the "signature" of some children on their colourful drawings is mirror reversed. MW occurs when individual letters or whole word strings are produced in the reversed direction. Held to a mirror these words can be read normally. MW can be deliberate (Allen 1896), induced (Critchley 1928) or involuntary (Lebrun et al. 1989).

Instances of deliberate reverse writing can be found in biographies of famous people, including Lewis Carroll and Leonardo da Vinci (Schott 1979; Schott 1999).

MW can be induced in healthy individuals for instance by asking them to write with their dominant hand on a sheet of paper against the undersurface of a table. If under these conditions people start from the left as they normally would, the outcome will be MW; in order to write normally they should operate a mental rotation to imagine writing from the opposite point of view.

Involuntary MW is typically observed in people forced to use their left hand as a consequence of amputation or neurological damage to their preferred right hand, e.g. following a stroke (see review in Balfour et al. 2007). Involuntary MW is also frequently observed in pre-school children while learning to write (Cornell 1985) mainly between the ages of 3 and 7 years (Schott 2008) and has been claimed to be associated with slow intellectual development. This often mentioned claim (e.g. Heilman et al. 1980) sprang from anecdotal, early literature (e.g. Fuller 1916; Gordon 1920; for comments see Orton 1925) and from single case reports of developmental disorders

R. Cubelli (✉)
Dipartimento di Scienze della Cognizione e della Formazione,
Universita' di Trento, Corso Bettini, 31,
38068 Rovereto, TN, Italy
e-mail: roberto.cubelli@unitn.it

S. Della Sala
Human Cognitive Neuroscience, Psychology,
University of Edinburgh, Edinburgh, UK

(Carmichael and Cashman 1932; Wade and Hart 1991). Experimental studies however converge in demonstrating that the likelihood of MW is equipoise in normal and intellectually challenged children (Hildreth 1934; Wang 1992; Della Sala and Cubelli 2007).

Three further variables have been claimed, both in early observations and in more recent reviews, to be associated with MW in children, namely, deficits in orientation, i.e. left-right confusion (Lebrun et al. 1989; Orton 1925), left-handedness (Carmichael and Cashman 1932; Critchley 1928; Gordon 1920; Bertrand 2001; Heilman et al. 1980; Lebrun et al. 1989), and age per se (e.g. Cornell 1985; Davidson 1935). In this paper we address the alleged relationship between these variables and MW.

Several theories have been proposed to account for the frequency of MW in young children as well as for MW associated with brain damage. Given the complexity of the phenomenon, different causes are said to account for its presence in different people (Gottfried et al. 2003; see reviews by Fellows 1968; Lebrun et al. 1989; and by Schott 1999). On the contrary, we recently proposed a unitary theory of MW (Della Sala and Cubelli 2007) capable of accounting for MW manifestations in both children learning to write and brain-damaged adults. This theory assumes that in MW the motor programmes for writing letters contain information about shapes but not about direction either because this has yet to be specified fully (children learning to write) or because of its damage (acquired brain injury). For this reason, we propose that the lack of directional information relevant to writing be labelled 'directional apraxia'. This account of MW (described in details elsewhere, see Della Sala and Cubelli 2007) would predict a correlation with age, considered as a rough indicator of writing exposure but no association between MW and left-right discrimination or handedness.

## Experiment

### Participants

The sample consisted of a group of Italian pre-school children, ($N = 108$, mean age 57.30 months, SD 9.35, range: 41–74 months). All lived in a lofty quarter of a wealthy area in Romagna and spoke Italian as their mother tongue. All were regularly attending nursery since age three and none required special needs. They were all judged by their teachers and parents to show normal development and behaviour; none had overt learning difficulties in any domain. Sixteen were left-handed as evinced by a formal questionnaire that their parents filled on their behalf (Oldfield 1971).

### Material and procedures

The participating children were tested with a series of four writing tasks which consisted of (a) writing their name (or copying it, should they fail to write it spontaneously), (b) copying 5 single, capital letters, (c) copying 5 single digits, (d) copying 2 words in capital letters. All letters and words were presented individually on the top half of an A5 page. At least one instance of MW, i.e. if a single letter or the entire word is mirror reversed, qualifies the participant as mirror writer.

They were also asked to perform a perceptual (change detection task) and an orientation judgment task (same-different task). Both the perceptual and orientation task were based on the "odd-one-out" procedure. In the perceptual task the children were asked to single out which of three stimuli, presented in a row at equal intervals from one another, had a detail which differed from the other two (for instance one of three fish had a smaller fin). Four triplets were presented, and the position of the odd stimuli was counterbalanced across trials. The orientation task followed the same procedure though the difference consisted in one of the stimulus being oriented at 180° with respect with the other two, e.g. one fish was facing right while the other two were facing left. Therefore, the perceptual task requires a local, analytic process whilst the solution of the orientation task implies a global, holistic approach.

## Results

Table 1 details the demographic features of the participating children according to whether or not they showed at least one instance of MW. Their respective performances in the perceptual and orientation judgment tasks are also reported. Table 2 reports the number of children showing instances of MW in each of the specific writing tasks composing the testing battery.

**Table 1** Demographic features of children ($N = 108$) who showed at least one instance or did not show episodes of mirror writing

| | Normal writers | Mirror writers |
|---|---|---|
| No. of children | 51 (47%) | 57 (53%) |
| Mean age (months) | 62.12 (8.13) | 52.98 (8.24) |
| Sex (M/F) | 21/30 | 24/33 |
| Handedness (R/L) | 45/6 | 47/10 |
| Writing/copying | 19/32 | 44/13 |
| Perceptual errors (%) | 29.4 | 49.7 |
| Orientation errors (%) | 41.2 | 60.1 |

Their respective performances in the perceptual and orientation judgment tasks are also reported

**Table 2** Number of children showing at least one episode of mirror writing across the different writing tasks

| | Mirror writers ($N = 27$) |
|---|---|
| Writing own name (whole name) | 0 |
| Writing own name (single letters) | 14 (25%) |
| Copying single letters | 14 (25%) |
| Copying digits | 40 (70%) |
| Copying words (whole stimulus) | 12 (21%) |
| Copying words (individual letters) | 15 (26%) |

Mirror writers were younger than non mirror writers ($F[1,106] = 33.496$, $p < 0.001$). Neither gender nor handedness had a significant influence on whether or not the child mirror wrote. Most non mirror writers (63%) spontaneously wrote their own name; in contrast most mirror writers (77%) only managed to copy it. This suggests that mirror writers were less familiar with writing than non mirror writers.

An ANOVA on the errors made in the judgment tasks showed a main effects of Group ($F[1,106] = 19.669$; $p < 0.001$) and Task ($F[1,106] = 12.448$; $p < 0.001$), showing that mirror writers made on the whole more errors than non mirror writers, and that the orientation task elicited more errors than the perceptual task. However, no interaction between Group and Task was found, indicating that mirror writers were no more prone to orientation errors than perceptual errors.

Double dissociations were also apparent. Aside from the 46 children writing normally and showing orientation errors, 12 mirror writers performed flawlessly in the orientation task. For instance, case 74 who performed at ceiling in the orientation task copied in mirror fashion one single letter, one digit and a whole word. It is worthwhile mentioning that in all instances in which the children copied whole words in mirror reversed fashion, they did not reverse individual letters.

## Discussion

Within a larger project on MW (see e.g., Balfour et al. 2007; Della Sala and Cubelli 2007) the current experiment should be considered as a pilot study assessing the relationship between MW and learning to write. Aim of this study is to ascertain the variables associated with MW in pre-school children before they enter formal education.

Contrary to accepted wisdom (Carmichael and Cashman 1932; Lebrun et al. 1989) but in agreement with previous experimental observations (Hildreth 1934; Della Sala and Cubelli 2007), left handed children in our study had no more probability than right-handers of developing MW.

Current results also speak against the right-left confusion hypothesis (Lebrun et al. 1989; Orton 1925), which would predict that, compared with normal writers, MW children would present with considerable more difficulties in picture orientation than in perceptual judgments tasks.

A relationship between the children's age and the probability of MW (e.g. Davidson 1935; Cornell 1985) cannot be ruled out. However, the inability to write their own name spontaneously was more frequent among MW children than non MW ones indicating that the stage of writing acquisition skills, rather than age as such, is associated with high number of reversal errors.

Learning to write words and numbers entails acquiring both the shaping and the orienting of these mostly asymmetrical symbols. MW reveals that these two types of information are independent from one another and that the ability of shaping letters precedes the knowledge of writing direction.

This contrasts with the observation of MW in brain damaged patients (see review in Della Sala and Cubelli 2007). Another relevant feature which distinguishes MW of normal children from that of brain damaged adults is that children reverse letters and words writing with their dominant hand, while typically patients mirror write with their left (non dominant) hand following a left-sided brain damage.

We propose a unitary account of MW, which should be conceived as a form of apraxia (defined as a deficit of learned motor programmes) affecting the direction of actions, impaired in the case of brain-damaged patients, not yet fully acquired in young children. The assumption is that an abstract representation of direction is inherent with the action to be learned, in the case at issue either learning to form a given letter shape or to write a text. At odds with other visual objects which do not change their identity according to visual angle, letters are not constant according to rotation angles. Before acquiring this specific knowledge, children would process words and letters exactly as they process other objects, orientation being irrelevant to the stimulus identity. It follows that children would show directional writing problems, producing letters either rightwards or reversed, until the knowledge of writing direction of their language stabilises. Before the writing direction parameters are set by experience and exercise, the child's directional cognitive system is necessarily dichotomous at birth to permit compliance with leftwards or rightwards languages. Learning (a writing direction) would mean to stamp out the unwanted alternative rather than acquiring one anew. This would predict that children little exposed to writing would randomly compose asymmetrical letters and digits facing left or right with either hand, as observed in the current study.

Our hypothesis implies that MW is a transient phenomenon not predictive of any difficulties in learning to write or read in primary school. This prediction needs to be tested formally by means of a full-blown, longitudinal study.

## References


Allen FJ (1896) Mirror writing. Brain 19:385–387. doi:10.1093/brain/19.2-3.385

Balfour S, Borthwick S, Cubelli R, Della Sala S (2007) Mirror writing and reversing single letters in stroke patients and normal elderly. J Neurol 254:436–441. doi:10.1007/s00415-006-0384-8

Bertrand P-M (2001) Histoire des gauchers. 'Des gens à l'envers' Editions Imago, Paris

Carmichael L, Cashman H (1932) A study of mirror writing in relation to handedness and perceptual and motor habits. J Gen Psychol 6:296–329

Cornell JM (1985) Spontaneous mirror-writing in children. Can J Psychol 3:174–179. doi:10.1037/h0080122

Critchley M (1928) Mirror-writing. Kegan Paul, Trench, Trubner and Co. Ltd, London

Davidoff J, Warrington EK (2001) A particular difficulty in discriminating between mirror images. Neuropsychologia 39:1022–1036. doi:10.1016/S0028-3932(01)00039-2

Davidson HP (1935) A study of the confusing letters, B, D, P and Q. J Genet Psychol 47:458–468

Della Sala S, Cubelli R (2007) "Directional apraxia": a unitary account of mirror writing following brain injury or as found in normal young children. J Neuropsychol 1:3–26. doi:10.1348/174866407X180783

Ettlinger G, Elithorn A (1962) Transfer between the hands of a mirror-image tactile shape discrimination. Nature 194:1101–1102

Feinberg T, Jones G (1985) Object reversals after parietal lobe infarction: a case report. Cortex 21:261–271

Fellows B (1968) The discrimination process and development. Pergamon Press, Oxford

Fuller JK (1916) The psychology and physiology of mirror writing. Univ Calif Publs Psychol 2:199–265

Gates AI, Bennett CC (1933) Reversal tendencies in reading; causes, diagnoses, prevention and correction. Bureau of Publications, Teachers College, Columbia University, New York

Gottfried JA, Sancar F, Chatterjee A (2003) Acquired mirror writing and reading: evidence for reflected graphemic representations. Neuropsychologia 41:96–107. doi:10.1016/S0028-3932(02)00130-6

Gordon H (1920) Left-handedness and mirror-writing especially among defective children. Brain 43:313–368. doi:10.1093/brain/43.4.313

Heilman KM, Howell G, Valenstein E, Rothi L (1980) Mirror-reading and writing in association with right-left spatial disorientation. J Neurol Neurosurg Psychiatry 43:774–780

Hildreth G (1934) Reversals in reading and writing. J Educ Psychol 25:1–20. doi:10.1037/h0074907

Lashley KS (1938) The mechanism of vision: XV preliminary studies of the rat's capacity for detail vision. J Gen Psychol 18:123–193

Lebrun Y, Devreux F, Leleux C (1989) Mirror-writing. In: Aaron PG, Joshi RM (eds) Reading and writing disorders in different orthographic system. Kluwer, Dordrecht, pp 355–378

Mello NK (1965) Mirror image reversal in pigeons. Science 149:1519–1520

Oldfield RC (1971) The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia 9:97–113. doi:10.1016/0028-3932(71)90067-4

Orton ST (1925) "Word blindness" in school children. Arch Neurol Psychiatry 14:581–615

Schott G (1979) Some neurological observations on Leonardo da Vinci's handwriting. J Neurol Sci 42:321–329. doi:10.1016/0022-510X(79)90165-5

Schott G (1999) Mirror writing: Allen's self observations. Lewis Carroll's 'looking glass' letters, and Leonardo da Vinci's maps. Lancet 354:2158–2161

Schott G (2008) Mirror writing: neurological reflections on an unusual phenomenon. J Neurol Neurosurg Psychiatry 78:5–13. doi:101136/jnnp2006094870

Sutherland NS (1957) Visual discrimination of orientation and shape by octopus. Nature 179:11–13. doi:10.1038/179011a0

Wade J, Hart R (1991) Mirror phenomena in language and non-verbal activities: a case report. J Clin Exp Neuropsychol 13:299–308. doi:10.1080/01688639108401045

Wang X-de (1992) Mirror writing of Chinese characters in children and neurological patients. Chin Med J 105:306–311