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Visual Perception of Motor Anticipation in Handwriting: Influence of Letter Size and Movement Velocity

Sonia Kandel,[a] Jean-Pierre Orliaguet,[b] and Louis-Jean Boë[a]

a. Institut de la Communication Parlée, CNRS, Grenoble, France
b. Laboratoire de Psychologie Expérimentale, CNRS, Grenoble, France

Several studies have demonstrated the role of motor variables in the visual perception of space (e.g., Gibson, 1950; Johansson, 1973). Data provided by Viviani and Stucchi (1992) on dynamic manual movements and by Babcock and Freyd (1988) on static handwritten traces, among other, support the idea that visual perception could be influenced by *implicit knowledge* about our own production movements.

The present research was carried out within this theoretical framework. In particular, we investigated whether visual processes could exploit specific between-letter effects that are know to affect the timing of handwriting production.

Several studies revealed that the shape, the size, and the timing of the production of a letter are influenced by surrounding letters (e.g., Thomassen & Schomaker, 1986). Orliaguet and Boë (1990) have shown that in reproducing a letter *l*, the down-stroke production time is a function of the spatial features of the following letter: Changes in size (*ll* vs. *le*) as well as in size and rotation direction (*ll* vs. *ln*) generate temporal differences in the down-stroke for the *l*. This phenomenon indicates that the motor system *anticipates* the forthcoming motor sequences.

We sought to determine whether the visual system could exploit anticipatory kinematic information in handwriting. More specifically, we examined whether the temporal differences observed in the down-stroke of the *l* embedded in the digrams *ll*, *le*, and *ln*, could be used by the visual system to predict the identity of the letter following the *l* before spatial information was available.

Experiment 1

Participants ($N = 10$) were told that an *l* would be presented on the computer screen and that this letter could belong to digrams *ll*, *le*, or *ln*. These *l*s were progressively traced on the screen with their original kinematics. When the lowest point of the *l* was reached, the stimulus disappeared and the participant was asked to *predict* whether the presented *l* corresponded to the production of *ll*, *le*, or *ln*. These three *l*s were identical in shape and were the same size (6-cm high). They only differed in terms of production timing.

Correct identification was highly above chance (see Figure 1). A more detailed analysis revealed that responses were influenced by the kinematic pattern of the *l*. When the *l* belonged to *ll*, *ll* responses were more frequent than *le* responses, and *le*

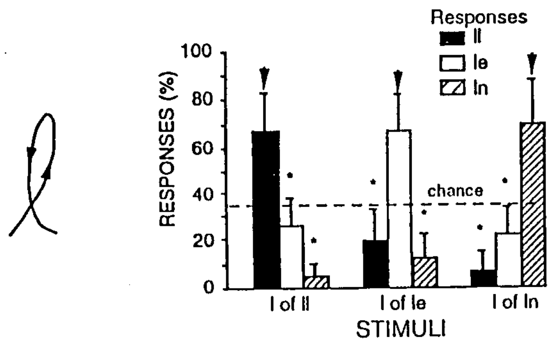

Figure 1. Percentage of occurrence of responses *ll*, *le*, and *ln* for each of the three actually presented digrams. Arrows identify correct responses.

responses were in turn more frequent than *ln* responses. A mirror-image pattern of results was observed for the digram *ln*. For the digram *le*, a significant difference was observed between the frequency of *ln* and *le* responses, but not between responses *ln* and *ll*.

These data demonstrate that participants used the timing information provided by the movement of the *l* to predict the forthcoming letter.

Experiment 2

The goal of this experiment was to test whether movement velocity and letter size could influence the percentage of correct responses. We only used digrams *ll* and *ln*. Stimuli were smaller (1.2 cm) than in the previous experiment, thus reducing the number of

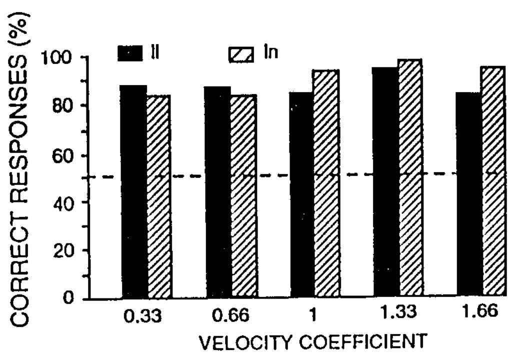

Figure 2. Percentage of correct responses as a function of velocity increase (gain coefficient = 0.33 and 0.66) and decrease (1.33 and 1.66).

effectors implied in the production movement (see Wright, 1993). The global velocity of the productions was increased and decreased by multiplying the original velocity by a gain coefficient. The procedure was the same as in Experiment 1.

The data, illustrated in Figure 2, show that the percentage of correct responses was highly above chance, while offering no evidence of an effect of the variation of velocity gain coefficient on performance. Similar percentages were observed for *ll* and *ln*.

Thus, the visual detection of motor anticipation does not seem to depend on letter size or handwriting velocity.

Discussion

The goal of this research was to establish whether the visual system could exploit the kinematic differences observed in the production of the *l*. Results indicate that the visual system can detect timing differences among *l*s and use this information to predict the identity of the forthcoming letter. Visual perception of motor anticipation is extremely efficient whatever the movement velocity and letter size.

The presented results therefore appear to be consistent with those reported in the literature on handwriting (Babcock & Freyd, 1988; Viviani & Stucchi, 1992) and speech perception (Cathiard & Lallouache, 1992). They suggest the possibility that the processing of visual information on the kinematics of manual gestures be mediated by information on the organization of production movements.

Implicit motor knowledge could therefore influence the perception of bodily motion by giving sense to what is being perceived visually. As suggested by Viviani and Stucchi (1992), perceiving is not only acting (Gibson, 1950) but also "knowing how to act."

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Encoding of Spatial Information During Navigation in a Visually Simulated Environment

Patrick Péruch,[a] Florence Gaunet,[b] Catherine Thinus-Blanc,[b] and Marie-Dominique Giraudo[a]

a. Cognition and Movement, CNRS, Marseilles, France
b. Cognitive Neuroscience Laboratory, CNRS, Marseilles, France

When moving through an unknown environment, people get new spatial knowledge, which may improve over successive displacements. The most elaborate level of spatial representation is characterized by panoramic survey maps which retain the general configuration of the environment. This form of representation is generally thought to be necessary in many tasks involving spatial inference, such as taking a shortcut or selecting a new route (Loomis, Klatzky, Golledge, Cicinelli, Pellegrino, & Fry, 1993). Usually, efficient decisions require survey maps to which knowledge of one's current position and orientation is related. In the lack of vision, spatial updating is possible on the basis of related proprioceptive information. However, many works have stressed the predominance of vision over other senses for the acquisition of spatial knowledge (Rieser, Guth, & Hill, 1986).

The present experiment can be considered complementary to Rieser et al.'s (1986), as here participants were only provided with visual information, that is, proprioceptive feedback was not available. Our aim was to evaluate the level of spatial knowledge and to determine whether updating is possible through a passive exploration of a simulated environment.

Method

A graphic, PC-based workstation was used to simulate ego-motion in a circular 3D environment composed of five different colored cones and 16 limiting white walls (Figure 1). The displacement was controlled by the observer with a joystick. The experiment alternated exploration and test phases.

The observer was shown a film of a recorded exploration. The film depicted the path starting and ending on D with the observer oriented to B, the path passing through the following points: D A D B D E D C D (Figure 1). All the objects could be viewed several times from different viewpoints.

At the end of the exploration film, a new scene was presented with the objects removed. The observer was requested to reach the location of a specified object. Three types of tasks were defined. (1) In *spatial-memory* tasks, the observer had to reproduce the DA, DC, and DE paths (spatial memory *from D*) or AD, CD, and ED paths (spatial

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Benoît G. Bardy
University of the Mediterranean
Marseille, France

Reinoud J. Bootsma
University of the Mediterranean
Marseille, France

Yves Guiard
Laboratoire de Neurosciences Cognitives, CNRS
Marseille, France

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