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This text is published in the following Reference:

Raab, M. & Perl, J. (2002) Visually driven movements or motor driven vision? In M. Koskolou, N. Geladas, & V. Klissouras (Eds.), ECSS Proceedings, Volume 2, 7th Congress of the European Congress of Sport Sciences, Athen, Greece (p. 604). Athen: Trepoleos.

VISUALLY DRIVEN MOVEMENTS OR MOTOR DRIVEN VISION?

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A simulation of continuous visuo-motor behavior in humans was used to support the idea of bidirectional transfer between perception and action. Four different visuo-motor mappings are compared. The first approach assumes that from the perception of distal space coordinates the movement of the hand is produced (perception generates action, PA). The second (action generates perception, AP) approach assumes that proximal angle positions are used as references to generate external movement trajectories. The third and fourth approaches, respectively, assume that motor and sensory references are mutually connected, either sequentially or simultaneously, and distal space information and proximal angle information serve to structure movement kinematics. This is called the bidirectional transfer of perception and action (cf. Hecht et al., 2001). This transfer can be started at the very beginning of learning (sensorimotor integration I, SMI I) or after separate representations of sensory and motor codes are built (sensorimotor integration II, SMI II).

To examine visuo-motor mapping we used a simulation of the class of self-organizing maps. The simulation device DyCoN (dynamically controlled network) was used to analyse data that had been previously generated in a pursuit tracking experiment designed to separate feedback and feedforward processes (Raab et al., 2001). Data of participants about start position and target information as well as the distance between start and target position were input for the networks (nets). The same input vector was trained and tested on four different reference networks, each of which represented one of the four assumptions about the interaction of perception and action. In the PA net only the target information was learned; in the AP net the movement effect (x-, y-coordinates) was learned. In SMA I and in SMA II the reference net learned target and movement information either sequentially (blockwise) or in parallel (pieces of time series of 200-ms length, with the initial time step incremented by 50 ms for each period). To measure quantitatively the learning success of the different nets in the meaning of already-stored information, an entropy function can be used: Testing a pattern P with a number of P-specific inputs results in an acceptance frequency distribution over the (400) neurons i of the net. Hence, using $p(i)$ as the probability of i to accept P, the P-specific entropy $h(P,N)$ of the network N is approximated ($r = .98$; max. entropy value 8.6) by: $h(P,N) = -\sum_{i=0,N} p(i) \cdot \log_2 p(i)$. Higher entropy values represent better fit of the input to the specific reference net. A visuo-motor mapping in the direction from vision to the motor system received the worst fit between simulation and human tracking data (Table 1, see PA net).

Table 1. Entropy values of the four simulated nets (Mean and SD of participants).

Net	Mean	SD
Net 1 (PA)	2.64	(.05)
Net 2 (AP)	4.05	(.06)
Net 3 (SMI I)	2.65	(.02)
Net 4 (SMI II)	3.24	(.05)

The AP net that describes the mapping from proximal information to distal information received the best fit. As shown before in human data, the bidirectional transfer between sensory and motor systems is

possible (Roginsky & Rosenbaum, 2000). The SMI II net with parallel acquisition of visuo-motor mapping received a one-point higher entropy value than the SMI I net with sequential acquisition. This finding support the idea that different sensory and motor schemes are not built up separately and sequentially but are mutually connected from the beginning of the learning process (Hecht et al., 2001).

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