Motor Memory: Movement- and Position-Specific Sequence Representations

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Introduction

Studies of sequence acquisition revealed that the movements of dominant right hand activate cortical areas of the left hemisphere, while non-dominant left hand learning demonstrate recruitment of many additional brain areas in both hemispheres (Grafton e.a., 2002). These areas were supposed to be "associated with memory processes that provide an alternative representation of the sequence, one that is less closely tied with action system". We tested the hypothesis that motor memory uses two types of sequence representations: *movement-specific representation* that codes the sequence of the trajectories of movements and *position-specific representation* that codes the sequence of hand positions.

Method

The hand of the blindfolded volunteer was moved by experimenter through 7 different positions at a sheet of paper A4. The volunteer had to remember and immediately after that to reproduce by pen the sequence of positions. Each of 47 right-handed volunteers completed one run with right hand and one run with left hand. The errors of coding in the case of movement-specific representation (eM) were estimated as an angle between vectors connecting the successive positions of the hand, when it was moved by experimenter and by volunteer himself; the errors of coding in the case of position-specific representation (eP) were estimated as a distance between position of the hand, when it was moved by experimenter and by volunteer. To reveal the prevalence of movement- or position-specific representation, the average values eM_{aver} and eP_{aver} were calculated. Then the sign of difference between each value of eM_i and eM_{aver} ; eP_i and eP_{aver} was estimated. The cases when $(eM_i-eM_{aver})<0$ and $(eP_i-eP_{aver})>0$ were supposed to demonstrate the prevalence of movement-specific representation, the cases when $(eM_i-eM_{aver})>0$ and $(eP_i-eP_{aver})<0$ - the prevalence of position-specific representation.

Results

Table 1 demonstrates the percentage of cases when the differences $(eM_i - eM_{aver})$ and $(eP_i - eP_{aver})$ have the same signs (1, 2) or different signs (3, 4). The quantity of cases (3) are lower than the quantity of cases (4) both for the right and for the left hand. According to our suggestion it means the prevalence of movement-specific representation during sequence acquisition. The differences between (3) and (4), estimated by sign test, are significant for the right hand ($p<0.001$) and are not significant for the left one ($p>0.05$). Thus the prevalence of movement-specific representation is significant for the right hand only.

Table 1.

	$(eM_i - eM_{aver})$	$(eP_i - eP_{aver})$	Right hand (%)	Left hand (%)
1.	< 0	<0	55.3	52.6
2.	> 0	>0	21.2	25.5
3.	< 0	>0	6.8	8.3
4.	> 0	<0	16.7	13.6

Discussion

It is supposed that the prevalence of the movement-specific representation in the case of the right hand corresponds to the role of the left hemisphere in sequence movement control, while position-specific representation is specifically connected with the right hemisphere role in spatial relations coding (Bradshaw, 2001; Jager, Postma, 2003). The absence of the significant prevalence of one or another type of representation during task performed by the left hand corresponds to the data on recruitment of both hemispheres in sequence acquisition by non-dominant left hand (Grafton e.a., 2002). Two types of sequence representation in motor memory, movement- and position-specific one, are supposed to reflect the hemispheric specialization in perception and motor control.

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References

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