Sensomotoric Correlations As Basis For a Model Of Motor Control

Silke Steininger (kstein@phonetik.uni–muenchen.de)
Institute of Phonetics and Speech Communication
Schellingstr. 3
80799 Munich, Germany
Jochen Müsseler (muesseler@mpipf–muenchen.mpg.de)
Max Planck Institute for Psychological Research
Amalienstr. 33
80799 Munich, Germany

Abstract

Voluntary acts are assumed to be initiated by their anticipated sensoric consequences. This old assumption (James, 1890/1981) was taken up recently by new models of Artificial Life and Psychology which share the notion of a close linkage between perception and action. The models of both disciplines stress the importance of the ability of a cognitive system to act and the importance of being situated in an environment (for an overview: Steininger, 1999). Whereas psychological approaches set action control at a high cognitive level, AL models refer mostly to its low level functions. Nevertheless**,** the combination of the ideas of both disciplines seems promising.

The Common–Coding Approach of Action Control

Two assumptions form the starting point of the model presented here: (1) There is a common domain of representation for perception and action (Common Coding). (2) Actions are initiated by codes that represent their – perceptual – effects (principle of effect control of actions). Both principles are derived from the '*T*heory of *E*vent *C*oding' ('TEC'; Hommel, Müsseler, Aschersleben & Prinz, 1998). TEC assumes that perceived events (= perceptions) and events that are to be produced (= actions) are both represented by an integrated network of *feature codes* (called *event code)* that forms as appropriate for a certain task. The features refer to the kinesthetic, tactile or visual effects of a motoric movement (e.g., of the hand position), but also to *distal* effects of the movement like the light emissions of a bulb after operating a switch.

An Artificial Life–Model of the Learning of Motor Sequences

Aitken (1994) has proposed an AL–learning architecture that allows a mobile agent to acquire sensorimotor representations. His model consists of modules that are interlinked in such a way that correlations of their inputs can be detected and stored. The output state of a single module is a stochastic function of the vector of inputs. For any input vector, a distribution across the possible output states is formed (as a function of the input vector). The output state is then chosen according to this distribution. After the output state is chosen the distribution is updated so that later the correlated inputs in this vector will be more likely to cause the same output state.

To learn sequences of movements, Aitken assumes two of these modules that are connected in a special way. The so called sensory module gets input from the environment

Proc. of the Third International Conference of Cognitive Modeling. Groningen, 2000, pp. 299-301.

and from the motor module and itself passes on output to the motor module. The so called motor module gets input from the sensory module and passes on output to the environment and to the sensory module. Through the connection of the sensory module and the motor module to the environment the inputs to the sensory module are no longer random: Motor output has effects in the environment which leads to non–random input sequences at the sensory module. Because the modules can detect correlated inputs, they learn to link the state of the motor module with the state of the sensory module. This general architecture is able to learn 'mini'–motor sequences and their sensory consequences.

Sensomotoric Correlations As Basis Of Motor Control

In TEC the acquisition and the precise structure of '*event codes*' is not determined in detail. To close this gap we modified the learning architecture of Aitken by introducing a '*sensomotoric correlation code*': In Aitken's architecture perceptual–motor associations are established by the correlations of the input of an effect with the motor state that *follows* the effect–triggering motor state. In this way, sequences of effect–movement series can be learned. However, this assumption does not answer the question of how the system can learn the connection between a certain motor output and the *appropriate* effect or input. As a solution we assume sensorimotor codes to be structured like the sensory and the motor module of Aitken, thus enabling the learning of an ordered movement sequence. However, this sequence then is integrated – in other words the assumed code consists of a 'temporal averaging' over the individual effects of a the parts of the movement sequence that are then all connected to the motor sequence as a whole. We then assume that each sensoric input that conforms to an individual effect of the learnt movement sequence activates the whole code. Because of the underlying temporal organization that consists in the correlations between the sensory and the motor representations of the code it is ensured that the individual motor activations take place in the correct order. If the code is activated through one or several of its effects, a kind of reflex or fixed movement pattern is the result.

Space permits only an example of empirical evidence supporting the assumptions presented above: If action and perception share the same representations, this should lead (among other things) to a conflict, when both functions have to use the same resources at the same time. Müsseler and Hommel (1997) were able to show that subjects could detect a briefly presented masked arrow head worse if at the same time they had to prepare a compatible response.

To what extent the described sensomotoric correlation code is actually used in human information processing remains an open question. Anyway, the model assumes only a simple, biologically plausible learning algorithm (only correlations similar to learning a la Hebb are necessary), which might be used as a basis for further empirical investigations.

Acknowledgements

This research was funded by a grant from the Max Planck Institute for Psychological Research, Munich, Germany.

References

Aitken, A. M. (1994). An architecture for learning to behave. In D. Cliff, P. Husbands, J.–A. Meyer & S. W. Wilson (Eds.), From Animals to Animats 3. Proceedings of the Third International Conference on Simulation of Adaptive Behavior (p. 315–324). Cambridge, Mass.: MIT Press, Bradford Books.

Hommel, B., Müsseler, M., Aschersleben, G. & Prinz, W. (1998). The theory of event coding (TEC). A framework for perception and action. Max Planck Institut für Psychologische Forschung, Abteilung

Kognition und Handlung, Paper No. 3/1998.

James, W. (1890/1981). Will. In James, W. (Ed.), The Principles of Psychology (Volume II, p. 1098–1193). Cambridge, Massachusetts: Harvard University Press.

Müsseler, J. & Hommel, B. (1997). Blindness to response–compatible stimuli. Journal of Experimental Psychology: Human Perception and Performance, 23, 861–872.

Steininger, S. (1999). Wahrnehmung und Handlung. Eine experimentelle Analyse einer Wahrnehmungsbeeinträchtigung bei simultan ausgeführten Handlungen. Aachen: Shaker.