"Abnormal" movements: What are they reflections of?

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Abstract: We agree with Latash & Anson that therapeutic approaches should be directed toward solving the underlying problem, not toward adapting the abnormal to normal behaviour. The fundamental obstacle, however, is that doing so requires a solution of the "equivalence problem" in movement control.

Any experimental study on movement control should be guided by (at least an implicit) hypothesis that gives rise to specific predictions about the expected results. Without assuming that "we know more about motor control than the CNS does," the formulation of an hypothesis is inevitable and scientifically the only correct way to devise experiments to test model-specific predictions. These hypotheses are not reflections of a presumptuous nature, but rather an expression of a modest model, which will be rejected when the predictions are falsified by experimental results. I therefore do not believe that the interpretation of abnormal motor behaviour and the therapy of motor disorders is based on the premise that "we know more about motor control than the CNS does." The major problem is that we do not yet know which constraints or control algorithms give rise to the more or less consistent motor behaviour in normal persons and in patients with motor disorders. As a consequence, we cannot solve the inverse problem either: to give a good interpretation of normal and abnormal motor behavior. This is the central issue of the target article.

The search for coordinative rules that underlie the convergence of the learning process for movement coordination is one of the most important issues in motor control these days. It is generally accepted that the control of movements is the result of some learning process in which high-level cognitive factors (such as the aim of the movement, the interpretation of the motor task, the perceived instruction) are related to particular muscle activation patterns for the effector system (e.g., related to force, position, accuracy of movement, velocity and timing of the movement, available degrees-of-freedom in the effector system). This coupling between processes at various hierarchical levels in the motor system is thought to be achieved by a learning process based on various feedback mechanisms. This concerns both direct feedback from muscle receptors and feedback about the result of a movement (during or after it) that may give rise to a modified motor program for a similar subsequent movement.

The fundamental problem is the motor-equivalence problem:

how to control the many degrees of freedom of the motor system for simple motor tasks. With regard to learning, this problem is equivalent to the question of how the learning process may converge with the observed motor behaviour, which is one out of many feasible behaviours. There is no solution yet for this problem. Only a few suggestions have been provided as to how to approach this problem (see, e.g., Zajac & Gordon 1989; Nichols 1989; Gielen & van Ingen Schenau 1992). Recent studies (Tax et al. 1990; Theeuwen et al. 1994) have shown that a different interpretation of the motor task by a subject may give rise to a different muscle activation pattern for the very same movement. This gives the opportunity to study how instructions may affect motor behaviour. Similarly, a comparison between motor behaviour in subjects with motor disabilities and that of normal subjects performing the same motor task may provide insight into the effects of the effector system on motor behaviour. These studies should be guided by predictions based on good hypotheses about the function, organisation, and structure of the motor system. Careful studies along these lines will provide us with valuable information about the adaptive learning processes in the motor system and will give us a better understanding of so-called abnormal motor behaviour.

We fully agree with the final conclusion that our present lack of understanding of the basic principles of motor control prevents us from making a distinction between normal and abnormal motor behaviour. However, the different (not necessarily "abnormal") behaviour of various subjects in different experimental conditions will give us a unique opportunity to get a better understanding of these basic principles. That should be the main goal of research for the coming years.