The Influence of Reward and Punishment on Motor Learning

Galea JM, Mallia E, Rothwell J, Diedrichsen J. The dissociable effects of punishment and reward on motor learning. Nat Neurosci. 2015; 18:597-602.

By the carrot or by the stick? Any music teacher or sports coach will have no doubt mused over this age-old idiom when trying to optimally motivate their students. Should one dangle a carrot in front of one's subject (in this case a theoretical mule), rewarding their good behaviour with a bite of carrot, or does one threaten one's subject (again, a theoretical mule) menacingly with a stick, "punishing" them for perceived failures in their performance?

Motivational factors are well known to influence human behavior, and in the field of motor learning the power of these modulators has recently begun to be deconstructed. Existing studies suggested that positive and negative feedback have dissociable effects on procedural[1] or motor skill learning.[2] Error-based motor learning (motor adaptation) had been considered automatic and insensitive to such feedback.[3] Galea et al.[4] have recently blown away this assumption by using a well-established motor adaptation task. Participants were trained to make reaching movements toward targets, guided by a visual cursor. After the introduction of a perturbation, which transformed visual feedback by a number of degrees, an error of reaching accuracy was induced. Learning was then quantified as the ability of participants to update their subsequent movement in response to this error. By using reward- or punishment-based monetary feedback, based on reaching accuracy, the authors were able to examine the influence of positive and negative feedback on the learning and retention components of motor adaptation. They showed that negative feedback (graded or binary) accelerated motor learning. To have an effect, the negative feedback had to be clearly related to performance on the preceding movement. In contrast, positive feedback increased *retention* of motor memory, and the authors hypothesized that this effect was mediated by dopaminergic projections to M1. They concluded that reward seems to enhance memory retention across different types of motor learning. In contrast, the influence of punishment seemed to be more specific to error-based learning, and the cerebellar circuitry was proposed as the likely neuroanatomical site.

These findings have interesting implications for the study and treatment of movement disorders. For example, disorders of dopaminergic signaling such as Parkinson's disease could be investigated with such a framework.[5] Perhaps only by testing discrete components of motor learning will we be able to fully understand how neuropathological changes in the brain translate into the movement disorders we observe phenotypically in practice. Another important implication of this study is in the field of rehabilitation. The intriguing question of whether focused negative feedback may have utility when accelerated learning is desired is raised. Clearly many steps are needed to translate this work fully from the laboratory to the bedside, but likely neuro-rehabilitation of the future should be fine-tuned to optimize rehabilitation gains by exploiting reward–punishment motivators. Thus, both the carrot and the stick seem to be important modifiers of motor learning. The onus is now on us to define the significance of these observations in pathophysiology and treatment of patients with movement disorders. ■

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References

1. Wächter T, Lungu OV, Lui T, et al. Differential effect of reward and punishment on procedural learning. J Neurosci 2009;29:436-443.
2. Abe M, Schambra H, Wassermann EM, et al. Reward improves long-term retention of a motor memory through induction of offline memory gains. Curr Biol 2011;21:557-562.
3. Mazzoni P, Krakauer. An implicit plan overrides an explicit strategy during visuomotor adaptation. J Neurosci 2006;26:3642-3645.
4. Galea JM, Mallia E, Rothwell J, Diedrichsen J. The dissociable effects of punishment and reward on motor learning. Nat Neurosci 2015;18:597-602.
5. Frank MJ, Seeberger LC, O'Reilly RC. By carrot or by stick: cognitive reinforcement learning in parkinsonism. Science 2004;306:1940-1943.

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