We're talking about feedback ... aren't we?

Lawrence E. M. Grierson

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As a young scientist interested in motor skills learning and new faculty member working in the field of medical education research, I'm often visited by health professions education specialists with questions about feedback in learning. And that's okay because I know a thing or two about feedback. I know that feedback is the foundation of at least three of the major processes that govern our control of action. I know that it is the numerous instances of feedback that we accumulate over our experience that form the global bases of the representations that govern the generation of our actions (Elliot et al. 2010). I know that it is the temporal constraints associated with the evaluation of concurrent action-related feedback that characterize the corrections we can make to our actions online, while they are unfolding (Woodworth 1899). And I also know that feedback about the outcomes of our actions—how what we have done looks, sounds, and feels—helps us re-parameterize our systems for our subsequent attempts at the action (Cheng et al. 2008).

When I share this knowledge with my inquisitors, I am usually successful in piquing their interest enough to give them the early confidence that they've come to the right place. So I continue on. I share what I think to be some of the more important things the research has unearthed about how we use feedback to perform actions and what it means about learning. For instance, contrary to popular belief we do not become less reliant on feedback as we become more expert. Rather, we become more reliant on it. I explain that as our learning proficiency progresses we become more efficient at attending to the feedback that is crucial for our success and ignoring the rest (Proteau et al. 1992). So while the expert who is so good at diagnosing heart sounds she can do it with your eyes closed suggests that she needs less feedback than the novice, you can imagine how difficult she might find it with her ears plugged. And what happens is the occurrence of the critical feedback information—the sounds—becomes the very foundation of the experts' action control. In this way she finds herself disadvantaged more severely when the critical feedback isn't available than does the novice. Thus, I explain, the feedback that students experience in learning should be as close as possible to that which will be experienced in actual performance. And if they can expect to encounter a variety of feedback environments, then

L. E. M. Grierson (✉)

Program for Educational Research and Development, McMaster University, Hamilton, ON, Canada
e-mail: griersle@mcmaster.ca

they should be permitted to experience feedback across the entire range of possibilities during their practice. *Specificity of feedback, variability of practice*. This is the general rule (Elliot et al. 2011).

Around this time, my visitors—at least those who aren't interested in simulation fidelity—begin to show signs that they are concerned about the young scientist they've approached. It would seem I have become a little tangentially obtuse. They have some very specific questions about feedback in learning and they are not sure if I'm addressing them. If, by now, they haven't said it aloud, their faces are expressing quite plainly: What are you talking about!? With a clearer articulation of their curricular dilemma, they restate their questions about feedback: what type of information should be delivered to students during their performance, after their practice, and in their assessments and how often should it be delivered?

It's clear that we have fundamental differences in what we understand to be *feedback*. What I am talking about is sensorimotor feedback. The type of information that mediates a performer's actions on the basis of sensory information (afferent feedback)—like vision of a limb in motion (Elliot et al. 2010) or proprioception about joint angles (Feldman 1966)—or on the basis of copies of the motor commands that generated the impulses (efferent feedback) (Desmurget and Grafton 2000; von Holst 1954). In contrast, more often than not, what my health professions education specialist visitors are inquiring about is feedback in the more colloquial sense: the delivery of criticism or praise about a student performance.

There are some important differences between these two meanings. *Feedback*, a term derived from neuroscience and engineering, refers to the process whereby a sample of an output signal is looped back into the control system that generated it and re-integrated with the input signal. Consider laparoscopic surgery, for example. At the foundation of this precision skill are rapid goal-directed aiming movements that are bound by very important spatial and temporal constraints. To perform each of these movements, the CNS sends an impulse to the neuromuscular system. The impulse specifications are generated on comparisons made by the visual system regarding the distance between the grasper and the anatomical structure of interest. In essence, the distance between the effector and the target represents an *error* in grasper position, which provides the framework for the direction and distance parameters of CNS input. But because the endoscope alters the spatial relationship between movement perception and movement action, and because our neuromuscular systems are inherently variable, even an expert surgeon's movements are often inaccurate at the outset. Luckily, one of the outcomes of moving the grasper toward the target is a change in the spatial distance between the two. This change in error signal is, via vision, fed back into the central nervous system and works to augment or mitigate the propagation of neuromuscular impulses until the error between the hand and the target is zero.

Alternatively, when we discuss performance and/or assessment feedback from an instructor, coach, or peer we are talking about *reinforcement*—a term derived from the psychological literatures on operant and classic conditioning. Feedback processes in the reinforcement sense seek to increase the probability of a behavior by the delivery or removal of punishment or praise immediately upon or shortly after the behavior is performed. Think Pavlov's dogs. While feedback combines with the immediate input signal to modify the output without changing the system's basic responsiveness to future signals, reinforcement does just the opposite—it changes the basic responsiveness of the system to future signals without combining with the immediate input signals. To some degree, the difference between reinforcement and feedback parallels Schon's distinction between reflection *in* action, which is correction occurring during the performance of the behaviour, and reflection *on* action, derived from a retrospective review of the overall performance

(Eva and Regehr 2005). However in other respects, the mechanism is very different—feedback arising almost automatically within the actor without conscious awareness and reinforcement typically derived from external appraisal by an observer.

Perhaps this distinction isn't terribly interesting to medical educators and education scientists. Research meetings between the two almost always begin with a period in which a term like feedback receives some operational definition. This is necessary because we already know feedback, even in the reinforcement sense, can mean many very different things. There is afferent and efferent sensorimotor feedback. There is the criticism and praise type of feedback that accompanies student assessments (i.e., test scores; verbal evaluations); the straightforward didactic feedback that instructor provides a student to direct his or her attention to the cues that are most critical for success ("Make sure you pay attention to..."); the hidden curriculum can be construed as feedback; there is feedback about errors ("What you did wrong is...") and feedback about successes ("What you did right is..."). The term is pervasive and has come to describe any information an individual receives in response to their own actions.

Indeed, in this issue of AHSE, we find five different papers that focus on the process of feedback. Yet they could hardly be less alike; and together cover much of the spectrum of meanings I have described above. The study by Eva examines the receptivity of students to feedback. Clearly, the feedback fell into the psychological realm; external comments, positive or negative, by a supervisor. Walther's study of web versus paper-based written comments by peers is in a similar vein. On the other hand, the study of interim assessment by Bekkink and particularly the study describing the utility of identifying and encouraging "positive deviance" are much closer to the engineering conceptualization, although even here, the approaches encourage deviance from some normative approach, rather than damping out differences.

We should be wary of the meanings that we ascribe to feedback as the field of medical education research is expanding to include specialists of different domains. Especially since the differences in meanings can become magnified as the word is modified as *negative* or *positive*. Negative feedback, in the engineering and neuroscience sense, refers to a system-generated signal that is inverted with respect to the input signal—it dampens the input and leads to stability around optimal states. The human homeostasis, the thermostat, and the above laparoscopic control are examples of negative feedback systems. On the other hand, positive feedback refers to a signal that is in-phase with the input signal. This type of signal works to amplify the input and leads to instability. Without clear understandings of each other's definitions, the course educator may think that the positive feedback that the biomedical engineer is talking about is some sort of "Good work, Johnny!", when really what is being expressed is the propagation of a destructive signal, the shriek of a microphone too close to the amp, or a nuclear chain reaction.

References

- Cheng, D. T., Luis, M., & Tremblay, L. (2008). Randomizing visual feedback in manual aiming: Reminiscence of the previous trial condition and prior knowledge about feedback availability. *Experimental Brain Research*, 189, 403–410.
- Desmurget, M., & Grafton, S. (2000). Forward modeling allows feedback control for fast reaching movements. *Trends in Cognitive Sciences*, 4, 423–431.
- Elliott, D., Grierson, L. E. M., Hayes, S. J., & Lyons, J. (2011). Action representations in perception, motor control and learning: Implications for medical education. *Medical Education*, 45, 119–131.

- Elliott, D., Hansen, S., Grierson, L. E. M., Lyons, J., Bennett, S. J., & Hayes, S. J. (2010). Goal-directed aiming: Two components, but multiple processes. *Psychological Bulletin*, *136*, 1023–1044.
- Eva, K. W., & Regehr, G. (2005). Self-assessment in the health professions: A reformulation and research agenda. *Academic Medicine*, *80*(10 Suppl), S46–S54.
- Feldman, A. G. (1966). Functional tuning of the nervous system with control of movement or maintenance of a steady posture. II. Controllable parameters of muscles. *Biophysik*, *11*, 667–675.
- Proteau, L., Marteniuk, R. G., & Le'vesque, L. (1992). A sensorimotor basis for motor learning: Evidence indicating specificity of practice. *Quarterly Journal of Experimental Psychology A*, *44*, 557–575.
- von Holst, E. (1954). Relations between the central nervous system and the peripheral organs. *The British Journal of Animal Behaviour*, *2*, 89–94.
- Woodworth, R. S. (1899). The accuracy of voluntary movement. *Psychological Review*, *3*(2), 1–114.