Reinforcing vs. informative feedback while controlling a dynamic system

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Dealing with the issue of implicit learning in dynamic system control, more particularly with the so called Sugar Factory task, we developed (Fum & Stocco, 2003; in press) a model that explains the performance improvement normally shown by participants by relying exclusively on the ACT-R subsymbolic procedural learning mechanism. Our model contrasts sharply with more popular accounts of the phenomenon that assume that people store in memory, and successively exploit, concrete, declarative knowledge of the single interaction episodes (instances) they deal with.

The model got three main achievements. First, it has been able to replicate the results put forward as a support for instance-based models. Second, it has been able to explain the findings of three new experiments dealing with: (a) the role of the target, (b) the effect of a target change, and (c) the role of the subjective performance evaluation criterion, respectively. Third, it is congruent with some intriguing results appearing in the literature concerning: (a) the lack of generalization normally shown by participant (Marescaux, 1997), (b) the need to physically operate with the system to be able to obtain learning (Berry, 1991), and (c) the capacity shown by amnesic patients to learn to control the system (Squire & Frambach, 1990).

In the last times we extended the model to deal with the case of continuous (instead of discrete) output and Gaussian (instead of stepwise) distributed stochastic noise, and we ran a series of extensive simulations that allowed us to make some bold predictions. In this paper we present the results of two experiment carried out to test the model under some critical conditions.

A distinguishing feature of the model is constituted by the fact that any improvement in the capacity to control the system is obtained through the increased use of the "best" productions, i.e. the productions with the greatest likelihood to obtain a success. Every successful application of a production augments its expected utility and, hence, the probability that the production will be chosen next time. A critical condition for the ACT-R subsymbolic parameter learning mechanism to apply is, however, that a production could experience a certain amount of success.

The first experiment tested the effect of an anomalous discrete condition in which it was made impossibile for the participants to experience explicit success. In such a case the model predicts: (a) a degraded performance similar to that obtained by providing random responses (b) no learning during the interaction with the system. Surprisingly, participants: (a) gave a performance that, while being lower than that found in the standard conditions, was significantly higher than a random one, and (b) showed a substantial amount of learning, similar to that obtained in standard conditions.

The second experiment tested a conceptually similar situation (impossibility of success) cast in a continuously varying output framework. We contrasted a condition in which the subjective performance evaluation criterion was positively defined (and the success reasonably easy to reach) with a condition in which it was almost impossible to hit a specific target because of the vastness of different possible results. The model again predicts higher performance and learning in the former condition, and random behavior without learning in the latter one. On the contrary, participants gave essentially similar performance, and were equally able to learn to control the system.

We conclude the presentation by discussing the role of the reinforcing vs. informative (i.e. outcome evaluation) feedback in controlling a dynamic system, and make some speculations concerning the implications of these findings for the ACT-R production selection mechanism.

References

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