MOTOR CONTROL

To break a habit, timing's everything

When angry, we are often advised to 'hold your breath and count to ten' to prevent a rash response. Could a similar time conflict underlie the expression of unwanted habits? A new study in *Nature Human Behaviour* shows that habits can be provoked with greater time pressure, but are overridden if an individual is given sufficient time to prepare.

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Despite the ubiquity of habits—good and bad—in our lives, we struggle to understand their neural basis. While there are many colloquial interpretations of the word 'habit', the scientific view is that it is a learned association between a stimulus and response. Surprisingly, it has been difficult to elicit habitual responses in human in the laboratory, limiting our understanding. However, a recent study[1] has developed a novel approach to do so, providing a window into the underlying mechanisms. At its core, a habit is an automatic response to a stimulus, independent of whether the outcome is beneficial. Habits are distinct from goal-directed responses, which consider the associated costs and rewards and choose the best response available. Current theory suggests that habits and goal-directed responses compete with one another in determining behaviour[2,3]. Habits are hailed as efficient responses that allow us to bypass the complex and slow deliberations of goal-directed action. However, they are also derided for their inflexibility to environmental changes, preventing behavioural adaptation to adverse outcomes. For these reasons, habitual behaviour is relevant in a range of neurological disorders such as addiction, depression, obsessive compulsive disorder, Tourette's syndrome and Parkinson's disease.

A key issue stymieing progress is the surprising difficulty of eliciting habitual behaviour in humans in lab-based experiments. Animal work has provided vital insights regarding the neural loci of habit formation and demonstrated that extended practice strengthens habitual behaviour by leading to greater inflexibility in adapting to environmental change[2,4]. However, there is little evidence of extensive practice inducing a similar response in humans[5], and others have not been able to replicate these findings[6]. To explain the difficulty of eliciting habits in the lab, Hardwick and colleagues propose a new way of looking at habitual behaviour[1] built upon the idea that habits may exist without necessarily being expressed behaviourally. They suggest that previous experiments are primed to elicit goal-directed behaviour, masking the expression of any underlying habits. They develop a corresponding experimental paradigm that can reveal hidden habits in humans, thus advancing our understanding of habitual responses and providing a powerful method with which to probe them further.

The authors have previously shown, in goal-directed movements, that movement preparation and initiation are separate processes, with movements not necessarily being initiated once they are prepared[7]. Likewise, they propose that there should be a corresponding distinction between the preparation and initiation of a habitual response. If habits are prepared quickly, and more deliberative goal-directed responses prepared more slowly, then perhaps habits are simply being over-ridden by goal-directed responses. If this is the case, then forcibly triggering faster responses may unmask habits normally hidden by a slower goal-directed response. The authors elegantly demonstrate that an otherwise hidden habitual response can be expressed by forcing subjects to respond earlier than they would normally choose to. This means that self-paced behaviour may over-ride existing habits by allowing for a delay between habit preparation and response initiation, during which the habitual response is replaced by a goal-directed one.

Subjects performed a stimulus–response task in which they were cued with one of four abstract symbols on a screen and responded by pressing a corresponding key button. After 4 days of training, task performance improved in that there were fewer incorrect key presses and faster responses. To test whether this association had become habitual, subjects then trained on a new association. If the first association had become habitual, then this should lead to greater inflexibility in adapting to the change, expressed in greater errors when performing the second association task. However, as previous studies had found, when self-paced, subjects performed the second association task just as well as the previously learned one.

Motivated by their hypothesis that there was a time-dependent competition between habitual and goal-directed processes, the authors turned to a new behavioural assessment they developed. Rather than simply asking subjects to respond as quickly as possible to the new association, subjects were forced to respond when cued, independent of their degree of readiness. Subjects heard a sequence of four beeps, each 400 ms apart, and were instructed to respond on the fourth beep. Critically, the symbol cue indicating which button to press could appear at any time within those four beeps, giving them anywhere from 0 to 1,200 ms to prepare a response. In this way, the forced response would reveal the extent and nature of the movement planned. Surprisingly, even though subjects had apparently learned the second association when tested in a self-paced task, under time pressure they were less accurate, and more importantly, these errors were due to the incorrect expression of the first-learned, now-habitual association.

A hallmark of habitual behaviour observed in animal experiments is that extended training increases the strength of a habit, expressed as its inflexibility to change. The authors probed this by also testing subjects on the first association task after only 1 day of training or after an extended 20 days of training. In agreement with a practice effect on habit formation, the group that trained for only 1 day did not express habitual responses under time-pressure, while subjects that trained for 20 days became more strongly habitual: struggling to overcome habit to learn the new association and becoming even more likely to respond habitually, rather than in a goal-directed manner, when under time pressure.

Unanswered by Hardwick and colleagues, however, is the converse question: how does one unlearn an existing habit? An effective follow-up study for the authors would involve performing the opposite experiment, retraining the groups on a new mapping and tracking the replacement of one habit with another. In this way, the temporal properties of retaining one habit while under pressure of learning a new habit would be revealed. The current results suggest this will depend upon the individual preparation speed, but it is not straightforward how time-dependent competition alone could lead to the unlearning of an existing habit. Understanding what other factors determine the likelihood of a habitual response and the timescale of effectively breaking a habit perhaps have more significant clinical applications than forming habits.

Overall, these results provide evidence that that the strength of a habit is enhanced with practice and that there is a short window of preparation time in which a goal-directed response does not have enough time to form, requiring a more-quickly prepared habitual response to be used instead. In other words, eliciting or restraining habits in humans may be an issue of time, not of learning. Though a simple mapping of symbol-to-key-press does not necessarily explain movement preparation and initiation for more complex movements, understanding the temporal distinction of preparation phases for habitual and goal-directed movements has critical implications for breaking—or forming—habits seen in neurological disorders, disease and even competitive sport. ❐

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Competing interests

The authors declare no competing interests.