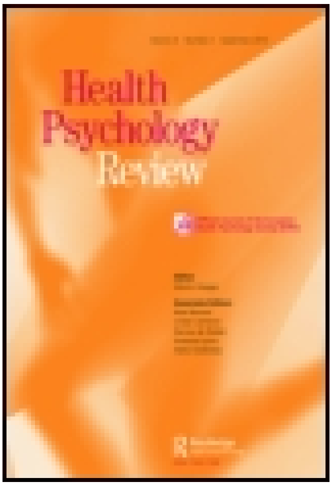

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What measures of habit strength to use? Comment on Gardner (2015)

Jennifer S. Labrecque[a] & Wendy Wood[a]
[a] Department of Psychology, University of Southern California, 3620 South McClintock Avenue, Los Angeles, CA 90089-1061, USA
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COMMENTARY

What measures of habit strength to use? Comment on Gardner (2015)

Jennifer S. Labrecque* and Wendy Wood

Department of Psychology, University of Southern California, 3620 South McClintock Avenue, Los Angeles, CA 90089-1061, USA

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In this comment on Gardner's (2015) thoughtful review of the habit concept in health behaviour, we largely agree with his definition of habit, although we also suggest the benefits of grounding such definitions in the neuropsychology of habitual behaviour. We discuss neuroscience research that has emphasised the cued performance of habits with minimal influence of goals. We then identify the advantages of measuring habit directly via cognitive associations along with more traditional frequency-based measures, in comparison with the self-report measures of experienced automaticity emphasised by Gardner. The cognitive association measures possess high construct validity, and frequency-in-context measures have demonstrated strong predictive validity.

Defining habit to ensure construct validity

Gardner (2015) defined habits as automatically activated impulses to respond to a stimulus that are triggered by stimulus–response associations formed over repeated experience. This definition seems particularly promising in characterising habit as a process rather than the consequence of a process or the behaviour itself.

This definition also acknowledges circumstances under which habits are not enacted, such as when they are overridden by competing motivational forces before they are translated into behaviour. Both of these aspects of habit are important and help to reconcile findings that habit performance can be modified through inhibition and other motivations (Quinn, Pascoe, Wood, & Neal, 2010). Gardner further distinguishes the habitual initiation from the habitual performance of a behaviour, noting that the former may be automatically cued but may require effort to enact, whereas the latter may require deliberation to instigate but can be executed effortlessly. This distinction seems particularly useful when considering complex health behaviours such as exercising.

The definition of habits in health psychology also can benefit from insights from reward learning and the brain systems undergirding habit performance (Lally & Gardner, 2013). In learning research, habits are defined with specific behavioural criteria. One of these involves performance of a learned behaviour that continues despite a change in reward contingency or value (Smith & Graybiel, 2014). In devaluation paradigms, for example, participants form habits to respond for a reward and then continue to respond

*Corresponding author. Email: labrecqu@usc.edu.

even when that reward loses its value, providing evidence for the goal-independence of habits. In an illustrative study, participants formed habits to press a button when one of two images was presented, rewarding them with either chips or candy (Tricomi, Balleine, & O'Doherty, 2009). They were then given the reward to eat until they were full. When working again on the task, they continued to press the button to the image associated with the food reward, even though they did not want it. Their habit persisted despite devaluation of the reward, and this absence of reward modulation was linked to activity in the sensorimotor striatum.

A second criterion concerns the chunking process in habit formation. As stimulus–response associations are learned over time, individual actions are unitised or chunked into larger behavioural representations that are activated and performed as a unit (Graybiel, 2008). Once selected, these action sequences can be executed with minimal attention.

Research on the neural mechanisms underlying habits helps us to understand this insensitivity of habits to changes in reward and the chunking of individual actions (Seger & Spiering, 2011). Two cortico-basal ganglia loops are involved in habit formation: the associative loop and the sensorimotor loop (Graybiel, 2008; Yin & Knowlton, 2006). The associative loop supports goal-directed action and connects structures in the prefrontal cortex with the anterior putamen. Activity in the sensorimotor loop, in contrast, facilitates the formation of cue–response associations underlying habits, connecting the somatosensory and motor cortices with the medial and posterior regions of the putamen. As habits strengthen gradually over time, behavioural control largely shifts from the reward-responsive associative loop to the stimulus–response associations of the sensorimotor loop (Graybiel, 2008; Yin & Knowlton, 2006). Dopamine, a neurotransmitter involved in reward processing, is intrinsically involved in the development of habit associations tied to the sensorimotor striatal loop. Providing additional evidence for a neural shift from associative to sensorimotor systems, well-established habitual responses are less dopamine dependent over time, contributing to habit maintenance (Wickens, Horvitz, Costa, & Killcross, 2007).

In summary, Gardner's definition of habit can be further elaborated by including learning and neural research on the role of reward in behaviour. Using this framework, habits can be additionally characterised by their failure to respond to the changing value of rewards, the chunking of action sequences and the signature shift in neural activity from the associative to the sensorimotor loop. Including these literatures provides additional means of defining and operationalising habit with a wider range of measures.

Measuring habit to ensure predictive validity

Gardner's definition of habit is largely consistent with a variety of different habit measures, including (1) experienced automaticity as captured in the Self-Report Habit Index (SRHI) and related subscales such as the Self-Report Behavioural Automaticity Index (SRBAI), (2) the frequency of past performance in a stable context (typically assessed through Behaviour Frequency × Context Stability) and (3) direct tests of cognitive associations. Although Gardner emphasised the experienced automaticity measures, this focus is challenged by emerging evidence on the *predictive validity* of each type of measure. Gardner noted two hallmarks of predictive validity: Habit strength should predict the performance of future behaviour, and strong habits should reduce the impact of conscious behavioural intentions on performance. As we explain, these hallmarks can be used to evaluate the relative merits of the different habit measures.

Measures of frequency in context (Danner, Aarts, & de Vries, 2008; Wood & Neal, 2009) build on Triandis' (1977) traditional frequency measure of habit strength to include the cue-dependent nature of habits. These echo standard manipulations of habit strength in experimental settings in which strong habits are formed through repeated performance of a response given particular context cues (e.g., Hay & Jacoby, 1999; Poldrack et al., 2001). Strong habits are responses that have been performed frequently in stable contexts, whereas weak habits or non-habits have been performed infrequently or in unstable contexts.

Can people reliably report on the stability of the cues in the performance context and the frequency of their past performance? In prior studies, participants meaningfully reported on general categories of contexts, including prior responses in a sequence, locations, times of day, presence of other people and psychological moods (Ji & Wood, 2007; Ouellette & Wood, 1998). Some of our research has also been successful with broad frames of the context stability question (Labrecque, Lin, Wood, & Neal, 2012).[1] In addition, participants in a number of studies successfully reported on the idiosyncratic context cues that activated their personal habits (Danner et al., 2008; Judah, Gardner, & Aunger, 2013; Neal, Wood, Labrecque, & Lally, 2012). Also, participants seem to be reasonably accurate in their reports of past performance frequency. For example, reports of performance were substantially correlated with more objective indicators of frequency of flossing (based on change in floss packet weight; Orbell & Verplanken, 2010), gym attendance (based on computerised gym records; Armitage, 2005) and use of a new fabric refresher (based on change in container weight; Labrecque, Wood, Neal, & Harrington, 2014).

The SRHI was developed to directly capture the automated experience of habit performance (Verplanken & Orbell, 2003). However, the initial version of this measure has been criticised for being too broad and including items reflecting performance frequency and self-identity (Sniehotta & Presseau, 2012). Accordingly, the automaticity subset of items in the original scale was developed into the SRBAI (Gardner, Abraham, Lally, & de Bruijn, 2012). Gardner argued that these experience measures are preferable to frequency measures because they tap automaticity, a central feature of habits, rather than the causes of this automaticity. However, these automaticity measures require people to report, not on observable features of their performance (e.g., frequency and context stability) but on the inaccessible aspects outside of conscious awareness. Given that people cannot directly observe the relevant features of the habitual behaviour, experienced automaticity measures are grounded instead in people's inferences about what it feels like to engage in the behaviour. Past research suggests that these inferences are often inaccurate (Hagger, Rebar, Mullan, Lipp, & Chatzisarantis, 2015; Neal et al., 2012; Sniehotta & Presseau, 2012).

To understand the challenges of using measures like the SRBAI to assess habit automaticity, a brief thought experiment might be useful. Specifically, how effective would such measures be at capturing automaticity under controlled conditions in the lab? For example, in a classic priming study, participants completed an initial task designed to activate concepts of the elderly, and then the effects of this prime were demonstrated through participants walking slowly down the hall to the elevator (Bargh, Chen, & Burrows, 1996). If this experiment had relied on self-report measures to assess automaticity, then participants would have been asked to report on their experiences of their walking speed. We suspect that most readers would anticipate that participants would not be able to provide reliable reports. Of course, primed responses differ in a number of ways from habit performance, but this example highlights the challenges in relying on people's insight into non-conscious processes. Especially, given that cued behaviour may be interpreted as reflecting one's own desires (Loersch & Payne, 2011), responses on an experienced automaticity measure may be influenced by factors outside of the habit itself. In sum, although experienced automaticity measures might sometimes correlate with habit strength, we doubt that they are reliable indicators of habits under many circumstances.

Most importantly, for research designed to measure habits, the SRHI and the SRBAI may not reliably deliver on Gardner's key requirements for the predictive validity of habit measures – predicting future behaviour and moderating the intention–behaviour relationship. In our lab, for example, we have included experienced automaticity (SRHI) in several studies alongside our standard frequency-in-context measure and found the latter to be a more consistent predictor. For example, Labrecque et al.'s (2012) participants trialled a new shampoo for four weeks so as to develop habits and then had the opportunity to continue to use it for another four weeks. In the results, use of the new shampoo during the final four weeks of the study was predicted by both the frequency-in-context and experienced automaticity (SRHI) measures, at least when these were entered separately as predictors. However, when entered together into a regression model, only frequency in context explained significant variance in shampoo use behaviour. If automaticity most directly captures the mechanism underlying habits, as Gardner contended, then it should have remained significant as the critical predictor of behaviour rather than becoming non-significant when frequency was also entered into the model. However, with respect to Gardner's other test of predictive validity, neither measure moderated the effects of participants' intentions to use the new shampoo on their actual use of it.

Similarly, indicating the importance of including an assessment of performance frequency in habit measures, the correlation between habit strength and behaviour was smaller for the SRBAI (automaticity alone) than for the SRHI (automaticity and behaviour frequency) in three of the four data-sets that Gardner, Abraham et al. (2012) reviewed when validating the SRBAI. Furthermore, Verplanken and Orbell (2003) compared the predictive validity of the SRHI with the frequency item included versus excluded across several studies and reported that the measure always had slightly higher predictive validity when behavioural frequency was included. Thus, habit measures including behaviour frequency appear to be stronger than measures without.

Gardner's own review of the literature provided additional reason to use measures of performance frequency to assess habit strength. In reviewing the literature on exercise habits, Gardner reported that three studies found reverse moderation – indicating that as habit strength increased, intentions *better* predicted behaviour (de Bruijn, Rhodes, & van Osch, 2012; Gardner, de Bruijn, & Lally, 2012; Rhodes & de Bruijn, 2010), and four studies found that habit strength did not moderate the effects of intention on performance (Gardner, Abraham, et al., 2012; Murtagh, Rowe, Elliott, McMinn, & Nelson, 2012; Norman, 2011; Rhodes, Bruijn, & Matheson, 2010). Of course, exercise habits are complex, and so they may involve both intentions and habits in initiation and performance. Furthermore, the reviewed studies differ in a number of features, any of which may be responsible for these unexpected results. Nonetheless, it is noteworthy that all seven of these studies utilised either the full or an abbreviated version of the SRHI. In contrast, the four exercise studies in Gardner's review that used frequency-in-context measures all found the expected interaction pattern: As habit strength increased, intentions had less power in guiding future behaviour. These failures to find the expected moderating pattern raise additional questions about the usefulness of self-reported automaticity over performance frequency as an indicator of habit strength.

Measures of habit associations in memory

As yet another measure of habit strength, we and others have been developing tests to directly measure the strength cue–response associations. Gardner calls these the 'gold standard' for habit measurement, and we agree. However, he cautions that they require extensive experimental control and may be impractical when measuring some health habits. We have used these tasks on multiple occasions in our lab, and although they can be challenging to implement, we have found them to be useful measures of habit strength in a variety of domains, including health-related behaviours.

In a study of exercise habits, Neal et al. (2012) demonstrated the construct validity of the frequency-in-context measure with a lexical decision task testing the strength of cognitive associations between context, goals and running/jogging. In order to generate appropriate cues for the task, participants provided one-word descriptions of their goals for running (if any) and the typical contexts in which they ran (if they ever did so). For the lexical decision task, participants decided whether letter strings, including the words, 'jogging' and 'running' were words or not. These decisions should be faster to the extent that a preceding prime has strong cognitive associations with running and jogging. As anticipated, participants with strong habits based on frequency-in-context measures also had thoughts of running readily brought to mind by the contexts in which they typically ran. That is, they were faster to recognise running words after being primed with the context in which they ran. Furthermore, consistent with the findings of reward learning research, habits were not dependent on goals, and strong habits were not brought to mind given goal primes.

Measures of cognitive associations also show good evidence of predictive validity, as indicated by Danner et al.'s (2008) study of habitual cycling behaviour. Participants were briefly exposed to a destination, followed by a mode of transportation, and they had to indicate as quickly as possible whether that mode was a reasonable means to reach the specified destination. If destinations can be thought of as context cues for cycling, then reaction times to make judgements could reflect accessibility of the habitual response given the cue. Suggesting the predictive validity of this association measure, strong habits, as indicated by quick judgements, moderated the relationship between intentions and cycling behaviour during the next four weeks. Specifically, intentions guided behaviour when habits were weak (i.e., slow associations), but when habits were strong (quick associations), participants cycled to their destinations regardless of their intentions.

Although we believe that cue–response association tests are the gold standard for habit measurement in a laboratory context, implementing these kinds of tests can be complicated. These measures require that researchers identify universal cues for a behaviour or ask participants to generate their own idiosyncratic cues. Identifying context cues that apply broadly is much simpler for some behaviours (e.g., teeth brushing) than others (e.g., smoking). Asking participants to generate their own cues requires that they understand and can produce appropriate terms to be included in the judgement tasks. Furthermore, researchers may be challenged by the significant additional computer programming often required to present participants' idiosyncratic cues. In addition, participants sometimes are not aware of these cues, or they might hold false theories about the mechanisms that actually guide their habitual behaviours (Labrecque & Wood, 2014; Neal et al., 2012). Furthermore, association tests are also generally more computationally intensive to evaluate than simple self-reports, as they require a large number of trials to detect subtle differences in speed of response to a primed target. However, the strong construct validity of these tests makes them promising candidates for future research.

Conclusion

Gardner concludes his discussion with several thought-provoking issues remaining that challenge researchers as we move forward in understanding health habits. One area that seems particularly promising for health habits is the emerging work on the positive consequences of habits. Reductions in self-control during times of stress or depletion promote an increased reliance on beneficial habits, including habitually healthy food choices (e.g., avoiding chocolate; Wood, Labrecque, Lin, & Rünger, 2014).

It also seems particularly valuable to investigate how new habit associations replace existing associations that develop as people learn new habits. With habit formation, people often substitute a new behaviour for an old one. As this new behaviour gradually comes to be cued habitually, the strength of the cued associations for both behaviours should alter, with the new habit gaining in accessibility. Walker, Thomas, & Verplanken (2014) recently examined this question in a study of travel mode choice among relocated office workers. They found that old habits decayed slowly over time rather than disappearing abruptly, while new associations strengthened simultaneously. Habits were evaluated using experienced automaticity (SRBAI) measures in this study, however, and we suggest that reaction-time measures of cognitive associations could more precisely probe these relationships so as to determine when, for example, the new behaviour becomes the dominant response over the old. Measures of cognitive associations should be able to reliably examine these and other questions in areas in which self-report measures, given the lack of insight participants have into such processes, might be less sensitive.

Note

1. Example context stability question that does not require generating cues for participants: 'When you [perform Behavior X], do you do it in a stable context? By "stable context" we mean that the time (time of day), place (physical location), and the situation (circumstances, e.g., after exercise, before bed, etc.) are similar each time you [perform Behavior X]. When these three aspects of context are similar each time you [perform Behavior X], then the context is stable. If they are different each time, the context is unstable. Please rate the context stability for when you [perform Behavior X] on the following scale from 1 "unstable" to 9 "stable"'.

ORCID

Jennifer S. Labrecque http://orcid.org/0000-0002-9685-9316

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