Association for Psychological Science

Perspectives on Psychological Science
1–16

DOI: 10.1177/1745691621994226
www.psychologicalscience.org/PPS
SAGE

Habits and Goals in Human Behavior: Separate but Interacting Systems

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Abstract
People automatically repeat behaviors that were frequently rewarded in the past in a given context. Such repetition is commonly attributed to habit, or associations in memory between a context and a response. Once habits form, contexts directly activate the response in mind. An opposing view is that habitual behaviors depend on goals. However, we show that this view is challenged by the goal independence of habits across the fields of social and health psychology, behavioral neuroscience, animal learning, and computational modeling. It also is challenged by direct tests revealing that habits do not depend on implicit goals. Furthermore, we show that two features of habit memory—rapid activation of specific responses and resistance to change—explain the different conditions under which people act on habit versus persuing goals. Finally, we tested these features with a novel secondary analysis of action-slip data. We found that habitual responses are activated regardless of goals, but they can be performed in concert with goal pursuit.

Keywords
habit, action slips, goal pursuit, behavior change

An esteemed professor, perhaps thinking about an important research project, tries to enter his office building through the doorway he has used for years, despite knowing that the entry was recently closed for renovations (example from Kruglanski & Szumowska, 2020). On realizing his mistake, he alters course toward a still-open doorway. This scenario reflects a central question in action control: How do habits and goals guide action selection and performance?

The answer you give to this question depends on your definition of habit. In most modern accounts of habit, habitual responses are directly cued by contexts (de Wit, 2017; Gardner, 2015; Knowlton & Diedrichsen, 2018; Verplanken & Orbell, in press; Wood & Rünger, 2016). The familiar cues as the professor walked through campus triggered him to take the habitual, but now blocked, path. Upon encountering the barrier, conscious goal pursuit was activated, and he overrode his habitual response and chose a new way into the building.

Yet some researchers have recently proposed that "all human actions are driven by specific goals," with the result that "habitual behavior is goal-driven" and designed to achieve valued behavioral outcomes (Kruglanski & Szumowska, 2020, p. 1257, see also Ainsle, 2020; De Houwer et al., 2018). In this view, the professor's overlearned behavior persisted because a residual goal to use the old entrance overrode his goal to use the new entrance.

As we show in this article, the view that all behavior (even habits) must be goal driven is intuitively compelling because it fits with people's well-entrenched belief in their own agency. However, this alternative account suffers a major flaw: In practice, it is not falsifiable. Research might successfully demonstrate goal independence of overlearned behavior by accounting for one, two, or 100 goals. However, researchers could infer post hoc a near-endless supply of other goals. Thus, in practical terms, the notion that all behavior is goal driven is not open to empirical test; ruling out dependence on one goal leaves open the possibility of other, as yet untested, goals. As even one proponent acknowledged,

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this argument has the downside of creating an "irrefutable claim that the behavior must be mediated by some type of goal" (De Houwer, 2019, p. 4).

This debate has been perpetuated by false dichotomies implying that behavior must be either completely goal directed or completely impervious to goals. In the history of science, conflicts framed in terms of dichotomies (e.g., nature vs. nurture, situation vs. person) have rarely been resolved by critical tests showing that one process wins over another. Instead, scientific progress in this area is likely to emerge through empirical tests examining how and when behavior is guided by habits and when by goals, as well as how habits and goals interact.

In this spirit, we begin by explaining the tensions between habit and goal accounts of action in the history of psychology. We then review the extensive evidence from multiple subfields (e.g., animal learning, cognitive science, human neuroscience, behavior prediction) showing that habits are directly triggered by context cues (e.g., external settings, times of day, prior actions in a sequence) in ways that do not require the activation of goal states. As we explain, the direct context cuing of habit differs from the goal-dependent automaticity often studied in social psychology. Nonetheless, in evidence that habitual responding involves a process separate from goal pursuit, different moderating conditions promote each type of action control. Finally, we report a new analysis of existing data that supposedly showed the goal dependence of habit. Instead, as we show, the findings reveal the separate but interacting effects of habits and goals on behavior.

Evolution of the Habit Construct

William James (1914) made the prescient argument that habits differ from conscious will in that habitual "action goes on of itself" (p. 42). Specifically, he observed that

> a sequence of mental action which has been frequently repeated tends to perpetuate itself, so that we find ourselves automatically prompted to *think, feel*, or *do* what we have before been accustomed to think, feel, or do, under like circumstances, without any consciously formed *purpose* or anticipation of results. (p. 24)

Nonetheless, he noted that goals can set a habit in motion or correct habitual responses when they go awry. Thus, James's view of habit aligns with the direct context-cuing account that prevails today across most of psychology.

In the following decades, researchers took more partisan views by valuing either habits or conscious will. Early behaviorists embedded the habit concept in mechanistic models of stimulus-response learning that treated all action as a product of environmental control (Hull, 1943; Skinner, 1938). This approach was quickly challenged by Tolman's (1948) *purposive behaviorism*, in which all action is motivated by flexible mental representations—a perspective that laid some of the groundwork for the ensuing cognitive revolution. Social psychologists in particular embraced the Gestalt roots of Tolman's (1948) theorizing and replaced the behaviorists' stimulus-response mechanisms with motivational models of how people coordinate actions within their environment (Campbell, 1963). Even today, some social psychologists subsume habits within goal-dependent action, offering straw-person caricatures of modern habit theory (e.g., "purposeless behavior," "an empty class," "void of sense," Kruglanski & Szumowska, 2020, pp. 1256, 1257, 1258).

Contemporary research, however, has revealed characteristic features of habit formation and performance that distinguish it in systematic, theory-driven ways from goal-dependent action (de Wit, 2017; Gardner, 2015; Knowlton & Diedrichsen, 2018). In brief summary of the emerging consensus, habits are formed largely through instrumental learning (Amodio, 2019).[1] As people repeat a rewarded action in a stable context, they incrementally develop associations in *procedural memory* between the response and recurring cues in that context (Verplanken & Orbell, in press; Wood & Rünger, 2016).[2]

Once formed, habits are directly brought to mind by context cues without the need for recruiting the goal that may have motivated initial learning (or any other goal; Mazar & Wood, 2018). This direct cuing is possible because habits are guided by *cached representations* in memory that store direct cue-response associations (Haith & Krakauer, 2018). In other words, the habit system generates behavior by directly activating response units (de Wit, 2017). Once the response is triggered in mind, people tend to act on it through *ideomotor* processes whereby the thought of a behavior brings about the corresponding physical response in a reflexive, automatic manner (James, 1890/2007). However, habitual action is not obligatory—given sufficient motivation and opportunity, people can override the response in mind.

In modern theorizing, then, habits are not goal dependent; they are activated directly by context cues without supporting goals. Thus, people can act on habits independently from their current goals. Nonetheless, habits can still be goal aligned, in that they yield a future desired state without depending on goals as underlying causal drivers.[3] For example, a seatbelt-wearing habit could be aligned with a goal of safety, but this does not mean that people, consciously or unconsciously, activate a safety goal each time they habitually reach for a seatbelt.

Although these basic features of habit performance are broadly accepted, the field is by no means monolithic in its treatment of habit. To avoid overclaiming a unified perspective, we note that researchers have adapted this basic model in diverse ways. For example, habits may reflect the formation of hierarchical action sequences in which a prior action directly cues a subsequent one (Dezfouli & Balleine, 2013), and habits may be additionally propelled by Pavlovian instrumental transfer (Wiltgen et al., 2012). Still another line of work equates habit with *model-free* choices, reflecting cached knowledge from experience (Dolan & Dayan, 2013; Hackel et al., 2019).[4] Thus, different research programs have emphasized different features of habit performance and revealed that habit characteristics do not always cluster together (Foerde, 2018).

As another caveat, readers should note that, for simplicity, we refer to habits as either strong or weak, even though habit memories develop gradually with repetition and show no categorical demarcation between weak and strong habits (Lally et al., 2010). In addition, habits do not function in isolation but integrate with other psychological processes in guiding behavior, especially for complex behaviors with multiple steps (e.g., going to the gym). For example, habits can integrate with conscious goal pursuit, as when activated goals boost the performance of desirable habits and inhibit undesirable ones (O'Reilly et al., 2020; Wood & Neal, 2007). Nonetheless, for ease of presentation, we refer to responses as more or less habitual.

This central feature of habit performance—direct context–response cuing without requiring a corresponding goal—is supported widely by research. The next section of the article summarizes this research from multiple fields and then explains how habit differs from the goal-dependent automaticity often studied in social psychology.

Habits Are Directly Activated by Recurring Context Cues

Behavior-prediction studies

The independent influence of habits and goals in guiding behavior is a cornerstone of behavior-prediction research. As Triandis (1977) argued, people act on their *intentions* (behavioral goals) when their habits are weak; however, when people have formed strong habit associations in memory, these guide behavior with minimal intentional control. This hypothesis has since been supported with everyday behaviors ranging from recycling to eating, physical activity, and safe sex (see meta-analyses by Gardner, 2015; Ouellette & Wood, 1998).

A key finding in behavior-prediction studies is that explicit goals, regardless of how they are measured, are poor predictors of strongly habitual behavior. For example, when participants had formed strong habits to take the bus, they continued to do so regardless of how they personally framed their bus-riding intentions (e.g., reducing my carbon footprint vs. getting to school) or the associated level of abstraction (e.g., catching the 9:45 shuttle vs. using public transit; Ji & Wood, 2007). Thus, the behavior-prediction findings are not due to failures to appropriately assess people's behavioral goals. However, the relative influence of habits and goals is more nuanced than the simple interaction demonstrated in behavior-prediction studies; as we show, it depends on a variety of moderating factors (see Moderators of Habit Performance section).

Behavioral neuroscience of habit

A central finding in behavioral neuroscience is that the brain circuits activated during habit performance are separate from, but interconnected with, those associated with goal-dependent actions. Yin and Knowlton's (2006) landmark analysis of basal ganglia function identified distinct *cortico-basal ganglia* networks mediating habits and such actions. Specifically, as habits form through instrumental learning, the cortical networks associated with action control shift from the goal-driven *associative network* to the habit-based *sensorimotor cortico-basal ganglia network*.

Empirical evidence of habit-related neural systems comes from Patterson and Knowlton's (2018) meta-analytic review of neuroimaging (functional MRI [fMRI]) studies during repeated performance at various tasks (i.e., sequential decision making, motor sequence learning, outcome devaluation of instrumental tasks). After participants practiced these tasks extensively, activation peaked in the lateral *putamen*, an area associated with habitual responding, but not the *caudate*, an area associated with *declarative* memory involved in conscious goal pursuit. These findings suggest a repetition-associated habit neural system that is engaged through repeated task performance without necessarily activating systems associated with goal pursuit.

Additional evidence of the neural basis of habit learning comes from selective impairments evident in patients with brain damage (Knowlton & Diedrichsen, 2018). Damage to striatal regions (especially the putamen), as occurs with Parkinson's disease, impedes performance at serial reaction time tasks requiring habit learning without impeding the ability to learn these tasks in flexible, goal-driven ways, using declarative knowledge (Foerde, 2018). In contrast, damage to the *hippocampus* or *medial temporal lobes*, as with amnesia, preserves habit learning but impedes flexible retention of declarative knowledge to guide goal pursuit. In like manner, cocaine dependence can disrupt functioning in the putamen so as to promote habitual responding versus goal-directed control (Ersche et al., 2021). This pattern of double dissociation, whereby habit learning can be selectively impaired but goal pursuit is not, and vice versa, cannot readily be explained by the goal-dependent view of habit. Instead, these findings suggest that habit memory captures features of task learning that can guide responding separately from knowledge of desired outcomes.

Animal learning of habits

In animal-learning research, the "general consensus is that parallel and competing circuits exist in the brain for habits and goal(s)" (Amaya & Smith, 2018, p. 145). In support, habit circuitry involving the dorsolatoral striatum has been identified and shown to interact with separate circuitry for goal-mediated behavior (O'Hare et al., 2018). Other lines of research have shown that repetition is responsible for shifting the neural control of flexible, goal-dependent behaviors to the less goal-sensitive habit system (Corbit, 2018).

In animals, similar to findings with brain-damaged people, disruption of the *dorsolateral striatum*, a neural area corresponding to the human putamen, decreases habitual responding and promotes goal pursuit. That is, after disruption to habit neural systems, animals navigate by using goal-directing spatial cues, respond flexibly to changes in action outcomes, and show increased variance in action structures (Amaya & Smith, 2018).

Perhaps the canonical demonstration of the goal independence of habit comes from animal learning research using the *outcome-devaluation paradigm*. In Dickinson's (1985) classic experiment, rats extensively trained to press a lever for food continued to do so even when the food was no longer valued or expected. In daily life, this aspect of habit performance emerges in action slips of the kind that began our article (i.e., taking a familiar but recently blocked route). We provide new evidence of the role of habits in action slips in a later section (see Action Slips).

Computational models

Finally, the distinction between goal-mediated and habit-based responding is reflected in current computational models of behavioral control (e.g., Botvinick & Plaut, 2004; K. J. Miller et al., 2019). Notably, the conceptual precursors to these computational models conceived of all actions as explicitly oriented toward attaining a goal (Carver & Scheier, 1982; G. A. Miller et al., 1960). However, as these models evolved in response to the emerging behavioral and neural data discussed above, they generally shifted to postulate distinct learning algorithms and computational modules for goals and habits. For example, Sun et al.'s (2005) CLARION model used a rule-extraction algorithm to account for goal-based learning but a very different back-propagation algorithm to account for habit learning. Likewise, K. J. Miller et al. (2019) postulated a goal module that selects actions on the basis of their outcome value and a separate habit module that selects actions that were frequently repeated in the past, regardless of outcome.

Computational accounts also identify the ways that goals and habits coordinate. One possibility invokes an arbiter module to weigh the strength of habits against the motivation of goals and other action drivers (K. J. Miller et al., 2019). Another allows for a continuum of interaction between these two systems (O'Reilly et al., 2020). Still another possibility envisions a speed/accuracy trade-off between the fast but inflexible habit system and the slow-in-choice-selection-but-flexible goal system (Keramati et al., 2011). Thus, computational models of human action have generally coalesced around the view that habits and goals arise from distinct, albeit interacting, underlying mechanisms.

In summary, the multiple levels of analysis reflected in human behavior research, behavioral neuroscience, animal learning, and computational modeling all converge to show that habitual responding and goal pursuit are characterized by separable patterns of learning, behavioral expression, and underlying brain systems. Specifically, habit memory is largely insensitive to current behavioral goals; it is tied to activation in different neural substrates than are goals; and it is effectively modeled computationally through a habit module that interacts with, but is separate from, goal-based action control.

Automatic goals in social psychology

The extensive evidence that habit memory is insensitive to explicitly held goals has led to recent claims that habits must, instead, be guided by implicit goals, or needs outside of conscious awareness (Kruglanski & Szumowska, 2020). However, direct tests challenge this possibility, revealing instead that people act habitually regardless of their implicit attitudes or goals. For example, participants with strong habits to watch TV or to recycle continued to perform those behaviors regardless of the accessibility of their attitudes toward TV watching or recycling (accessibility was assessed from reaction time to report attitudes; Ouellette & Wood, 1998). Likewise, hungry participants extensively trained in a food-choice task to select carrots (thus forming habits to choose carrots) persisted in doing so even when they could have M&Ms, and this effect maintained despite participants' implicit attitudes toward carrots or M&Ms (implicit attitudes assessed with the affect-misattribution procedure; Lin et al., 2016). In addition, a standard procedure to manipulate nonconscious goals guiding speech volume did not influence participants with habits to speak loudly in a particular context (Neal et al., 2012).

Classic goal theory provides additional reason to differentiate habits from implicit goals. Automatic goals are thought to activate a variety of responses instead of being tied to one specific response (Kruglanski et al., 2002). Thus, a hungry person with an implicit goal for comfort might choose pizza, fried chicken, or pie. Even strongly desired goals that stably characterize people's motives are met flexibly through multiple substitutable behavioral means (Kruglanski et al., 2002). To select from multiple means, people supposedly choose the one with the highest expected value to meet their current goals.

The different ways that implicit goals and habit memory guide behavior was illustrated in research that primed achievement goals (Hassin et al., 2009). After priming or not, all participants then repeatedly performed an instrumental task in which the correct choices changed several times without warning. As expected, participants implicitly primed with achievement goals flexibly learned the newly correct choices. Participants without goal priming, however, persisted with responses that had been successful in the past, before the change. Thus, implicit achievement goals prompted flexible changes in behavior to accommodate the changing outcomes. When these goals were not activated, participants gave habit-like responses insensitive to changing values.

In general, automatically activated goals and explicit goals appear to function similarly in promoting a strategic orientation to adapt to changing environmental demands. In findings demonstrating this similarity, manipulations of implicit and explicit goals to work hard were associated with comparable physiological changes (Takarada & Nozaki, 2018). Implicit and explicit goals also have similar effects in guiding behavior (Bargh, in press). For example, a meta-analytic review of achievement goals concluded that priming of implicit goals functions similarly to conscious goal setting and pursuit (Chen et al., 2021). Furthermore, the finding that implicit goal pursuit depends, at least in part, on explicit reasoning suggests an additional connection between them; people act on implicitly activated goals and concepts by attributing them to their own thoughts (e.g., "I am thinking of money, so I must want to stick to my budget"; Loersch & Payne, 2011).

In summary, implicit goals align with explicit ones in guiding action in ways that are distinguishable from the direct cuing of habits. Implicit goals activate a flexible range of possible behaviors, establish a strategic orientation to achieve current desires, proceed in part through conscious inference, and, at least for achievement, have effects similar to explicit goals. Furthermore, in direct empirical tests, implicit motives did not account for habit persistence (e.g., Ouellette & Wood, 1998).

In the next section, we elaborate on two features of the procedural memory system underlying habitual responding that are especially relevant to distinguishing habits from goal-dependent responding. First, habits connect responses to context cues (places, people, preceding actions) associated with past performance, such that those responses are brought to mind automatically in those contexts. Second, the procedural memory system learns slowly and incrementally, making habit memory relatively resistant to short-term shifts in goals, preferences, and beliefs.

Feature 1: Habitual Responses Are Directly Activated by Past Performance Contexts

The direct activation of habit responses from memory enables speedy selection and preparation of the response (Keramati et al., 2011). In evidence, participants extensively trained to respond with specific key presses to each of a series of pictures of Phoenician letters were then informed that the correct responses had changed and alternative keys were now correct (Hardwick et al., 2019). Although participants easily learned the new responses, when put under time pressure, they reverted back to responding out of habit (and against current goals). Nonetheless, given more time, participants could override their habits to act consistently with the new instructions (Hardwick et al., 2019). Thus, at short latencies, responses were guided by habit memory and not by current goals. At latencies long enough to enable evaluation and selection of responses, habits were masked by goal-dependent processes.

In an experiment that directly assessed the activation of habit responses and their effects on overt behavior, Labrecque et al.'s (2021) participants practiced a sequential task extensively or only twice. Showing habit activation, participants with extensive practice responded faster to an association test that involved selecting the correct response after priming with a prior one in the sequence. A second part of the experiment then demonstrated the effects of response activation on overt behavior: Participants with shorter reaction times on the association test were able to more accurately repeat the full sequential task when under cognitive load. This study also demonstrated that effective performance did not depend on goals; the effects of direct associations between context cues and habitual responses emerged after statistically controlling for a number of goals that might vary with practice, such as intentions to accurately perform the task, fluency and ease of performance, and liking for the task.

Evidence of direct cuing in habit memory is not limited to novel lab tasks. Everyday habits are similarly activated quickly in mind (e.g., Danner et al., 2008). For example, frequent runners were faster to detect the words, "running" and "jogging" after being subliminally primed with the places where they typically ran (i.e., location-running associations, Neal et al., 2012). Priming participants with their self-nominated goals for running did not activate thoughts of running for frequent runners, which provides additional evidence that habits are cued without goals. Thus, running habits were not linked to implicitly activated goals. Instead, goal priming was associated with running only for occasional runners, presumably because they still had to actively motivate themselves to run.

Research has thus demonstrated that greater practice, whether at experimental tasks or in everyday life, increases the speed with which people access that response when perceiving relevant context cues. Habits may thus persist as a result of a kind of mental horse race in which the practiced response is selected more rapidly than other potential guides to action (see Verbruggen & Logan, 2008). In contrast, goal-systems theory suggests a lengthier process of evaluating various substitutable behavioral means to select the one with the highest current value for goal pursuit (Kruglanski et al., 2002). In fact, the narrowing of response options may be an important function of habits, in that they constrain the broad set of responses that people could give at any moment (Morris et al., 2019).

In summary, habits often assume precedence in action control because of the speed of activation and the specificity of the response in mind. Furthermore, these features appear to underlie the persistence of habitual responding (Labrecque et al., 2021). In the next section, we consider a second systematic implication of the definition of habit in current research.

Feature 2: Habit Memory Is Insensitive to Newly Changed Goals and Beliefs

Habit memory is a conservative action system that insulates repeated experience from short-term whims and transient shifts in people's goals and plans. Thus, unlike goals that energize and direct action flexibly in response to current desired ends (Kruglanski & Szumowska, 2020), strong habits persist in memory regardless of whether they are consistent with current goals. Like procedural learning, or learning how to perform an action, habits develop gradually with practice and reflect the slow, incremental tuning of processing units in memory (Gupta & Cohen, 2002). The saying "you never forget how to ride a bike" illustrates this aspect of procedural memories.

Findings that habit automaticity remained relatively stable even when people failed to act habitually in a given circumstance illustrate this resilience (Lally et al., 2010). Habit automaticity also persists despite people's intentions to act in other ways. For example, in the time-pressure research discussed earlier, habits continued to be activated despite participants' goal to override their habits (Hardwick et al., 2019). This effect has also been demonstrated in animal learning, in that habit memory decays only slowly and seems to maintain through reward extinction after animals have stopped responding (Adams, 1980; Bouton, 2019). Finally, computational models have successfully replicated the slow-learning feature of habit memory using simple Hebbian mechanisms that gradually connect contexts and responses in memory in ways that bypass goal-mediated control of behavior (e.g., K. J. Miller et al., 2019).

In summary, two basic features of habit memory provide the underlying mechanism by which habits are cued directly by contexts without mediation by goals: Specific responses are quickly brought to mind by relevant contexts (Feature 1), and such habit memories endure despite changes in goals and failures to act (Feature 2). In the next section, we build on these features to identify the conditions in which people are likely to act on habit and ones in which they are likely to pursue goals.

Moderators of Habit Performance

If habits and goal pursuit are guided by different psychological mechanisms, then different conditions are likely to influence each type of action control. First, moderators that remove context cues should disrupt the process of habit performance but leave the process of goal pursuit relatively intact. That is, for participants with strong habits, changes in cues disrupt response activation so that the practiced response is not brought quickly to mind (see Feature 1). With a change in context, people with weaker habits might be spurred to pursue different goals, but these goals should continue to guide behavior through the same basic goal-based processes. Second, moderators that alter the process of goal pursuit should not necessarily impede the activation of previously learned habit memories (see Feature 2). Thus, a second test of our account is whether stressors, fatigue, and time pressures that impede goal processes leave habit processes relatively intact. Together, these two moderator tests provide evidence of a kind of double dissociation, suggesting an underlying mental process that is required by habit but not by goals (and vice versa). As noted above, this double-dissociation logic has been used to isolate the different neural systems associated with habit and declarative memory (Knowlton & Diedrichsen, 2018).

Habits are altered by context change

Studies of *habit discontinuity* reveal that habit performance is disrupted when people move to a new residence or start a new job (Verplanken et al., 2008). With the change in context cues, the habitual response is no longer activated in mind (Feature 1), and behavior is more amenable to being guided by goals and other action-control processes. Thus, new residents to an area, who would have recently experienced a disruption in everyday contexts, were influenced more by a proenvironmental intervention than long-time residents, whose living context would have remained stable (Verplanken & Roy, 2016). Furthermore, these effects of habit discontinuity proved to be independent of motives as reflected in proenvironmental values and behavioral intentions.

A study of transfer students to a new university isolated the role of context cues (versus change in general) in habit discontinuity (Wood et al., 2005). When the contexts in which students exercised shifted from the old to the new university, strong exercise habits were disrupted; students persisted in exercising only if they held strong exercise intentions, a replication of the classic discontinuity effect. In addition, however, when exercise contexts were stable across the move (e.g., indoor track at both schools), students maintained their workout habits regardless of intentions. These results are impressive given that exercise is beneficial in the long term but sometimes aversive in the short term and might be especially prone to the disruptive effects of context changes. Indeed, the same pattern emerged with other, more immediately gratifying habits, such as watching TV. Just as with exercise, students' TV watching habits were disrupted when the transfer produced a change in the relevant cues supporting this activity. Changes in performance cues were unrelated to students' intentions to exercise or to watch TV when at either university, which indicates that this pattern was not due to a shift in motivation.

Controlled experiments have similarly demonstrated the moderating role of context cues on habit performance. For example, hungry participants were trained in an online task to choose carrots in response to an abstract image cue (Lin et al., 2016). Some were trained extensively so as to form a strong habit of choosing carrots when the specific cue was present. Others, with limited training, formed a weaker habit. All were subsequently given choices between carrots and M&Ms. Participants with strong habits were more likely to stick to their habitual (and healthy) choice on trials in which the specific cue displayed on the screen compared with trials without the cue. This was especially true for participants who reported high automaticity in their choice. Participants with weaker habits, in contrast, were more likely to choose M&Ms regardless of the cue. This research challenges the folk wisdom that eating habits are generally detrimental. It shows instead that healthy habits can protect people against choosing unhealthy foods. More relevant to the present point, the study varied an arbitrary cue (a fractal image) that is not plausibly associated with any change in eating goals. Thus, the change in participants' choices when habit cues changed cannot easily be traced to altered motives.

In summary, habit performance is disrupted when changes in contexts alter the cues that bring habits to mind. Regardless of whether the shift in cues was due to an altered living environment or to an experimental manipulation, the absence of habit cues leaves people acting in more goal-dependent ways. When cues remained stable, however, people responded out of habit regardless of their personal intentions or the apparent desirability of the action. Furthermore, the parallel findings across everyday performance contexts and a controlled experiment with artificial cues challenges goal-driven explanations in which changes in cues influenced the performance of strong habits by altering participants' goals.

Time pressure, stress, and fatigue impede goal pursuit but not habit

Time limits, stress, and fatigue reduce people's capacity and motivation for deliberate goal pursuit but leave habit memories intact. Specifically, time pressure is likely to limit decision capacity, stress focuses people on coping with the stressor, and fatigue reduces motivation more broadly.

We already discussed research in which time pressures impede pursuit of new, habit-inconsistent goals (see Feature 1 section). For example, under time pressure, participants expressed habitual responses regardless of whether they were correct, whereas with more time, they were able to prepare and express the correct response to meet current task goals (Hardwick et al., 2019). It is also relevant that extensively learning an instrumental task under time pressure created conflict and delayed responding, suggesting that participants' habitual responses continued to be activated even when the correct outcomes changed (Luque et al., 2020). Thus, time pressure may encourage not only habit expression at the response stage but also habit formation at the learning stage.

Stress. In a review of stress effects on neural activation during performance of a variety of learning and memory tasks, Wirz et al. (2018) identified shifts from flexible, cognitively driven action control to more rigid habitual control. With navigation tasks, for example, stress induced a shift from the hippocampal system, which is associated with flexible and integrative learning, to the putamen and the sensorimotor cortico-basal ganglia network, which are involved in stimulus-response learning. Neurotransmitters activated by stressors (catecholamines, nongenomic glucocorticoids) help marshal cognitive resources to process the threat and to orient memory toward relying on habitual control (Quaedflieg & Schwabe, 2018).

In results illustrating the behavioral effects of stress, Schwabe and Wolf (2011) initially stressed participants (or not), who then performed an instrumental task in which they repeatedly chose between two responses to get a reward. The task was easily learned regardless of stress levels. Rewards then were withheld on some blocks of trials (i.e., extinction). Stressed participants persisted in making the habitual choice even during these extinction trials. Those not stressed, in contrast, explored alternative responses that might be rewarded. Ironically, by sticking with their habitual choice through the series of rewarded and unrewarded blocks of trials, stressed participants gained more rewards overall, whereas unstressed participants were exploring (unrewarded) alternatives even when the rewards started to be delivered again.

Fatigue. Research that experimentally manipulated fatigue also reveals that it impaired deliberate decisions despite leaving habit performance intact. In one study, for example, participants were mentally fatigued by using their nondominant hand for answering the phone and other activities (Neal et al., 2013). On days when they were fatigued in this way, participants continued to perform habitual, frequent behaviors but not more occasional actions, which presumably required more decision effort. The result of this differential moderation was that participants actually performed *more* habitual actions when fatigued than when rested. It is noteworthy that habit performance increased across the board, including both good habits that achieved participants' goals as well as bad ones that impeded goals. Thus, fatigue increased habit performance regardless of goal pursuit.

In findings supporting this dissociation pattern, students fatigued by a difficult midterm exam were more likely to select snacks that were their usual, habitual choices than when they were not fatigued (Neal et al., 2013). Again, fatigue appeared to reduce deliberate control over behavior but left habit performance intact. The end result was that habit performance increased after the fatiguing exam. Note that fatigue did not affect motivational drivers of choice, including the perceived healthfulness of snacks or liking for them. Thus, fatigue increased habit performance without influencing motivations to act.

Additional evidence comes from a persuasion study in which participants did or did not complete a fatiguing task and then received a message on the health risks of sugar (Itzchakov et al., 2018). Fatigue increased persuasion and the negativity of attitudes toward sugar consumption. However, when subsequently taste-testing beverages, fatigued participants with strong habits to drink sugared beverages continued to consume them despite their new attitudes. In contrast, those not fatigued, much like all participants with weak beverage-drinking habits, acted on their new attitudes and avoided sampling sugared drinks. This study is especially informative because fatigue had reverse effects on motivations and habits—it increased everyone's attitude change but decreased behavior change among those with strong habits.

In summary, stress and fatigue, much like extreme time pressure, reduce people's capacity to actively pursue current goals but have limited effect on habit performance, suggesting that habit memory stayed intact. In fact, these moderators that impeded goal pursuit also increased the likelihood that people acted habitually. Furthermore, people repeated both habits that yielded undesired outcomes as well as habits that generated desired ones, which supports the notion that habit automaticity does not depend on goals.

Doubly dissociated moderators within a single behavioral domain

The strongest evidence that habitual control is distinct from goal-dependent control comes from demonstrations of multiple moderators of a given behavior—one moderator that influences habit performance but fails to affect goal pursuit, and another that influences goal pursuit but not habit performance. Comparisons within a single behavioral domain are possible because habit refers to how a behavior is performed and not a response type. Specifically, these studies identify (a) one moderator that impedes performance for participants with strong habits but does not influence goal pursuit among those with weaker habits along with (b) a second moderator of that same behavior that impedes the influence of goals on participants with weak habits without affecting the performance of those with strong habits. If separate moderators influence habits and goals, then goals are not plausibly the underlying construct driving habit performance.

This form of double dissociation was evident in the strategies that people use in daily life to control unwanted responses (Quinn et al., 2010). In this experience-sampling research, participants' control efforts included inhibiting strong habits, or actions performed repeatedly in stable contexts, as well as temptations, or behaviors motivated by immediate positive feelings despite longer term regret. Participants successfully controlled habits by using a strategy of *vigilant monitoring*, or actively inhibiting acting on the response in mind. In contrast, participants effectively controlled temptations by distracting themselves. In a pattern of double dissociation, the habit-controlling strategy of vigilant monitoring had little impact on temptations, apparently because it increased focus on the tempting item, whereas the temptation-controlling strategy of distraction had limited impact on habit performance, apparently because it allowed the habitual response to run off unattended.

Posting on social media also reveals a pattern of double dissociation (Anderson & Wood, 2021). Facebook users who posted only occasionally increased the frequency of their posts when they got more rewards from others in the form of likes and reactions. However, more frequent posters on the site, who respond automatically out of habit, did not increase posting when they got such rewards. In contrast, a change in the Facebook platform in 2008 altered context cues on the site, which decreased the rate at which frequent users posted messages, presumably because it disrupted habit automaticity. This same change, however, increased the frequency of posting for more occasional users.

Finally, eating research showed a double dissociation when liking for food as well as cues in the eating context were experimentally manipulated (Neal et al., 2011). Specifically, patrons in a movie theater with strong habits to eat popcorn did so even when given stale popcorn that they reported disliking. In contrast, participants with weaker habits ate more fresh popcorn than stale. Thus, weak but not strong eating habits were responsive to motivation. A second study changed the context so that participants were given popcorn in a darkened meeting room on campus while watching music videos. Participants with strong habits to eat popcorn at the cinema were no longer cued by the circumstances and responded much like participants with weak habits participants: Everyone ate more fresh popcorn than stale popcorn. Thus, strong habits were most responsive to the change in context cues.

In evidence that these popcorn-eating habits were not goal dependent, Neal et al. (2011) measured participants' hunger and liking for the popcorn. Neither of these motives statistically accounted for the effects of habit strength on behavior. In this way, habits persisted without input from the most plausible goals that could drive behavior. Nonetheless, De Houwer (2019) speculated that participants with strong habits persisted in eating stale popcorn in this research because of yet another goal that had not been assessed—that popcorn consumption was a valued part of moviegoing for habitual participants. However, if participants with a strong habit had valued the stale popcorn, they would plausibly have reported liking it more, but they did not. Furthermore, as noted earlier, this line of argument is unfalsifiable because an additional, as-yet-undiscovered goal can always be proposed post hoc to explain habitual responding.

In summary, our definition of habit along with the features of habit memory identify different conditions under which habits and goals influence responding. When context cues shift, habits fail to be activated, and people are more likely to choose actions on the basis of their current goals. In contrast, time pressure, fatigue, and stress disrupt slower, more effortful goal pursuit and leave people acting on habits, both goal congruent and goal incongruent. Finally, the clearest evidence for double dissociations occurs within a single behavioral domain, as when factors that hinder goal pursuit leave habit performance relatively intact, whereas factors that disrupt habits leave people acting on goals. We reviewed these effects in three investigations involving the inhibitory control of everyday actions, posting on Facebook, and eating popcorn.

The separate conditions that promote habit performance versus goal pursuit challenge the claim that habits depend on goals. Yet the evidence of separate moderators does not imply that habit performance is necessarily an alternative to goal pursuit. Although these two forms of action control engage different psychological processes, they integrate in various ways to guide behavior (see Wood & Neal, 2007; Wood & Rünger, 2016). Complex behaviors are especially likely to require the coordination of habits and goals.

In the next section of the article, we provide a novel test of the characteristic features of habit memory. Specifically, we report a reanalysis of past research on action slips that had been interpreted as showing that habits are goal dependent (De Houwer et al., 2018).

Action Slips

People experience action slips about six to seven times a week, according to experience-sampling research (Jónsdóttir et al., 2007). Such slips often involve repeating unwanted habits when intending to do something else. This phenomenon is partly a reflection of Feature 2, in that habit memories are insensitive to changes in goals. The persistence of habits despite current goals was captured in a study of new product adoptions in which 25% of consumers reported that they failed to follow through on their intentions to use a newly purchased product because they fell back on their old habit and did what they used to do (Labrecque et al., 2017). Another demonstration comes from habitual smokers in British pubs, who reported slips of starting to light up after the United Kingdom instituted bans on smoking in public settings (Orbell & Verplanken, 2010). Furthermore, consistent with the fast activation of habits (Feature 2), action slips are most likely when people are acting before thinking, such as when absentminded or distracted (Reason, 2017). Thus, habit-based action slips are a consequence of the persistence of habit memories despite current goals as well as the speed with which they are activated in mind.

Our understanding of habit slips can potentially explain a paradox in recent research: If human habits do not depend on goals, then why have outcome-devaluation experiments in the lab failed to consistently demonstrate that people's habits are insensitive to alterations in goals? As noted earlier, the outcome-devaluation paradigm was originally developed with rodents. Animals extensively trained to perform a task for a reward continue to perform it even after the reward is devalued (animal is sated) or is no longer available (extinction; e.g., DeRusso et al., 2010; Dickinson, 1985).

In humans, some evidence—albeit limited—that people respond habitually in outcome devaluation experiments comes from neuroimaging research suggesting competing goal-dependent and habit systems (see review in de Wit et al., 2018). In addition, the predicted pattern of behavioral persistence has emerged in a few controlled experiments. For example, participants trained extensively in an online task continued responding for a food reward even after they had eaten that food to the point of discomfort (Tricomi et al., 2009). However, a recent set of studies failed to find evidence that overtraining and habit formation led to persistent responding after an outcome was devalued (de Wit et al., 2018).

To explain the inconsistent findings in lab research, some researchers have argued that outcome-devaluation effects actually depend on goals (e.g., De Houwer, 2019; Kruglanski & Szumowska, 2020). Supposedly, participants sometimes fail to respond to changes in experiments' outcomes not because they have a strong habit but because researchers have varied the wrong goal outcomes. In this view, participants with stronger habits persist in acting on habit when they are pursuing an alternative goal than the one that was changed in an experiment. However, one complication with this account is that participants with weak habits consistently alter their behavior in this paradigm. Thus, they must be following different goals than participants with strong habits. Of course, this possibility is inconsistent with evidence that both kinds of participants hold comparable goals (i.e., Lin et al., 2016; Neal et al., 2011).

De Houwer et al. (2018) nonetheless claimed to have tested the goal account by substituting a novel description of goals into an existing action-slip paradigm (de Wit et al., 2007, 2012). In three studies, participants first repeatedly learned to associate cues (pictures of fruit) with responses (left or right key presses) that earned them points. After this training, participants were informed that responses that previously earned points would no longer do so and that alternative responses would now gain points. According to De Houwer et al. (2018), this instruction addressed participants' true goal in responding, which was to earn points, in contrast with the original studies, which framed the change in terms of correct and incorrect choices of experimental stimuli (i.e., fruits; de Wit et al., 2012). When informed about the point changes, De Houwer et al.'s (2018) extensively trained participants flexibly altered their responses, which supposedly indicated that they were driven by goals to acquire points and were not constrained by habitual choices. The continued sensitivity to point values held even for items designed in this paradigm to maximize habitual responding, labeled *incongruent items*.

We reasoned, however, that overt behavior is not an adequately sensitive measure of habit effects. If habit memories are quickly activated by associated cues (Feature 1) and persist despite change in goals (Feature 2), then De Houwer et al.'s (2018) participants would have had to inhibit the now-incorrect habitual response to pursue the goal of gaining points. Thus, on incongruent items, which were designed to maximize habits, they should demonstrate slower response times. Such a pattern would mirror findings from other paradigms in which inhibition manifests in slower reaction times even when overt responses are correct (e.g., a Stroop task; MacLeod, 1992). In support, a recent set of studies

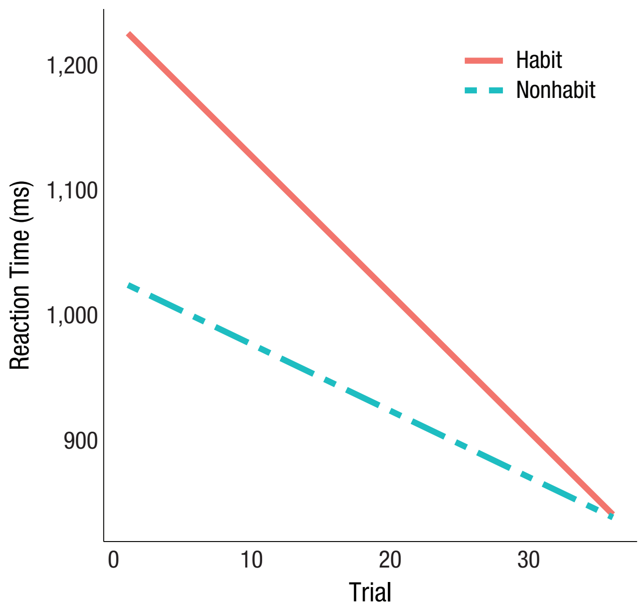

Fig. 1. Time to respond after change in goal outcomes as a function of trial number, presented separately for habit and nonhabit items.

measured both overt responses and reaction time in an outcome-devaluation paradigm (Luque et al., 2020). As in De Houwer et al. (2018) and de Wit et al. (2018), even participants with strong habits were able to change their overt responses flexibly when outcome values shifted. However, response times on outcome-devalued trials were slower in conditions more likely to have created habits (greater training, greater time pressure, greater rewards during learning), which suggests habitual responding. Thus, it may be that previous studies did not observe habit effects because their outcome measure—overt responding—was not sufficiently sensitive to capture habit.

To test this hypothesis, we obtained and analyzed the (hitherto unreported) reaction time data from all three studies from De Houwer et al. (2018). Specifically, we evaluated whether, after the instructions that goal outcomes had changed, participants were slower to respond on the incongruent items, designed to promote habit formation, than on other types of items (*congruent* and *biconditional*), designed to reflect goal-dependent decisions. If habits were formed during the initial training on the habit items, then participants should respond more slowly, given that they had to inhibit the incorrect response in mind and select the correct one.

For the analysis, we constructed a multilevel linear model predicting reaction times from item type (effects coded as habit = 1, nonhabit = −1),[5] trial number following the instructions (1–36), and interactions between trial and each item type (see multilevel model equations in Fig. S1 in the Supporting Materials at OSF). Trials with response times more than 3 *SD* slower than the mean were excluded from analyses (93 trials, or 3%). Nevertheless, the present findings persisted when all observations were included. Raw data as well as code for these analyses can be found at OSF (https://osf.io/zjw7t).

Regression results are illustrated in Figure 1. The analyses revealed a significant difference between habit items (incongruent) and nonhabit items (congruent and biconditional), b = 103.54, 95% confidence interval [CI] = [64.40, 142.68], $t(2777) = 5.18$, $p < .001$, indicating that participants indeed gave slower responses on habit items than nonhabit items. A significant interaction between trial number and item type also emerged, b = −2.84, 95% CI = [−4.59, −1.10], $t(2777) = -3.19$, $p < .001$, indicating that the difference between habit and nonhabit items decreased with practice. A main effect of trial number, b = −8.16, 95% CI = [−9.90, −6.41], $t(2777) = -9.15$, $p < .001$, demonstrated the expected decrease in reaction times on all items given practice.

Thus, consistent with Feature 1, habitual responses appeared to be quickly prepared on habit items even after the task rules were changed and participants were aware that acting on the habit would fail to gain points. Furthermore, consistent with Feature 2, the habitual memory trace apparently persisted despite the change in participants' goals. However, with continued practice of the newly correct response across the 36 reevaluation trials, participants appear to have streamlined their responding to the task and equalized reaction times across incongruent items sensitive to habit formation and other items that were guided by goal pursuit.

Despite this evidence of the switch costs created by the automatic cuing of habit, De Houwer et al.'s (2018) study design may not be an optimal test. Detection of habits is challenged because all participants had extensive practice on all items. Even initially goal-directed actions can become habitual through sufficient repetition, and participants may have begun to develop habits for biconditional and congruent items. Further clouding interpretation, De Houwer et al.'s (2018) procedure deviated from de Wit et al.'s (2012) original outcome-devaluation paradigms in more ways than just the altered goal description (e.g., reversal of all values, incorrect responses lost points).

In sum, the paradox of outcome devaluation does not appear to be due to a failure for habits to persist when goals change as much as a failure for research assessments to be sensitive to habit activation. It seems that humans are almost as bedeviled by unwanted habits as are lab rats. However, with greater capacity to inhibit them, people are better able to control responses in action-slip or outcome-devaluation paradigms. As de Wit et al. (2018) speculated, failures to find evidence for action slips in experimental paradigms with humans could be due to participants' ability to deliberately override habits in settings that are not subject to stress, fatigue, or extreme time pressure.

Despite the considerable evidence showing that habits do not depend on goals, we recognize that explaining behavior in terms of goals has broad appeal. The next section addresses how the compelling nature of goal accounts can blind us to the workings of habit in everyday life.

Intuitive Appeal of Goal Accounts

Goal explanations have an inherent veneer of plausibility, both for people explaining everyday actions as well as for researchers. Such explanations are ubiquitous, and people readily infer goals behind even the movement of geometric shapes; for example, participants reasoned that one shape was chasing another or trying to get away (Heider & Simmel, 1944; Scholl & Gao, 2013; Scholl & Tremoulet, 2000). Accordingly, in controlled experiments, people favor goal explanations for behavior over other potential causes. Even when people consider dispositions or situational constraints, these are assumed to affect action indirectly via the goals being pursued (Böhm & Pfister, 2015). Such goal inferences are made spontaneously (Gilbert et al., 1988; Hassin et al., 2002) and are evident as early as the age of 6.5 months (Csibra, 2008). However, the prevalence and ease of goal-based attributions does not, of course, qualify as evidence that goals are casual drivers of habits.

We recently tested whether the plausibility of goal attributions might lead people to underestimate habit in their own behavior (Mazar & Wood, 2021). In one study, coffee drinkers rated the extent to which their coffee drinking was driven by habit and by fatigue—the two most common explanations given in pilot testing. Then, over the course of a week, participants reported eight times per day on their current fatigue, context, and coffee drinking. Results showed that people drank coffee out of both habit and fatigue, and these had comparably sized effects. However, in participants' attributions, fatigue was a much stronger driver of their own coffee drinking than habit. This underestimation of habit persisted regardless of whether participants were making attributions (a) for themselves or others, (b) for their coffee drinking as a whole or for a single coffee-drinking episode, and (c) when financially incentivized to provide accurate attributions for themselves.

In summary, people generally favor goal inferences, and these inferences feature prominently in lay explanations of behavior. Even when acting on habit, people overestimate the influence of goal pursuit and underestimate the influence of habit. The appeal of goal accounts may reflect the sense of agency and control that they establish for people in understanding of their own and others' actions. In our final, concluding section, we discuss the broader implications for continued research on habit formation and performance.

Conclusion: Moving Forward

In this article, we showed that habits—direct context-response associations learned through repeatedly rewarded responding—can account for important behavioral, cognitive, and neural phenomena in a systematic way. Moreover, the findings we reviewed highlight the separate but interacting contributions of habit and goal processes in action control. Our integrative account offers predictive utility and avoids the nonfalsifiability of post hoc goal explanations.

Our analysis has implications for the research paradigms best suited to detect habits. Lab settings differ from everyday contexts in ways that often encourage goal-directed control over habit performance. For example, lab paradigms typically instruct participants to use one of a limited set of responses (e.g., left keypress or right keypress). Such designs contrast with the myriad actions possible at any given moment in daily life. Tellingly, in studies providing a free choice of food (rather than choice of one of two), participants' habits helped constrain the possible set to a small number of food choices (Morris et al., 2019). In addition, experiments often provide incentives and sufficient time for thoughtful responding while limiting distractions and multitasking (e.g., phones, music). As we showed in our review of time pressures, stress, and fatigue, these features likely promote goal pursuit over habit responding. Furthermore, experiments may fail to create strong habits because of practical limitations on the number of response repetitions.

Our point is not that habit researchers should abandon lab paradigms. Closely controlled settings can illuminate the mechanics of habit performance. Yet experimental lab research provides a specific lens on human psychology that highlights certain processes over others (see Bless & Burger, 2016; Yarkoni, 2019). In this vein, we encourage future researchers to be sensitive to the features that trigger and maintain habit performance that we identified in the present article. Thus, lab paradigms would best be structured with extensive repetition to build strong habits, recurring context cues to trigger them, and time pressures and distractions to derail goal pursuit. Also useful are measures, such as reaction time, that can track habit activation despite people's pursuit of goals (e.g., Luque et al., 2020).

Lab paradigms are best complemented by field and longitudinal methods to replicate real-world action control. To illustrate the payoff to a more naturalistic approach, we close with Rebar et al.'s (2014) elegant example of the interplay between exercise habits and goals in daily life: Over the course of 2 weeks, these researchers measured the strength of participants' exercise habits, daily intentions to exercise, and actual physical exercise (via an accelerometer). On days when intentions to exercise were strong, habit strength did not predict physical activity, providing evidence for goal-directed control. However, on days when intentions to exercise were weak, stronger exercise habits led to greater physical activity. This longitudinal exploration highlights the functional utility of habits in maintaining behavior stability over time as goals inevitably fluctuate. We hope that the present article will encourage researchers to explore these separate but intersecting influences of habits and goals on human behavior.

Transparency

Action Editor: Laura A. King
Editor: Laura A. King
Declaration of Conflicting Interests
The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Acknowledgments

We are grateful to Claire Gillian, Merel Kindt, Trevor Robbins, Sanne de Wit, and Poppy Watson for their insightful comments on an earlier version of this article and Jan De Houwer for graciously providing data from his research.

Notes

1. People also may form habit associations from repeated contiguity, or the simple co-occurrence, of contexts and responses (K. J. Miller et al., 2019).
2. Procedural memory underlies knowledge of how to perform a task. Although inaccessible to conscious introspection, it supports the expression of skills as well as the repetition of habits (Gupta & Cohen, 2002).
3. Note that, for clarity, we refer to such behaviors as goal aligned, instead of Moors and De Houwer's (2006) more ambiguous term, "goal directed." We thank an insightful reviewer for this suggestion.
4. Still other work differs from our central model by equating habit with automaticity in general, thereby overlooking its distinguishing features (e.g., Hommel, 2019). Also worth comment is research that locates habits in episodic retrieval of stimulus-response episodes, thereby conflating recency and frequency of responding (Giesen et al., 2020)—despite the fact that recency is held constant in most experiments that manipulate habit in terms of practice frequency.
5. The present analysis collapsed across the two nonhabit item types (congruent and biconditional). When analyzed separately, congruent items differed most from incongruent (habit) items; biconditional items yielded results that fell between those from the other two types. Results were aggregated across all three studies to improve statistical power given the highly similar study designs. Power simulations for the single-study analyses using the *simr* package (Version 1.0.5; Green & MacLeod, 2016) suggested 68% power for an interaction with a t value of 4.1 (corresponding to a medium Cohen's d effect size of 0.30), compared with 99% power for the analyses aggregating across studies.

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