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Place in Habits and Habits in Place

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The concept of habit has had a controversial history in psychology, but support for a habit theory is plentiful in various areas of research, such as learning and environmental psychology, including embodied and dual-process theories of cognition. Further, recent advances in measurement have provided support for habit as an independent construct and enabled research into the contribution of habits to a wide variety of behaviors. As a framework to guide further advances, I propose a 3-part conceptualization based on recurring elements within the definitions of habit in previous research: Habits are patterns of responding characterized by repetition, automaticity, and psychological association. While previous research has focused heavily on repetition and automaticity, association has mostly been assumed rather than explored directly. I conducted 3 studies with the goal of demonstrating the presence of association in habit, testing association-based assumptions in previous habit research, and developing a tool for measuring the associative strength of a habit. This work may have useful implications for health behavior change—habits are likely to be key determinants of many health behaviors, and the hypothesized associative nature of habits may be a particularly effective target for novel intervention strategies.

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Place in Habits and Habits in Place

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Thank you to my advisor, Blair T Johnson,
who pulled me out of the frying pan and into the forge.

In addition, I owe *everything* to the lovely people in my life.
I am so grateful for everything you are and everything you do.

CHL
You built me
from nothing.

RNL
You made smooth
the path.

RJL
You walked
with me.

JJK
You held my hand
in the dark.

TLM
You were
the stars.

SDS
You are the child
of my heart.

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A Three-Component Framework for Habits

What Is a Habit?

Deriving an integrated definition. Habit researchers have used a variety of definitions of "habit" in recent years, and the patterns that emerge from shared elements offer insight into the theoretical nature of habits in two important ways (see Appendix A for an overview). First, the most overt goal of such definitions is delineating the characteristics of a habit—that is, describing what a habit would look like. Here, we base a conceptualization on a selection of themes that reappear with relative consistency across the literature. The first of these themes is *repetition*, which is thought to support the formation of a habit. The second is *association*, especially between a contextual cue and a response, and is thought to be learned from repetition. The third is *automaticity*, which is thought to result from the learning and subsequent activation of the cue/response association. Automaticity, in turn, is thought to increase further repetition. Together, these features—repetition, association, and automaticity—form the three central defining characteristics of a habit, and differentiate habits from other related constructs (see Figure 1).

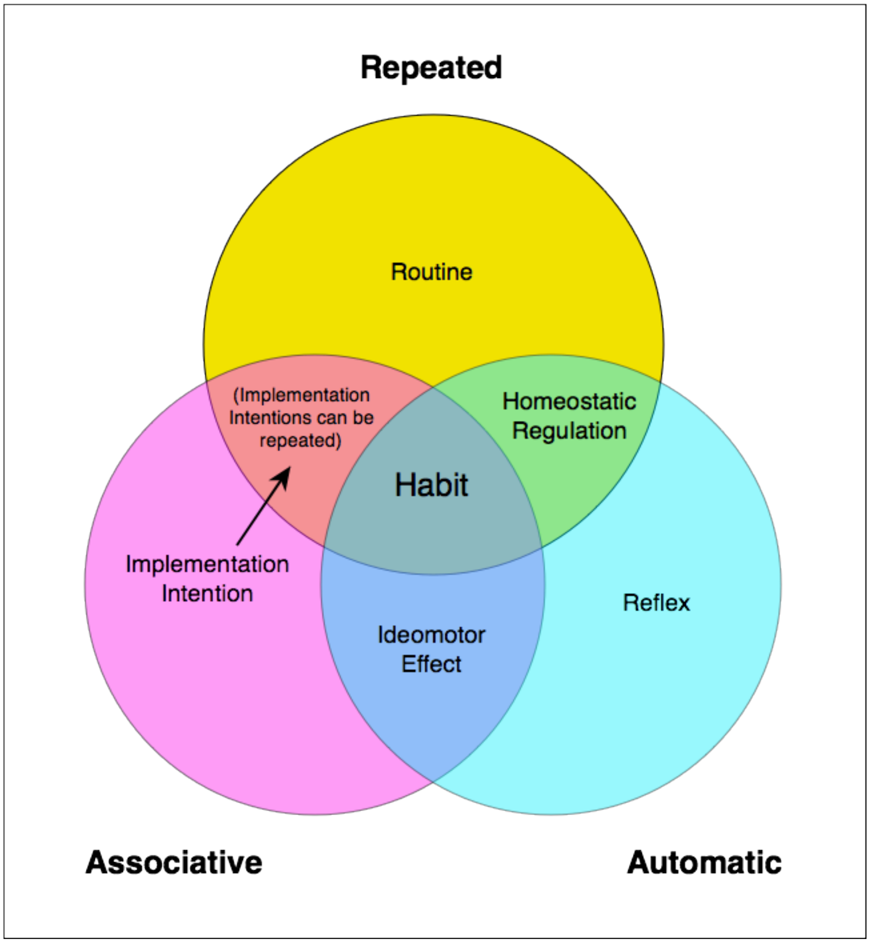


Figure 1. A 3-component definitional model of habits differentiates habits from similar and related constructs, such as routine and reflex.

The second goal of defining a habit is pinpointing exactly what it is that, when it possesses the above characteristics, may be labeled as a habit. That is, specifying exactly what the word "habit" refers to. Past definitions display variation on this issue as well, and appear to refer to a variety of concepts, including behavior, behavioral tendencies or dispositions, mental representations, and even automaticity itself. In the current view, the term "habit" is most

usefully applied to a *pattern of responding.*[1] We argue that "response" is a more appropriate term than "behavior," because (a) some habits are not behavioral, but rather cognitive or emotional (see below); and (b) it implies the presence of the eliciting cue. In addition, we argue that "pattern" is more appropriate than "response" alone, because (a) an isolated behavior, thought, or feeling does not constitute a habit; and (b) the term "pattern" implies the necessary feature of repetition over time.

Based on the synthesis of previous theoretical and empirical treatments of habits, we therefore suggest the following integrated definition: Habits are patterns of responding that are (a) repeated over time, (b) mediated by a learned psychological association, and (c) automatically activated.

Specifying component definitions. To best clarify the above conceptualization of habits, consider the following definitions of the terms that it constitutes. A **response** is any change in the cognitive or sensorimotor systems produced as a reaction to the perception of a cue. A response could take many different forms. Although empirical studies have focused on behavioral responding, a handful of studies have investigated cognitive responding (Verplanken, Friborg, Wang, Trafimow, & Woolf, 2007), and previous theorizing does make mention of "habits of thinking" (e.g., Lewin, 1943). Presumably affective responding falls within the domain of "habit" as well, though we are not yet aware of any relevant research.

A **cue** may be anything that can be perceived, including features of the physical or social environment, or even a person's own affects, cognitions, and behaviors. A given stimulus is defined as a cue by virtue of its ability to elicit a response. **Repetition** is expression of the response on multiple occasions. In colloquial use, the term "habit" is often used merely to

[1] Importantly, under this nomenclature, the term "habit" does not refer to a psychological construct or process, but rather an emergent phenomenon or set of outcomes that arise from the action and interaction of psychological constructs and processes (e.g., mental association, perception of a cue, behavioral schemata).

describe the things that a person does over and over. This view is reflected in a long history of research, wherein the construct of habit strength was operationalized as the frequency of a behavior's repetition (Ajzen, 2002). Including repetition as a definitional characteristic is, therefore, a matter of crucial face validity as well as discriminant validity. **Association** is a psychological connection between the cue and the response. This association is learned across repeated pairings of the cue and response. **Automaticity** is the production of the response as a reaction to the perception of the cue, without the need for conscious intent or awareness.

It may be important to note that this framework is distinct from, but compatible with, previous conceptualizations of habits that are structured around two "stages" of habits, acquisition and expression (see Table 1). These perspectives do not compete with each other, but rather serve different purposes. A stage-based model describes the life cycle of a habit, and a feature-based model forms a statement about what makes habits unique as a psychological phenomenon. Theoretically, the three defining characteristics that I propose play unique and crucial roles during both the acquisition and expression of habits. Further, the three proposed characteristics do not consolidate logically into two. Although they are related to each other and likely influence each other, I propose that they are separate from each other. Notably, in spite of the pervasiveness of the three components in contemporary definitions of habit, my efforts to date have not located any empirical evidence to substantiate that they are necessary and sufficient for the purpose of distinguishing habit from other related phenomena. This contradiction highlights the need for further work toward expanding knowledge of the associative nature of habits, as described in the research proposed below.

Nonetheless, this conclusion does derive some theoretical support from the apparent fact that it is possible for a phenomenon to possess any one or two of the characteristics without

possessing all three (see Figure 1). Reflexes such as withdrawing from pain are automatic (requiring no decision or intention), yet they are only infrequently engaged and do not appear to be mediated by psychological association (but rather nerve pathways in the spinal column). As Ajzen (2002) pointed out, certain actions may be performed so frequently as to be considered routine (e.g., a doctor deciding to send a patient into surgery), but they do not become automatic and are not triggered by psychological associations, and also are not considered to be habits. Experimentally induced "ideomotor" effects occur both automatically and as the result of psychological association, but they are not repeated in the course of normal life, and would not generally be considered to be habits.

Similarly, humans perform homeostatic regulation (e.g., maintenance of a stable body temperature) both automatically and repeatedly (e.g., circadian rhythms), yet there is no evidence that psychological association plays a necessary role in such processes, and being warm-blooded would not regularly be considered a matter of habit. Some interventions prompt participants to form implementation intentions by verbally pairing a healthy behavior (e.g., eating an apple) with an eliciting cue (returning home in the afternoon). Implementation intentions are thought to work by building psychological associations. Few would consider an implementation intention to constitute a habit if performed once during the intervention but never again afterward. Crucially, however, the end goal of interventions such as these is that the participant will articulate the implementation intention *repeatedly* (daily, or at each appropriate time interval), thereby causing the cue-response link to become *automatic*, and forming a full *habit* (Figure 1).

How Do Habits Relate to Other Constructs?

The history of habit research is rich with inquiries into the connections between habits and other factors that determine behavior. This abundance may be due to the striking ability of habits to defy intention. One very relatable example is meaning to take a new route on the drive to work, but inadvertently taking the old route without realizing (Fishbein & Ajzen, 1975). Research has proposed and explored multiple relationships between habits and other constructs.

First, habits can act as independent influences to behavior. One tradition in habit research is comparing the influence of habit on behavior to that of other behavioral precursors, such as the Theory of Planned Behavior's (TPB) constructs—intentions, attitudes, perceived social norm, and perceived behavioral control (Ajzen, 1991). Many researchers have attempted to improve on the TPB by adding constructs and links to account for influences such as habit (Haddock & Maio, 2004). An early attempt (Bentler & Speckart, 1979) used structural equation modeling to apply this inquiry to substance use on campus, and found that the inclusion of past behavior significantly improved the model's ability to predict future behavior. This same general finding has been replicated with a range of other behaviors, including condom use, class attendance, seatbelt use, and blood donation (Albarracín, Fishbein, Johnson, & Muellerleile, 2001; Jaccard & Blanton, 2005). The Model of Goal Directed Behavior (Perugini & Bagozzi, 2001) takes a similar approach by supplementing the TPB variables with automatic processes (i.e., habit), motivational processes, and affective processes. Such research is useful for demonstrating that central habit processes can have a direct effect on behavior that rivals that of other, well-supported sources of behavioral influence.

Secondly, habits moderate the effects of other behavioral precursors. In addition to exerting direct effects on behavior, research has demonstrated that habit-relevant constructs can

interact with other inputs to behavior. For instance, Eagly and Chaiken (1993) noted that in order for attitudes to affect behavior, they "must be coordinated with other psychological tendencies that regulate behavior. That is, the presence of a habit moderates the effect of persuasion on behavior. Consistent with this argument, a meta-analysis of intervention studies (Webb & Sheeran, 2006) found that changing intentions was significantly less effective at creating behavior change when the behavior in question was likely to be habitual—that is, performed frequently and in a stable context. As will be familiar to anyone who has ever tried dieting or giving up smoking, bad habits can be extremely hard to break.

Third, habits may affect other behavioral precursors directly, in addition to interacting with them. Due to processes such as self-observation and cognitive dissonance, repeatedly performing a behavior can affect the way that one perceives that behavior (Ouellette & Wood, 1998). This relationship is represented in theoretical models such as the Model of Goal Directed Behavior (Perugini & Bagozzi, 2001), in which past behavior—as a proxy for habit—exerts a direct effect on *intention* to complete a behavior. Bentler and Speckart's (1979) model specified the very same pathway, and received mixed support in empirical demonstration (Eagly & Chaiken, 1993). Similarly, a composite model of attitude-behavior relations (Eagly & Chaiken, 1993) specifies that past behavior has a direct effect on attitude, and an indirect effect on perceived self-identity outcomes, which relates to the extent thatevaluation of one's self will be affected by performing the behavior.

Fourth, other behavioral precursors can be involved in habits. In an experiment, habitual bicycle riders responded to the word "bicycle" faster after being primed with the goal of transportation to locations nearby (Aarts & Dijksterhuis, 2000). In that case, the sudden psychological salience of a goal served as a cue, eliciting the habitual response relevant to

reaching the goal. Various psychological precursors to behavior can also come into play as habitual responses themselves. For instance, Ajzen and Fishbein explained that, due to learned associations between an attitude and its object, the mere presence of the object can cue activation of the attitude and its attendant attitudinal beliefs (Ajzen & Fishbein, 2011).

Interestingly, Ajzen and Fishbein (2011) made this point in order to argue *against* the existence of habit. They point out that direct control of a stimulus over a behavior is not necessary to account for the ability of the former to elicit the latter—automatically accessed attitudes can explain this link as well. Nonetheless, the current model's inclusion of cognition (such as attitudes) in habitual responding would suggest that some form of habit is at work regardless of whether the habitual response takes the form of a behavior or an attitude. This conceptualization is relevant to theories in psychological research on stereotypes and prejudice, which involve the repeated, automatic activation of negative attitudes toward a social group due to a learned and practiced association between that group and some undesirable trait (Devine, 1989). In essence, we suggest that prejudice could be interpreted as a *habit* of negative thoughts and feelings toward another group and its members.

In sum, we propose a three-component framework: Habits are patterns of responding that are repeated, mediated by cue-response associations, and automatically activated. Though previous research has focused mainly on environmental stimuli as cues for behavioral responses, we posit that both cues and response can include any manner of perceptions, cognitions, affects, or behaviors. This conceptualization is useful because it helps integrate a complex and diverse body of research. Namely, it ties together research suggesting that habits (a) compete with other behavioral precursors, (b) moderate the effects of other precursors, (c) are shaped by other precursors, and (d) involve other precursors.

What is known about habits?

Repetition. Inquiry into the nature of habits dates at least as far back as Aristotle, who reportedly said, "We are what we repeatedly do." The history of habits in psychology stretches back over 120 years (James, 1890). Throughout the majority of this history, psychologists have conceptualized and measured habits in terms of the repetition of behavior. In particular, many studies used the frequency of past behavior as an indicator of habit strength, and there is consequently a rich body of literature demonstrating that repeated past behavior is among the best predictors of future behavior. Ouellette and Wood's (1998) meta-analysis revealed that, for behaviors performed daily or weekly in stable contexts, past behavior significantly predicted future behavior and even out-performed intention (βs = 0.45 and 0.27, respectively). The behaviors represented in their sample of studies included alcohol and coffee drinking, various exercises, seat belt usage, and classroom and church attendance.

Of course, conceptualizing habits as behavioral repetition *alone* presented a number of problems, not the least of which is its circular logic—if habits predict behavioral frequency and habits *are* behavioral frequency, then habits predict nothing more than themselves. In addition, not all frequent behaviors seem to form habits, and those that do seem to have an inconsistent relationship between frequency and future behavior (Verplanken, 2006). Moreover, a separate habits construct is not necessary to account for a relationship between past and future behavior. A variety of factors have been shown to influence behaviors (Ajzen, 1991), and to the extent that these remain stable it is reasonable to expect behavior to remain stable as well (Ajzen, 2002).

To address this concern, a body of research emerged with the apparent goal of demonstrating that past behavior predicted future behavior above and beyond any other

behavioral input. A particularly popular target has been the most proximal predictor of behavior as specified by the Theory of Planned Behavior: intention. Though some studies were indeed able to identify instances in which behavioral frequency outperformed intention (Ouellette & Wood, 1998), the body of evidence as a whole is somewhat mixed (Ajzen, 2002).

In addition, the meaning of a correlation between past behavior and future behavior is conceptually unclear, even when it is stronger than the correlation between intention and future behavior. Due to what is now known as the Principle of Compatibility (also called Principle of Correspondence), behavioral predictors are most effective when they match the behavior measured with regards to specificity in four areas (Fishbein & Ajzen, 1975), which they refer to collectively as TACT: (a) **target**—the entity toward which the behavior is directed, (b) **action**—the behavior itself, (c) **context**—environment in which the behavior is performed, and (d) **time**—the occasion on which the behavior is performed. For instance, the frequency of washing one's car is better predicted from attitudes toward washing one's car than from attitudes toward cleaning in general. Likewise, the consistency of washing one's car each Sunday is better predicted from attitudes toward washing one's car on Sunday than from attitudes toward washing one's car in general.

This is an important consideration when interpreting correlations between past and future behavior because, within a given study, measures of these behaviors are typically the exact same measure (e.g., "how often did you complete behavior X in the past 2 weeks?") administered at different time points. Past and future behaviors are therefore inherently and completely compatible with each other in terms of TACT specification. By comparison, measures of other predictors do not tend to be as compatible with the focal behavior in terms of TACT specification. Therefore it is difficult to conclude that the tendency of past behavior to predict

future behavior above and beyond other constructs is attributable to the operation of habit, and not merely the result of superior TACT compatibility and shared method variance (Ajzen, 2002).

Perhaps even more concerning to proponents of habit research, betting the construct validity of habits on their ability to outperform intentions is unwise and could ultimately limit their use and development in research. Cognitive dissonance theory (Festinger & Carlsmith, 1959) and self-perception theory (Bem, 1967) would both predict that people's self-reported intentions change to fit their behaviors. Indeed, at least one study found that habit strength predicted intentions better than did attitudes (Honkanen, Olsen, & Verplanken, 2005). A fixation on outperforming intention thus risks under-detecting the importance of habits because circumstances may render intentions a misleading point of comparison.

In addition, overruling intention is not a defining feature of the habit construct, but rather a convenient way of detecting their presence upon expression. Consider *good* habits, for instance. Habits can form as the result of the intention to perform a particular behavior regularly (Wood & Neal, 2007), and in such instances there is every reason to expect that intentions would continue to predict behaviors—people intend to carry out their good habits. In fact, in the case of the ultimate good habit—one that is performed with perfect adherence—both habit and intention would predict behavioral performance fully. Requiring habits to outperform intention thus may have the ironic effect of preventing the study of good habits! What is needed, then, is not to prove that behavioral frequency is a better predictor than any other psychological construct, but rather a way to measure habit strength independently from behavioral frequency (Ajzen, 2002; Verplanken, 2006).

Table 1: Tracking the roots of habits in extant theories.

Association		
Theory	*Specification*	*Application to habit theory*
Embodied Theories of Cognition (Barsalou & Niedenthal, 2005)	Knowledge is formed as features from similar experiences are combined and associated	Habits are learned from experiencing the cue and response together.
Theory of Learning (Thorndike, 1901)	The learning of an association is incremental	Habits are learned over time, through repetition of the cue-response pairing
	The strength of the association changes as a function of the frequency of its use (and disuse).	Frequent responses are most likely to become habits, and make for the strongest habits.
	Responses learned in one context can be transferred to a different context. This is facilitated by similarity between the two contexts.	Habits are context dependent, but a habitual response can be elicited in a different context, especially if it is a similar one.
Operant Conditioning (Skinner, 1938)	Rewarding a response increases its frequency	Rewarding a response helps form or strengthen the habit
	Punishing a response decreases its frequency	Punishing a response can weaken or prevent the formation of habit
Ecological Theory (Gibson, 2000)	People are attuned to opportunities for action that the environment affords.	Stimuli and features present in the environment can act as cues for habitual responses.
Core Configurations Model (Caporael, 1997)	Human cognitive systems are specially adapted to facilitate social coordination	People and social interactions can act as cues for habitual responses

Automaticity		
Theory	*Specification*	*Application to habit theory*
Ideomotor Effect (Bargh & Chartrand, 1999)	In the case of strong mental associations, perceptions of a cue can lead directly to behavioral responses without conscious awareness or intent	Habitual responding is automatic. Activation of the cue-response association leads directly to the production of the response.
Impulsive and Reflective Systems Model (Strack & Deutsch, 2004)	The processing and output of the reflective system relies upon mechanisms of the impulsive system.	Habits can overpower conscious intentions.
	Impulsive processing is constantly engaged, whereas reflective processing fails when there is insufficient cognitive capacity available.	Habits are more likely to be expressed under cognitive load, distraction, or exhaustion.
Ironic Processes of Mental Control (Wegner, 1994)	Suppressing a thought requires keeping it cognitively activated	The cognitive availability of a habitual response cannot be decreased through direct intentional suppression

Automaticity. Thankfully, another defining feature of habits, automaticity, has provided the basis for inroads toward measuring habit strength independently from behavioral frequency. Theoretically, habits derive their power over behavior from automaticity. To illustrate, consider the premises of the various theories that focus on a divide between conscious and unconscious or automatic cognitive processes, loosely united under the rubric of "dual-process" theories (Smith & DeCoster, 2000). A prominent recent example is Strack and Deutsch's (2004) model of impulsive system and reflective systems[2]. Cognition in the impulsive system is automatic and preconscious, and is mediated by a network of associative links. Here, behavior is produced when the activation of a concept spreads through the network to a behavioral schema. Cognition in the reflective system is optional and usually conscious, and relies on a system of rules and evaluations of consistency and veridicality. Here, behavior is produced once a behavioral decision is reached, and the corresponding behavioral schemas are activated.

Consistent with other major models of cognitive automaticity (Anderson, 1996), the model specifies that the impulsive system is constantly engaged. The reflective system, by comparison, is often disengaged. Its operation requires high cognitive capacity and fails when available capacity is insufficient. It is therefore vulnerable to interference from distraction, exhaustion, and very high and low levels of arousal. This feature of the two-system model and other dual-process models accounts for the powerful effect of habits, as patterns of automatic behavior. One reason for this phenomenon is that the operation of conscious processes *relies on* automatic processes. Strack and Deutsch's two-system model illustrates this idea: The reflective system retrieves concepts from the impulsive system and creates semantic meaning by imposing a relational schema (specifying how the concepts fit together) to create *propositions*, assigning a

[2] Strack and Deutsch prefer the term "two process," which emphasizes the concurrent operation of both systems, in place of "dual process."

truth value (specifying how true the resulting proposition is) to create *semantic and episodic knowledge*, and applying syllogistic rules (e.g. if A=B and B=C, A=C) to make *inferences*.

In addition, the crucial last link in the reflective system's output, the behavioral schema, resides within the impulsive system. Stated simply, the reflective system is capable of making its own conclusions, but it is not capable of reaching these conclusions or of acting on them without the help of the impulsive system. Therefore, when intention and automatic tendency are at odds, as in the case of a bad habit that one is trying to break, there are many advantages that the automatic processes of cognition can claim. Most vitally, in the above model, interfering with the function of the automatic systems also disrupts the conscious systems. This effect is apparent in the embodied cognition literature mentioned in the previous section. For instance, blocking the automatic facial movements that are involved in cognitive processing of emotion words reduces the accuracy of judgments regarding the meaning of the word (Niedenthal, Winkielman, Mondillon, & Vermuelen, 2009). Consequently, efforts by the conscious system to directly change the course of the automatic system are often futile at best, and counterproductive at worst.

Wegner's research on the so-called *white bear effect* further illustrates this phenomenon. In a series of studies, participants who were instructed not to think about a white bear predominantly reported becoming increasingly preoccupied with the unwanted mental image, and success in banishing it by distraction was short-lived (Wegner, 1989, 1992). Wegner (1994) invoked a dual-process model to explain this effect, and hypothesized that the conscious (or "operating") system that is responsible for intending to avoid the thought cannot do so without the help of the automatic (or "monitoring") system that checks new thoughts for the presence of the unwanted one. To perform this task, however, the automatic system must keep the unwanted

thought active so that it may act as a standard of comparison, thus ironically increasing its availability to the conscious system. Similar ironic effects have been found in research on conscious attempts to control other states that are largely regulated by automatic processes, such as concentration, mood, relaxation, pain, belief, prejudice, and even movement (Wegner, 1994). Accounts such as these highlight the profound influence over behavior that a habit gains from its automaticity. A habit, once formed, can either be a mighty ally, ready to step in during times of need, or a nefarious saboteur, unblinking and spiteful.

Given that automaticity seems to be the source of a habit's power, it is sensible to measure habit strength in terms of automaticity. To this end, Verplanken and Orbell (2003) developed the Self Report Habit Index (SRHI) is a generalized 12-item scale that asks participants to rate the frequency and automaticity of a behavior in terms of its ability to be performed without awareness, in parallel to other behaviors, and despite conscious self-control efforts (Appendix A). A sizeable body of evidence suggests that this measure performs quite well. Since its creation, the SRHI has been applied to a variety of behaviors, including a variety of health behavior domains, and accounts for the most convincing evidence to date of the influence of habits in health behaviors.

Researchers have gravitated toward this measure in part due to its sound theoretical basis. That is, in addition to capturing a construct that is independent from behavioral frequency, the measure appears to do just what we would expect a good measure of habit strength to do (Verplanken & Orbell, 2003)—it predicts future behavior (Study 1), correlates with other measures of habit strength such as response frequency (Study 2), and distinguishes between behaviors with different frequencies (Studies 3 and 4). In addition, it has been used to differentiate between frequency and habit strength by showing how a frequently-performed but

novel behavior increases in habit strength over time (Lally, Van Jaarsveld, Potts, & Wardle, 2010).

There may still be room for improvement in the measurement and application of the habits construct, however, as the SRHI has yielded mixed findings in the small number of intervention studies that have employed it. One intervention improved the exercise frequency of the children in the intervention group (relative to that of the control group), but this effect was not mediated by a change in habit strength as measured by the SRHI (Jurg, Kremers, Candel, Van Der Wal, & Meij, 2006). Similarly, an intervention to promote oral hygiene at school managed to increase tooth brushing without any apparent impact on SRHI habit strength (Wind, Kremers, Thijs, & Brug, 2005).

Whereas this inconsistency may simply be the result of the unpredictable nature of the time needed for habit formation (Lally, et al., 2010), it does introduce the concern that the SRHI might not always be able to detect changes in habit strength. A reconsideration of the assumptions of the measure suggests why this might be. First, the prospect of asking participants to perform a self-report of the automaticity of their behaviors is a curious notion. Even aside from the self-presentation and social desirability biases that tend to plague self-report measures in general (Paulhus, 1984), there people have limited ability to identify influences on their behavior (Nisbett & Wilson, 1977; Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008). Automatic influences may be especially difficult to detect, given that one of the hallmarks of the automaticity of a behavior is that its performance does not require conscious awareness (Verplanken & Orbell, 2003).

In addition, the singular focus of the SRHI on automaticity may be problematic. Theoretically speaking, automaticity is not equivalent to habit strength, but rather is a

consequence of a high degree of habit strength. To illustrate the importance of this point, consider the example of two familiar behaviors: breathing and blinking. They are extremely frequent and extremely automatic, yet it seems somewhat inappropriate to label them as habits. For one, there seems to be no reasonable alternatives to performing these behaviors. But moreover, they appear to operate without the need for a central feature of the habits construct: a mental association with an environmental cue. The fact that these behaviors meet the criteria for habits set by the SRHI highlights the problem with neglecting the cue-behavior association.

Association. Currently, there is almost no existing empirical research that investigates the role of association in habit formation and expression. Since repetition (behavioral frequency) and automaticity (SRHI) are already well studied with regard to habits, I suggest that efforts to expand habit theory and research should focus next on association. To illustrate the importance of association, I will draw on work from other fields, in which its role is highlighted (see Table 1 for an overview).

One field that is particularly well known and particularly useful in this endeavor is animal learning. Pavlov famously demonstrated that after repeated exposure to the sound of a bell followed by the presentation of food, a dog's natural salivation in response to receiving food could be elicited upon merely hearing the bell. Pavlov's early explanation centered on reflexes, and viewed the phenomenon in terms of shifting control between separate cues (Rescorla, 1988). In his terms, the control of an unconditioned stimulus (a naturally occurring cue, e.g., food) over a given unconditioned response (e.g., salivation) could shift to a conditioned stimulus (the experimentally imposed cue, e.g., a bell) given sufficient repetition of a pairing between the conditioned and unconditioned stimulus. Eventually, the presentation of the conditioned alone stimulus would elicit the unconditioned response, which would have thus transformed into the

conditioned response. Later explanations focused on associations, however, and viewed the phenomenon in terms of learning about relationships that exist between events in the environment (Rescorla, 1988).

Edward L. Thorndike, another central figure in psychological research on learning, developed the paradigm of the “puzzle box,” wherein animals trapped inside boxes gained freedom upon the completion of a specific behavior or set of behaviors, such as stepping on a lever (Thorndike, 2009). At first the criterion behavior occurred only at random, and typically only after a period of instinctual and ineffective behaviors (e.g., scratching at the door). With repetition, however, the animals would achieve freedom more and more quickly. Based on these findings, Thorndike developed the *law of effect*, which states that behaviors leading to a satisfactory outcome will be more likely to occur again in the given situation, and behaviors leading to an unpleasant outcome will be less likely to occur again in the given situation. Like Pavlov, Thorndike was able to shape animals’ behavior by imposing an association. Whereas Pavlov’s created associations between cues, Thorndike’s associations were between behaviors and outcomes. Using this paradigm, Thorndike was able to gain important insights into patterns of learning over time, and he developed these into a formal theory of learning. Several of this theory’s key propositions are important for habit theorizing.

Skinner expanded on the view of associative learning in his theory of operant conditioning (Skinner, 1938). In accordance with the law of effect, Skinner showed that animals tend to increase the frequency of behaviors that are followed by a reward, and decrease the frequency of behaviors that are followed by punishment. Further, by rewarding particular behaviors after the presentation of a cue, Skinner was able to condition animals to repeat certain behaviors, such as stepping on a lever; to modify the characteristics of behaviors, such as the

force or duration of stepping on the lever; and even to perform behaviors that would never occur spontaneously under natural circumstances, such as rolling a tiny bowling ball (Skinner, 1938, 1958). Skinner and colleagues were thoroughly able to control and shape animal behavior merely by constructing and altering associations between behaviors and reinforcements. Findings such as these demonstrate the power of associations as determinants of behavior.

Note that the work of Pavlov, Thorndike, and Skinner stemmed from the behaviorist tradition. As such it focused on observable behaviors and tended to avoid assuming the presence or action of any internal processes—the "association" existed as a feature of the environment engineered by the experimenters, and "learning" existed in changes in behavior. Later, theories belonging to a cognitive tradition returned to associations and learning, and located these ideas at the center of human thinking.

For instance, one recurring feature of traditional cognitive theories is a "semantic network," whereby concepts or "nodes," are connected through associative links, and activation of one node spreads to connected notes as a function of the strength of connection (Smith & Semin, 2004). Systems such as these can theoretically account for both abstract, higher cognition and automatic responding. Notably, the perception of an environmental cue can automatically produce or alter a behavior with which it is mentally associated. In research on the *ideomotor effect*, for instance, Bargh and colleagues (Bargh, Chen, & Burrows, 1996) reported that participants who were primed with words such as "grey," "Florida," and "bingo" walked more slowly to the elevator after ostensible conclusion of the experiment. They concluded that activating stereotypes about old people automatically shaped behavior so as to conform with associated stereotypes (i.e., "old people walk slow"). The automatic, associative responding that appears in traditional cognitive theories and research is the same that forms the basis for habits.

Alternative perspectives such as ecological and embodied theories of cognition have challenged many facets of traditional cognitive theories, including the existence of semantic networks, but retain an emphasis on associations and account for habits quite well. In particular, embodied theories such as the Perceptual Symbols System (Barsalou, 1999) and Grounded Cognition (Barsalou, 2008) cast perceptual and cognitive associations in a starring role.

This emphasis on association is evident in the embodied account of memory, thinking, and learning (Barsalou, 1999, 2008; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Niedenthal, et al., 2009). Acting and interacting with the world creates patterns of neural activity within the brain's perceptual and sensorimotor systems, or **modal systems**. These patterns are captured by **conjunctive neurons**, which combine inputs from multiple sources, and which exist in a hierarchical organization within brain regions known as **convergence zones**. Neural activation in this system is bi-directional, and the activation of a particular conjunctive neuron re-activates, the pattern of neurons in the modal systems. Due to the hierarchical structure, a relatively small number of conjunctive neurons can simulate a nearly infinite potential array of patterns. This reactivation, called **simulation**, forms the basis for all forms of cognition, including remembering, introspecting, considering ideas, and formulating action.

The same hierarchical structure accounts for learning, or the formation of knowledge. Encountering similar experiences over time activates similar (and overlapping) populations of conjunctive neurons, and these patterns are in turn captured by conjunctive neurons further up in the hierarchy. Information from the modal systems can therefore be integrated across multiple instances of encountering the same or similar experiences. For instance, for very young children, hearing and saying the word "dog" ties together multiple experiences of perceiving furriness, wagging tails, and excited licking. This process can lead to error in identifying an animal until a

child's experiences are rich enough to allow him or her to distinguish such a creature from the one that has been called "cat." Embodied theories of cognition thus give association a highly central role in the processes that are fundamental to human functioning: association is responsible (a) for the formation of knowledge, which is the currency of cognition, and (b) for simulation, the mode of action by which all cognition occurs.

In addition to highlighting the role of associations in cognition, ecological and embodied theories account for habits in an overt emphasis on the environmental context. A central feature in ecological theories of cognition, for instance, is a focus on affordances—opportunities for action that the physical or social environment offers to a person (Gibson, 1979). People perceive particular opportunities as a result of certain characteristics, called *attunements*, including their personal histories, psychological and emotional states, goals and motivations, and so on (Gibson, 1979).

Attunements are also the result of human evolution. The theory of Socially Situated Cognition (Smith & Semin, 2004) posits that (a) cognition is for action, and (b) cognition is situated. That is, cognition evolved to guide organisms' behavior in a way that is adaptive, contributing to its reproductive fitness. Because action necessarily takes place within and with regard to an environment, adaptive action must take the environment into account, and a system for guiding adaptive action (cognition) must therefore attend closely to the environment. This principle is illustrated in the ability of environmental factors to influence cognition. For instance, people define themselves in terms of their characteristics that are distinct in a given environment (McGuire & McGuire, 1986)—for instance, a Black woman might see herself as Black when surrounded by White women, and see herself as a woman when surrounded by Black men. Self-

perception, a fundamental feature of human cognition (Turner, Oakes, Haslam, & McGarty, 1994), operates with respect to a frame of reference that is defined by the environment.

The environment can also heavily influence the cognition responsible for the production of spontaneous behavior. For instance, studies on the *chameleon effect* (Chartrand & Bargh, 1999) have demonstrated that people unconsciously change their nonverbal communication behaviors to mimic those of interaction partners. In sum, theoretical and empirical research from an ecological perspective stresses the idea that cognitive mechanisms have evolved to be sensitive to the environment.

From an ecological perspective, not only does cognition change with respect to the environment, but also it relies upon and even includes the environment. The theory of Socially Situated Cognition (Smith & Semin, 2004) also holds that that cognition is distributed—it is can be offloaded onto physical objects and shared between people. For instance, a human can use a calculator to perform part of the cognition necessary for a difficult math problem. Likewise, the cognition necessary to operate a large ship is too much for any one person to perform, and must therefore be divided between the crew members, each of whom performs a different task (Smith & Semin, 2004). In turn, joint action such as this requires further distributed cognition, such as using language, devising a system for dividing and coordinating tasks, and reaching a shared perception of reality (Caporael, 1997). In sum, ecological theories of cognition (a) stress that cognitive mechanisms are designed specifically to attend to the environment, and (b) include the environment as an active participant in cognition. In sum, the ecological perspective is useful for habit theory in that it supports a strong focus on the environment as both a determinant of the course of thought and action and a constituent of the processes for thinking and acting.

Synthesis

To review, habit-relevant concepts permeate many different areas of inquiry throughout the history of psychology. Though direct research on habits has had a contentious record, recently there has been considerable progress toward a distinct identity for the habit construct. In particular, many studies have elaborated the role of repetition and automaticity in habits. There seems to be a consensus that psychological association with contextual features plays an important role in habit processes, but there remains a lack of attention to defining what the important context is (and to see whether elements of context matter), and how associations translate the perception of contextual cues into habitual action.

The Need for Further Habit Research

Why Are Habits Important? Habits can be powerful determinants of health behaviors. There is plentiful evidence that habits are an important determinant of behavior in general. First, habits seem to influence a large number of different behaviors. For example, a daily diary study of college students (Wood, Quinn, & Kashy, 2002) found evidence for habitual behavior in every facet of life investigated, including work for school and employment, entertainment and leisure, social interaction, eating and drinking, hygiene, transportation, sleeping, exercise, and cleaning. Not only did habits appear to play a role in a large variety of behaviors, but also a large proportion of all behaviors performed. The researchers reported that nearly half of all of participants' actions were performed frequently, in a stable context, without thought, and noted that this result was likely an underestimation of the prevalence of habitual behavior in daily life. Indeed, by some estimates 95% of all behaviors are performed in a non-deliberative, thoughtless manner (Bargh & Chartrand, 1999). Thus, to the degree that habits can be identified as behaviors that are frequent (Ouellette & Wood, 1998), performed in stable contexts (Webb & Sheeran,

2003), and are somewhat automatic (Verplanken & Orbell, 2003), evidence suggests that the influence of habits is far reaching.

Perhaps even more convincingly, habits can produce behavior that is directly contrary to intentions. This effect often appears when people first acquire the intention to change an oft-repeated behavior. A study of social smokers, for instance, revealed that for pub-goers, a strong habit of smoking in a pub preceded inadvertently lighting up in a pub even after newly-enacted laws banned smoking in pubs (Orbell & Verplanken, 2010). Similarly, participants with strong habitual tendencies to purchase fast food and watch television were unable to discontinue these behaviors in spite of possessing strong intentions to do so (Ji & Wood, 2007). These effects are by no means isolated—a meta-analysis of intention-behavior relations found that a change in intentions was insufficient to produce changes in behaviors that are frequent and occur in a stable context (Webb & Sheeran, 2006). Apparently, even wanting and meaning to behave in a particular way is insufficient when habits are well formed.

Habits Are Under-Used in Health Research. In spite of the evidence suggesting that habits play an important role in many health behaviors, the concept of the "habit" remains severely under-used in health behavior change research. To illustrate this, consider the health behavior of adherence to HIV medication. It is (ideally) performed frequently and in a stable context, and therefore is likely subject to the influence of habit. It is also important not only for optimizing patient outcomes, but also for preventing the development of drug-resistant strains (Chesney, Ickovics, Hecht, Sikipa, & Rabkin, 1999) and for reducing the transmission of the virus (Metzger, Woody, & O'Brien, 2010). A search through the most highly cited scholarly reviews of HIV adherence research reveals that, in spite of their apparent power as a determinant of behavior, habits are almost entirely absent in the literature. For example, although Bangsberg

(2008) notes that, “the best predictor of future adherence is past adherence,” he makes no mention of habits or any related constructs (cues, automaticity, etc.). Likewise, Rueda and colleagues (2006) point out that cues for remembering are important for adherence but do not mention habits at all. A review by Simoni and colleagues (Simoni, Pearson, Pantalone, Marks, & Crepaz, 2006) provides one mention of habits, and another by Haynes and colleagues (Haynes, Ackloo, Sahota, McDonald, & Yao, 2008) provides two.

A handful of studies do appear to offer a treatment of habits that is congruent with psychological theorizing. For example, one correlational study found that good adherence is positively associated with strong routines for socialization, sleeping, eating breakfast, having meetings to attend, and having a favorite television show to watch every day (Wagner & Ryan, 2004). This finding is consistent with the habit hypothesis that habitual behaviors are best learned when repeated in a stable context.

Two successful interventions (Haynes et al., 2008; Peterson, McLean, & Millingen, 1984) include the technique of structuring the patient’s pill-taking regimen around his or her daily habits. This strategy aligns with the notion that habitual behaviors are best learned in a stable environment. Another successful intervention reports that one of its goals was to encourage the acquisition of habits and the development of automaticity (Tuldrá et al., 2000). This goal seems to derive naturally from the hypothesis that habits, as automatic behaviors, are mentally efficient (Verplanken & Orbell, 2003) and thus less vulnerable than nonhabitual behaviors to disruption from competing life demands. This prediction was also supported by a study that found that the automaticity of self-administering asthma medication predicted adherence at follow-up (Bolman, Arwert, & Völlink, 2010)

Although these studies demonstrate the utility of the habit construct and provide preliminary support for the importance of habits in medication adherence, the body of evidence along this line is still in its early stages. For example, the two studies that provide the most thorough discussion of the habit construct are limited by their correlational designs (Bolman, et al., 2010; Wagner & Ryan, 2004). The three studies that do use a manipulation do not provide the details of the manipulation, do not discuss or even mention habits as a theoretical construct, and obscure the contribution of the habit-based component by including other intervention strategies (Haynes, Sackett, & Gibson, 1976; Peterson, et al., 1984; Tuldrá, et al., 2000).

The field of HIV adherence intervention could indeed benefit from an increased focus on habits as a psychological construct. Reviews of the efficacy of adherence interventions suggest that even the best interventions do not work nearly as well as we would like them to (Haynes, et al., 2008). One important contribution of the habits construct may be to help explain why this is so. While interventions based on traditional models of behavior and behavior change—such as the Theory of Planned Behavior (Ajzen, 1991), the Transtheoretical Model (Prochaska & Velicer, 1997), and the Information, Motivation, Behavioral Skills model (Fisher & Fisher, 1992)—tend to focus on convincing and motivating people to change their behaviors, there is evidence that this is not always the best approach. As mentioned before, a review by Webb and Sheeran (2006) of behavior change interventions suggested that habitual behaviors are not subject to an individual's deliberate attempt to change, regardless of how convinced or motivated he or she is.

The Present Research

Target Behaviors

Flossing, is an ideal choice for studying habits. Dental professionals recommend it for all people (Lindhe, Lang, & Karring, 2009), barring rare contraindications, which allows for the sampling of a very large population. Previous research has demonstrated that flossing is subject to the influence of habit, but there is still a great degree of variance in the degree to which people adhere to the recommended daily regimen (Judah et al., 2012; Orbell & Verplanken, 2010). Consequently, we expect that our participants will indeed have flossing habits that we may attempt to analyze and predict, but that there will not be a ceiling or floor effect in terms of habit strength and behavioral frequency. In addition, flossing offers important health benefits. Previous research indicates that flossing helps prevent gum disease (Sjogren, Lundberg, Birkhed, Dudgeon, & Johnson, 2004) and even provides some degree of protection against cardiovascular disease (Wu et al., 2000). The first two studies, therefore, focus on flossing as a target behavior. The third study, because it is a meta-analysis, includes all behaviors that have been studied in the habit literature in terms of self-reported automaticity.

Study Overview

Study 1 is an experiment designed to test the mental habit association in the context of flossing. As part of a word-completion task, I primed participants with a randomly assigned number of cues that reflect the typical flossing environment, and assessed whether this caused them to complete an ambiguous word stem as “floss.” The study also assessed participants’ flossing habits in terms of how frequently they floss, how automatically they floss, how consistently they floss in the same environment, and how good and bad it feels when they floss.

Study 2 is a test of a new measure of habit strength. I used the Implicit Association Test to measure the degree to which participants associate flossing with the features of the environment in which they floss. I created a new version of the IAT specifically for habit strength, which requires participants to customize the task by selecting the cues that are relevant to the context of their particular habit. This study also included measures of flossing frequency and automaticity.

Study 3 is a meta-analysis of the habit literature across multiple behaviors. I compiled data on the habit-behavior relationship from all studies that reported both habit strength (as measured in terms of behavioral automaticity) and behavior (as measured in terms of frequency, volume, or similar). I also conducted my own survey, wherein participants rated the various behaviors from the meta-analysis in terms of the consistency of the context in which they do them, the good and bad feelings that accompany their performance, and the frequency of their performance. Using meta-analytic regression, I explored how these variables, along with the characteristics of the samples in my meta-analysis, predicted the strength of the relationship between habit and behavior.

Research Goals

1. Searching for the mental association in habit. Thus far, in the course of conducting the above meta-analysis, I have uncovered no primary empirical evidence that mental associations underlie habits. Consequently, an intriguing question arises: Can we detect the presence of habits through mere mental associations? The first step, in Study 1, is a proof of concept to demonstrate that a mental association does indeed accompany a habit (even if it is not necessarily responsible for causing the habitual behavior). The second step, in Study 2, is to attempt to directly measure this association. If successful, the fulfillment of these steps would

provide both a validation of a key assumption of habit theory, and a useful measure of habit strength for future research.

2. Expanding the repertoire of habit constructs. Habit research from classic psychology measured habit primarily in terms of frequency. Recently, the habit literature has grown rapidly due to the introduction of the Self Report Habit Index (Verplanken & Orbell, 2003), which provided researchers a standardized and easily adaptable tool for measuring habit in terms of behavioral automaticity. Consequently, frequency and behavioral automaticity—two constructs that are central to habit theory—have been very well demonstrated in the empirical literature. Other constructs, though implied or even specified in common theorizing on habits, have received far less attention. Among these is the stability of the context in which the behavior is performed. During habit formation, a stable context is thought to facilitate the learning of the cue-behavior association. Once the habit is formed, consistently encountering the context that contains the key habit cues is thought to lead to consistent performance of the habitual behavior. So far, however, previous research has largely ignored the context of the behavior altogether.

As part of my research goals, therefore, I aim to evaluate the hypothesis of **contextual stability** as a test of the predictions of habit theory and as an effort to provide new tools for future habit research. In Study 1, I will employ a new measure designed to capture the stability of the context in which participants floss. I expect to find more stable flossing contexts will accompany stronger flossing habits. In Study 3, I will adapt this measure for the behaviors that appear most frequently in my meta-analysis. I expect to find that behaviors with higher contextual stability will tend to have high effect sizes for the habit-behavior relationship.

A second habit theory construct that has seen little use is the effect of a behavior's intrinsic rewards and punishments. In the classic associative learning literature, reinforcement is

used to shape behavior by rewarding some responses and punishing others. Among adult humans, most behaviors that we study as habits are not typically subject to this manner of instant, externally imposed reinforcement. Nonetheless, habit theory would predict that such behaviors are still shaped by the same processes: Outcomes that feel good tend to increase the associated response, and outcomes that feel bad tend to decrease it. Rather than being rewarded or punished (in the most immediate sense), we tend to simply experience behaviors as being rewarding or punishing. One might interpret this as a process of natural reinforcement. This may be an important consideration for the application of habit theory. Behaviors that are pleasant or that bring a person good feeling are likely to form into habits very easily, and these habits are likely to be hard to break. Behaviors that are naturally unpleasant may take much more deliberate effort to form into habits, and more care must be taken to maintain the habit.

As part of my research goals, therefore, I attempt to measure and explore this **natural reinforcement**. In Study 1, I introduce a new measure of natural reinforcement in flossing and test its relationship to flossing habit strength. Based on the predictions of habit theory, I hypothesize that more positive levels of natural reinforcement will predict high habit strength. In Study 3, I assess the natural reinforcement of the various behaviors in my meta-analysis. Here, I hypothesize that more positive levels of natural reinforcement will predict a larger habit-behavior relationship effect size. In both studies, I expect natural reinforcement to interact with contextual stability in the production and expression of habit.

3. Testing person-level variables: age and gender. Habits are often highly personalized. Even though people have habits for the many of the same behaviors, the details of each person's habit is particular to the life from which it arises, and of which it is a part. The cues that are relevant to each person's habit are those that are found in his or her immediate

environment. The associations that drive each person's habit are those that formed over the course of his or her unique experiences. Although as social psychologists, we often set out to understand how phenomena operate in a way that is true of all people, the ability to make sense of idiosyncratic behavioral processes is of great use to us as health psychologists in tailoring and targeting interventions. For example, we would never give the same nutrition and exercise intervention to a class of 5th grade girls and to a cohort of retired veterans at the VFW.

Habit studies tend to report basic demographic variables such as gender and age, yet rarely include them in their analyses or examine their roles as meaningful habit constructs. My research goals include an effort to change (or at least to oppose), this trend. In Study 1, 2, and 3, I will include age and gender in my measurements and analyses. Previous research has suggested at least a tentative link between gender and habit-relevant aspects of personality—women have scored higher on certain sub-scales of conscientiousness, such as orderliness (Weisberg et al., 2011) and self-discipline (Costa et al., 2001), although they have not scored higher on conscientiousness overall. We therefore predict that women in my sample will report a higher flossing automaticity than men. In addition, we predict an interaction between age and gender such that gender differences in behavioral automaticity will decrease with age. Previous research has demonstrated an increase in conscientiousness among men over the lifespan, and a slight decrease among women (Weisberg et al., 2011). The hypothesized interaction could also result from a ceiling effect, whereby the men simply catch up to the women over time.

Study 1: Testing for the Cue-Behavior Association, Contextual Stability, and Natural Reinforcement

To date, the great bulk of empirical research on habits in health psychology has focused on two theoretical components: behavioral frequency and automaticity. We aim to gather evidence relating to a variety of other, relatively under-explored components, including cue-behavior association, contextual stability, and natural reinforcement. My first study examines these theoretical facets in the context of flossing. In addition to the standard measures of frequency and automaticity, we use a word completion task to prime contextual cues and test their association with flossing, and we employ new measures to assess contextual stability and natural reinforcement.

Hypotheses

Mental association. In support of the view of habits as cue-behavior associations, we predict an interaction such that the effect of the context-priming manipulation on the cognitive availability of flossing should be more pronounced among those who report greater flossing automaticity.

Contributors to automaticity. In support of the hypothesized roles of frequency, stability, and natural reinforcement, we predict that these three components will not only contribute directly to automaticity, but will demonstrate a nuanced 3-way interaction. The effect of frequency on automaticity should be greater in cases of higher contextual stability, yet this pattern should be less visible in cases of lower natural reinforcement due to the overpowering effect of a behavior's highly appetitive or highly aversive consequences.

Gender and age. In the interest of using this research to inform and tailor health behavior change efforts, we are also interested in the effects of demographic variables. As

detailed in the introduction, I expect to find a main effect of gender and age, as well as an interaction between the two.

Method

Participants. Participants entered the experiment by signing up for an activity called "Word Game and Short Survey" on www.mturk.com, a website that allows users to complete tasks in exchange for money. The sample of 227 included 110 men and 117 women, who ranged in age from 18 to 69 (*M*=34.93, *SD*=11.60), and was 80.62% Caucasian (*n*=183), 6.61% African-American or Black (*n*=15), 6.61% Hispanic of Latino (*n*=15), 7.05% Asian (*n*=16), 2.20% American Indian or Alaskan Native (*n*=5), 0.88% Native Hawaiian or Pacific Islander (*n*=2), and 0.44% "Other" (*n*=1).

Procedure. *Word Completion.* After reading an IRB info sheet and indicating consent, participants began the study, which consisted of an online questionnaire. The first activity was a word completion task, in which participants responded to a series of 10 word stems (e.g., "__ARAGE") by providing the missing first letter (e.g., "G") as quickly as possible. The first 5 stems gave participants a chance to familiarize themselves with the game, and had no possible solutions directly relating to flossing or bathrooms. Next, participants completed a series of 4 stems consisting of a mix of bathroom-specific fixtures (e.g., "__OILET") and general-household items (e.g., "__TOVE"). The particular number of bathroom-specific stems was randomly assigned from 0 to 4, and any remaining slots in the series contained general-household stems. Last, participants completed the stem, "__LOSS" which has the possible solutions of "FLOSS" or "GLOSS."

Frequency and location. Participants indicated the number of times that they floss over the course of an average week, as well as the proportion of times that they floss in the bathroom in particular.

Automaticity (SRHI). Participants completed a version of the Self Report Habit-Strength Index (Verplanken & Orbell, 2003), in which they used a slider bar to rate their agreement with 12 statements such as, "Flossing is something I do without having to consciously remember" on a continuous scale from 0 to 100 (see Appendix B for full measure).

TACT Stability. Participants rated the consistency with which they tend to floss (a) at the same times of day, (b) on the same days of the week, (c) for the same amounts of time, (d) in the same particular manner, (e) in the same locations, (f) with the same people (who are also doing the behavior), (g) around the same people (who are not doing the behavior), and (h) using the same objects or items. We selected these questions in order to reflect Ajzen's set of facets that comprise a fully specified behavior: time, action, context, and target (TACT). Responses were given using a slider from 0 (disagree strongly) to 100 (agree strongly), and were averaged to represent the overall stability of the participants' flossing habits, with higher values indicating greater stability.

Natural reinforcement. Participants responded to a series of questions about the feelings that they experience as a result of flossing, and as a result of *not* flossing. These included both physical and emotional feelings separately, and also included both good and bad feelings separately. Responses were given using a slider from 0 (disagree strongly) to 100 (agree strongly). We combined them by adding the good feelings of doing the behavior, subtracting the bad feelings of doing the behavior, subtracting the good feelings of *not* doing the behavior, and

adding the bad feelings of *not* doing the behavior. Thus, a higher value for this variable indicated a natural reinforcement in favor repeating the behavior.

Demographics. Participants indicated their age, gender, and race.

Attention check. The last question served as a safeguard against the possibility that some participants might fill in random answers or fail to read and follow directions. The ostensible question text asked participants to choose their favorite ice cream flavor from a list, but a paragraph of instructions that preceded the question asked them to leave it blank. Participants who selected an ice cream flavor were to be excluded from the analysis, however all participants followed the instructions and left the question blank.

Results

There were no participants who met my exclusion criteria (giving nonsensical answers or failing the attention check), so my final sample included all 227 of the participants. There were 846 missing values (between 53 participants), which were excluded list wise from the relevant analyses. Due to the random assignment, the sample size for each condition (0, 1, 2, 3, or 4 primes) were 52, 45, 48, 44, and 39, respectively. Based on a multivariate analysis of variance, these groups did not appear to differ significantly in terms of any of the conceptual or demographic variables that we recorded (see Table 2). Overall 65.37% of participants completed "__LOSS" as "FLOSS." The average habit strength was 38.32 (of 100), and the average flossing frequency was 4.42 times per week (see Table 3 for full descriptive statistics and correlations). Both the SRHI and the contextual stability measures demonstrated good reliability (α =.973 and 0.826, respectively), but the natural reinforcement measure demonstrated poor reliability, α=.575.

Table 2: MANOVA Comparing Study Variables across Priming Groups

	F(df)	*p*
Automaticity (SRHI)	0.94 (4,187)	.44
Flossing Frequency	1.38 (4,187)	.24
Contextual Stability	1.39 (4,187)	.24
Natural Reinforcement	0.51 (4,187)	.73
Age	1.73 (4,187)	.14
Gender	2.20 (4,187)	.07

Table 3: Descriptive statistics and correlation matrix for Study 1 variables.

	1	2	3	4	5	6	7	8	9
1. Completed "FLOSS"									
2. # of Primes	.06								
3. SRHI	.04	-.09							
4. Frequency	.01	-.12	**.70**						
5. % in Bathroom	-.03	.03	-.05	-.12					
6. Stability	.05	-.03	**.49**	**.40**	**.34**				
7. Reinforcement	-.03	-.09	**.56**	**.48**	-.02	**.38**			
8. Age	**-.22**	-.07	**.17**	**.15**	-.09	.12	.11		
9. Gender (f=0, m=1)	-.09	**-.15**	.08	.13	.00	.04	.13	.12	
Mean	.65	1.88	38.32	4.42	81.86	61.60	15.01	34.93	1.52
SD	.48	1.41	32.09	4.72	28.60	23.38	13.92	11.60	0.50

Note. Boldface correlations achieved conventional statistical significance ($p<.05$).

To evaluate the cognitive availability of "floss," we performed a logistic regression on participants' completion of the target word stem as "floss" instead of "gloss." The model used participants' level of bathroom priming, SRHI, age, and gender as predictors. We also included the interaction between priming and SRHI to test whether sensitivity to the prime varied by flossing automaticity. We controlled for the percent of instances that participants flossed inside the bathroom (as opposed to in other places) because we did not expect the prime to successfully elicit the concept of floss in participants who flossed mainly outside the bathroom. We also controlled for flossing frequency in order to account for any associations with my theoretical predictors.

We found no significant main effects for bathroom priming, SRHI, gender, percent flossing in the bathroom, or flossing frequency (see Table 4). There was also no significant interaction between the effects of bathroom prime and SRHI. We did find a significant main effect for age, such that participants' likelihood of completing "floss" increased with age. The Nagelkerke R^2 for the model was .121.

Table 4: Logistic regression predicting the word stem completion as "floss."

	b	*SE(b)*	β	*t*	*p*
Bathroom prime	0.083	.115	0.03	0.74	.47
Flossing SRHI	0.010	.007	0.05	0.98	.17
Flossing Frequency	-0.010	.046	0.00	0.02	.83
Flossing % in Bathroom	-0.004	.006	-0.02	0.58	.49
Age	-0.040	.014	-0.12	3.12	<.01
Gender	-0.509	.323	-0.01	0.18	.12
Prime × SRHI	0.000	.004	0.00	0.04	.96
Intercept	2.688	.943		3.12	<.01

Notes: *N*=228, degrees of freedom=220 for all *t*-values.

To evaluate flossing automaticity, we used a multiple linear regression to predict SRHI score from flossing frequency, TACT stability, internal reinforcement, age, and gender (including a 2-way interaction between age and gender, and a 3-way interaction between frequency, TACT stability, and internal reinforcement). We also controlled for the number of bathroom word primes that participants encountered. There was a significant main effect for frequency, TACT stability, and natural reinforcement, but no significant interactions between the effects thereof (see Table 5). There were no significant main effects for age or gender (ß=.083, *p*=.19). There was, however there was a significant interaction between their effects, such that the general increase in automaticity with age was smaller for women than for men. There was no significant main effect for bathroom priming. The R^2 for the model was.761.

From a theoretical standpoint, my null finding could also signal a need to further question the nature of the cue-behavior association. We had expected, for example, that a person who habitually flosses in his bathroom, upon looking about this bathroom, might experience the activation of the concepts of "toothbrush" and "sink." These concepts, by means of the mental association in question, would then activate the concept of "flossing," and in turn, the behavioral schema for flossing. Instead, it is possible that the route from the perception of the cue to the performance of the behavior is more direct, entirely bypassing the mechanism of semantic concept activation. This would certainly be in concordance with the thinking that habits are mentally efficient. It would also be in concordance with the results of my study: If the sequence of seeing a bathroom and then flossing does not also involve the ideas of "bathroom" and "flossing," then there is no reason to expect that a person who flosses each night would associate these ideas any more strongly than a person who flosses only very occasionally.

Further research is needed to clarify the precise nature and action of the cue-behavior association, including any role that semantic activation might serve. Studies in this line of inquiry would need to compare the associations as enacted through word-based tasks with those expressed as actual behavior. It may be also necessary to move beyond an internet or even laboratory setting and conduct such studies in situ, using the actual habit environment—rather than depictions thereof—to elicit the behavior.

Automaticity. We found support for some of my hypotheses regarding the factors that contribute to behavioral automaticity. Beyond frequency, which is the most well demonstrated component of habit theory, we found evidence that people with strong flossing habits typically floss in a more stable context and seem to enjoy the experience of flossing more than do those with weak flossing habits. These results fall directly in line with the predictions of research on

Table 5: Logistic regression predicting SRHI.

	b	*SE(b)*	β	*t*	*p*
Bathroom Prime	-0.260	1.114	-0.012	-0.23	.82
Flossing Frequency	3.880	0.504	0.578	7.71	.00
Contextual Stability	0.267	0.086	0.191	3.12	.00
Natural Reinforcement	0.601	0.143	0.260	4.19	.00
Age	0.082	0.142	0.029	0.58	.56
Gender	4.814	4.070	0.076	1.18	.24
Age × Gender	0.371	0.139	0.167	2.67	.01
Frequency × Stability	-0.016	0.025	-0.047	-0.65	.51
Frequency × Reinforcement	-0.042	0.034	-0.107	-1.25	.21
Stability × Reinforcement	0.005	0.007	0.046	0.72	.47
Frequency × Stability × Reinforcement	-0.001	0.001	-0.065	-0.76	.45
Intercept	-11.040	9.627		-1.15	.25

Notes: *N*=192, degrees of freedom=184 for all *t*.

Discussion

Mental association. In my experiment, we found that exposure to bathroom-related words did not make people more likely to think of floss, regardless of the strength of their flossing habit. More generally speaking, we found no evidence to support or clarify the view of habits as cue-behavior associations. We also found no evidence that gender or age play a role in the action or expression of such an association. There are a number of explanations for this null effect from a methodological standpoint. Perhaps the forced contemplation of bathroom-related words, even in combination, was not sufficient to successfully activate the more general "bathroom" concept. Any future study on habits using similar methods would benefit from a manipulation check. Perhaps this general "bathroom" concept is not the crucial one, but rather a more specific "my bathroom" concept. Future, similar studies might take steps to ensure that participants call to mind their own bathrooms, or even utilize pictures of participants' actual bathrooms as primes.

associative learning, and in doing so, tend to support the view of habits as mental associations. In addition, they provide support for the use of these concepts and measurement instruments in future research. My confidence in the utility of the natural reinforcement construct is limited by its mediocre reliability. It is not clear that the various pleasant and unpleasant consequences of a habitual behavior should be combined into a single index, although we were unable to substantially improve the reliability by dissecting them into subscales. Given the construct's demonstrated effect, however, it certainly appears to warrant further investigation.

We did not find that the effects of frequency, stability, and natural reinforcement interacted as we had predicted, and further research is needed into relationship between these constructs and their effects on automaticity. In addition, evidence beyond my own correlational data is needed to establish causality. Future studies might attempt to observe the effect that manipulating frequency, stability, and natural reinforcement has on automaticity, as well as vice versa.

Gender and age. We found mixed support for my hypotheses regarding the role of demographic variables. While older people did not appear to have stronger flossing habits than younger people, nor women than men, we were able to observe a difference between men and women in terms of their flossing habit trajectory across the various ages represented in my sample. It appeared that, for men, flossing habit increases with age more than it does for women. Because my data on this effect are correlational, we are unable to determine if the role of age derives from developmental effects or cohort effects. The use of a longitudinal design in future research could shed light on this question. In addition, although we proposed that gendered differences in habit stem from gendered differences in personality traits, this explanation is purely speculative. Future research is needed to test any relationship between habits and various

personality characteristics, as well as any gender and age differences that these characteristics might exhibit.

Conclusion. Overall, my study furnished mixed support for a key role of the environment in habits. We were not able to detect it with a word-based experimental task, but we did see that it contributes to a stew of ingredients, the combination of which contributes to the production of automaticity. Although my study dealt only with flossing, the use of my constructs of interest in exploring other behaviors and interpreting the differences between them may teach us a great deal about the general structure of habits.

Study 2: An Implicit Measure of Habit?

Improving measures of habit strength has been a key factor in advancing the habit research literature. The SRHI, for instance, has allowed researchers to measure habit strength beyond mere behavioral frequency, and has enabled a deeper exploration of the mechanics habit acquisition and performance. We propose that a new measure of habit strength could unlock further advancements in habit research by measuring the mental cue-behavior associations that are thought to act as the habit mechanism. Such a measure could serve as a complement to the SRHI, and may broaden my understanding of key habit processes in a number of ways.

First, as discussed previously, there remains much work to be done in painting a more comprehensive theoretical picture of habits as a psychological concept. The behavior is only half of the cue-behavior pairing that comprises a habit. A new measure should seek to reflect the environmental and contextual features that elicit the behavior.

A further possible benefit of measuring the full cue-behavior association is the ability to observe changes in habit on a more detailed time scale. Meaningful changes in behavioral automaticity tend to occur only with a great deal of repetition and time—often more time than a health behavior intervention is able to continue. By comparison, mental associations are thought to form and fluctuate with relative ease. Studies that demonstrate the efficacy of implementation intentions have proposed that mental associations—even those created only by one instance of filling out a worksheet or saying a sentence aloud—are capable of not only persisting in the mind, but even bringing about the desired behavior. And while a quick fluctuation in mental association does not alone make or break a habit, my efforts to change large-scale patterns of health behavior can only benefit from a greater understanding of their small-scale underpinnings and precursors.

Finally, previous research has demonstrated that people do not necessarily possess accurate insight into the various forces that influence or even drive their behavior (Nolan et al., 2008). This may be doubly true of automatic, habitual behaviors—those that by definition occur without the need for conscious awareness. An ideal new measure, therefore, should minimize the reliance of habit research on participants' self-reporting.

One tool that may meet these benchmarks—incorporating environmental cues, reflecting fine-grained mental associations, and avoiding self-report—is the Implicit Association Test. The IAT has seen extensive use as a measure of mental association in social and health psychology. The IAT consists of a timed categorization task, wherein participants sort stimuli into paired categories (e.g. "White or Good" vs. "Black or Bad") and then repeat the sorting with the category pairings reversed (e.g., "White or Bad" vs. "Black or Good"). Using this technique, the mental association in question should manifest as a difference in sorting performance between the two category pairing schemes—participants are expected to have more difficulty using a category pairing that contradicts any existing association they might have. For instance, if a participant has prejudice toward Black people, they already associate "black" with "bad," and will therefore be able to sort stimuli more quickly into "Black or Bad" than "Black or Good." The magnitude of this performance difference is thought to represent the strength of the existing mental association.

Although its most prominent use has been for the measurement of implicit attitudes, the structure of the test allows for the exploration of associations with mental constructs of any sort, not merely attitudes or positive and negative emotions. One previous study, for instance, gauged the self-relevance of cigarettes by measuring the association between cigarettes and participants' names. Another study assessed gender stereotypes by measuring the association between women

and careers in science, technology, engineering, and mathematics. If the IAT can indeed be used to measure the strength of association between mental concepts beyond attitudes and racial categories, then it may well be configured to measures the association between the mental concept of a behavior and mental concepts of its cues. Such a test would promise to gauge the very theoretical core of habits.

To create such an IAT for the present study, we needed to expand the test's flexibility. Habits can be highly personalized, and the cues for any given behavior may vary greatly from one person to another. Consider, for instance, two people who both take the same medicine once a day. The one who takes it before bed might be cued by the feeling of drowsiness or the action of washing up, while the one who takes it at noon might be cued by an automatic text message reminder, or by the sight of co-workers leaving for lunch break. Even two people who take it at the same time of day are likely to have entirely different sets of cues, owing to the differences in the salient features of the immediate physical and social environments. In order to reflect this theoretical consideration, we programmed my IAT to customize itself for each user: Before beginning the IAT, participants view a list of potential cues and select the ones that best describe the context in which they perform the behavior of interest. The program then uses these items as stimuli in the IAT.

To make the best use of this feature, we sought to capture a wide range of cues by considering the various types, kinds, and modes of cues that have appeared in habit-relevant research. For instance, stimuli such as blinking lights and bells have been popular behavioral cues in associative learning trials, and important habit cues might therefore be expected to take the form of the visual or auditory features that are salient in the environment while the behavior is performed. Additionally, studies that have recorded participants' full sets of daily behaviors

suggest that many habits exist within the structure of routines, which are sequences of behaviors. A third type of important cue, therefore, may be the other behaviors that typically precede and follow the habitual behavior of interest. Thus, we tested three different versions of my IAT, each using stimuli meant to evoke a different general type of potential habit cue: sights, sounds, and actions.

Hypotheses

IAT as a measure of habit strength. We assess the suitability of this approach as a test of two hypotheses. First, if the IAT can be used as a valid measure of these mental associations, it should demonstrate some degree of convergence with the most commonly used measures of habit strength: the SRHI and behavioral frequency. Second, if the IAT indeed offers a tool that is useful in addition to the SRHI, its inclusion should improve the prediction of behavioral frequency from SRHI scores alone.

Demographic variables. As in Study 1, we also anticipate that demographic variables will relate to participants' flossing habits. We expect that a being a woman and being older will both predict higher flossing frequency, and we hypothesize an interaction such that the gender difference diminishes with age.

Methods

Pilot Study. In order to create the stimuli for the experimental procedure, we recruited three samples from www.mturk.com and asked them to create lists in response to simple, open-ended prompts. The first group (*n*=47) described behavioral sequences: 20 participants listed the activities that comprise their nightly routines (e.g., “put on pajamas,” “set the alarm”), 15 listed their weekday afternoon routines, and 12 listed their weekend afternoon routines. The second group (*n*=49) described visual features of their environments: 22 listed the objects in their bathrooms (e.g., “toilet,” “shower”), 14 listed the objects visible in their kitchens, and 13 listed the objects visible in their garages. The third group (*n*=79) described the sounds in their environments: 17 participants listed onomatopoeia corresponding to the noises that can be heard in their bathroom (e.g., “whoosh,” “hummm”), 21 listed the noises in their kitchens, 20 listed the noises in their workplaces, and 21 listed the noises of their grocery stores. From these various lists, we selected the most commonly occurring items to generate groups of stimuli representing potential flossing cues (45 nightly activities, 30 bathroom objects, 30 bathroom sounds), as well as groups of items for use as neutral, comparison stimuli (7 mid-day activities, 7 non-bathroom objects, and 7 non-bathroom sounds).

Participants. Participants entered the study by signing up to complete a task called “Sorting Game and Short Survey” on www.mturk.com and indicating their consent on an IRB information sheet. The sample of 657 included 260 men and 397 women who ranged in age from 18 to 68 (*M*=34.57, *SD*=10.84), and was 84% Caucasian (*n*=555), 6.7% African-American or Black (*n*=44), 6.2% Hispanic of Latino (*n*=41), 5. 1% Asian (*n*=34), 0.6% American Indian or Alaskan Native (*n*=4), and 2.4% “Other” (*n*=16).

Procedure. *Stimulus Selection.* Participants selected a group of items from one of the lists generated during the pilot study (either nightly routine activities, bathroom sights, and bathroom sounds). In the "activities" version of the procedure, participants chose the 7 actions that best corresponded to their own nightly routines. In the "sights" version, participants chose the 7 objects that best reflected the visual features of their own bathrooms. In the "sounds" version, participants chose the 7 onomatopoeia that best reflected the auditory features of their own bathrooms. In all versions, participants who selected more than 7 items were asked to choose the 7 that they felt were the most regular or important part of their daily experience.

Brief IAT. Participants completed a version of the Brief Implicit Association Test in which they sorted words and pictures into categories. The stimuli for all participants were pictures of (a) floss and people flossing, and (b) other items and their use (e.g., a man kicking a soccer ball), and participants sorted them into the categories of "Floss" and "NOT Floss." The word stimuli varied by version, and consisted of (a) the 7 items that participants had selected earlier (nightly activities, bathroom sights, or bathroom sounds), and (b) the 7 items of matching type (Mid-day activities, non-bathroom sights, or non-bathroom sounds) that were most commonly listed during the pilot study. Participants sorted word stimuli into categories of "Nightly Routine" vs. "NOT Nightly Routine", or "Bathroom" vs. "NOT Bathroom," depending on the type of stimuli.

During the task, category labels were displayed on the left and right sides of the screen, and participants used the "e" and "i" computer keys to identify the target stimulus as belonging to the category on the left or right side, respectively. Participants repeated this procedure during multiple blocks of stimuli: (a) a practice sequence sorting words only, (b) a practice sequence sorting pictures only, (c) a practice sequence sorting words and pictures, (d) a test sequence

sorting both words and pictures, (e) a practice sequence sorting words with the left/right categories reversed, (f) a practice sequence with word categories left/right reversed but picture categories normal, (g) a test sequence of the same. The IAT software calculated the strength of participants' mental association between "Nightly Routine" and "Floss" as the t-score for the difference in response times between the two test sequences (4 and 7).

SRHI. Participants completed a version of the Self Report Habit-Strength Index (SRHI), in which they used a slider bar (0 to 100) to rate their agreement with 12 statements about flossing (e.g., "flossing is something I do without having to think about it"). In this study, the SRHI demonstrated excellent reliability, with a Cronbach's alpha of .970.

Frequency. Participants indicated how many times they flossed in the past week.

Demographics. Participants indicated their age, gender, and all categories of race and ethnicity with which they identified.

Attention check. As in Study 1, the last question asked for participants' favorite ice cream flavor, but was preceded by a paragraph instructing them to leave the question blank.

Results

From the original 769 participants, 49 failed the attention check and 40 selected too few stimuli to populate the IAT, leaving a final sample of 681. There were 122 missing values from 104 participants, which we excluded pairwise for correlations and descriptive analyses, and listwise for the regression. In order to test the equivalence of the stimulus type subsamples, we performed a multivariate analysis of variance (see Table 6). We found that participants who took the "sights" version scored significantly higher on the IAT (*M*=6.72, *SD*=4.44) than did participants who took the "sounds" (*M*=6.36, *SD*=3.74) or "actions" (*M*=5.56, *SD*=4.34) versions, even though their SRHI scores were not significantly different. We also found a marginally significant gender imbalance, such that the proportion of males was higher in the "sounds" version (46%) than the "sights" (35%) or "actions" (39%) versions.

Table 6: Multivariate ANOVA relating IAT stimulus type to Study 2 variables.

	F(df)	*p*
Frequency	0.403 (2,670)	.67
SRHI	1.385 (2,670)	.25
IAT	4.981 (2,670)	<.01
Gender	2.622 (2,670)	.07
Age	1.449 (2,670)	.24

To test the convergent validity of the IAT as a measure of habit strength, we correlated it with the most frequently used measures of habit strength: behavioral frequency and the SRHI. We found that IAT scores correlated negatively with both SRHI scores, and flossing frequency (see Table 7 for full correlation matrix). With regards to demographic variables, age correlated significantly with all three habit-strength measures (flossing frequency, SRHI, IAT), but gender did not correlate significantly with any of them.

Table 7: Correlations, means, and standard deviations for Study 2 variables.

	1	2	3	4	5	6	7
1. Frequency							
2. SRHI	**.81**						
3. IAT	**-.10**	**-.11**					
4. Stimulus: Sight	.03	.06	**.09**				
5. Stimulus: Sound	-.03	-.05	.03	**-.44**			
6. Male	-.05	-.03	-.05	-.06	**.08**		
7. Age	**.13**	**.09**	**.13**	.05	.03	**-.10**	
Mean	2.14	2.66	6.16	32.20%	28.60%	40.00%	34.44
SD	1.97	1.18	4.23				10.79

Note. **Boldface** correlations achieved conventional statistical significance (p<.05).

To test the ability of the IAT to make a contribution over and above the SRHI, we used a linear multiple regression to predict flossing frequency from SRHI score, IAT score, IAT stimulus type (dummy coded), age, gender, and an age by gender interaction term. We found significant positive main effects for SRHI score and for age, but no significant effects for IAT score or any other predictor (see Table 8). With regards to demographic variables, we found flossing frequency had a significant positive relationship with age but not gender, and that there was no significant interaction between the effects of age and gender. The R^2 for the model was .665.

Table 8: Linear regression predicting flossing frequency.

	b	*SE(b)*	β	*t*	*p*
SRHI	1.338	0.038	0.807	35.37	<.01
IAT	-0.008	0.011	-0.017	-0.72	.47
Stimulus: Sight	-0.019	0.106	-0.004	-0.18	.86
Stimulus: Sound	0.084	0.109	0.019	0.77	.44
Age	0.009	0.004	0.052	2.26	.02
Gender	-0.062	0.091	-0.015	-0.68	.50
Age × Gender	0.006	0.009	0.017	0.75	.45
Intercept	-1.684	0.193	0.000	-8.74	<.01

Note, *N*=673, degrees of freedom = 648 for all *t*s.

Discussion

IAT as a measure of habit strength. In this study, we found no evidence that my implicit association test can be used as a measure of habit strength. Nor did it demonstrate any convergent validity in correlation with the SRHI, and it added nothing to the prediction of behavior from the SRHI. In fact, participants' IAT scores had a small *negative* correlation with behavioral frequency (the opposite of what would happen if the measure functioned as we intended). This pattern may be due to a correlation with age, as the effect disappeared when both IAT score and age were included in the regression predicting frequency.

From a methodological standpoint, there are many reasons why my IAT may not have successfully measured habit strength. Although we tested three different kinds of cues as stimuli, it is still possible that we failed to properly capture the cues that would be pertinent to participants' real life habits. Perhaps the key cues are of some sort other than sights, sounds, or actions. Or perhaps written text is simply unable to represent the visual, auditory, and kinesthetic information that constitute them sufficiently. Any future attempts to use the IAT as a base for a habit strength measure might try to use actual pictures or sound recordings from the actual environments of their participants. It may also be advisable to test future participants in person, as the IAT is a very cognitively intensive task. Even though we screened out participants who were paid little attention to the instructions, this experiment—conducted as it was on the internet—could not guarantee that participants were free of distractions or concentrating sufficiently.

From a theoretical standpoint, the inability to detect the mental associations of a habit mirrors the results of Study 1, and aligns with the idea that such mental associations do not work by means of spreading activation through linked semantic concepts. As we previously noted, if the connection from the cue to the behavior does not pass through the ideas that represent the cue

and behavior, there is no reason to expect to find an association between the words that represent the cue and behavior, even in the cases of the strongest habits. A second null finding is certainly not grounds for concluding that this idea is correct, but reinforces the idea that it is an important target for future inquiry.

Contributors to flossing frequency. As in many previous studies (see my meta-analysis for an overview), the SRHI demonstrated a good ability to predict behavior—in the case of this study, flossing frequency. We found that older participants flossed more frequently than did younger participants, which supported my hypothesis about age, however we found no support for my hypothesis about gender. Also, in contradiction with the findings of my first study, we found no interaction between age and gender. Overall, the support for the role of age and gender in my experiments remains mixed, and a more direct inquiry into their effects will most likely be required to fully understand them.

Conclusion. The implicit association test, at least as we formulated it in this experiment, did not make for a successful measure of flossing habit strength. The main contribution of this study seems to be that we have uncovered some strategies that do not work—a necessary step on a hopeful journey to uncovering one that does work.

Study 3: A Meta-Analysis of Multiple Habits

Whereas the present research has thus far been directed toward predicting the automaticity of a behavior (Study 1) or the performance of behavior (Study 2), another approach is to predict the relationship between the two. For any particular behavior, the strength of this relationship could reflect either: (a) the degree to which the performance of the behavior causes the development of automaticity, or (b) the degree to which automaticity tends to dictate the performance of the behavior. Most likely, both cases are valid interpretations of a causal cycle whereby the performance and automaticity of a behavior reinforce each other. In any case, it is likely useful to identify the behaviors for which this relationship is strongest. With regards to promoting health, we are interested in being able to target these behaviors for intervention with a habit-change approach. With regards to advancing psychological theory, we are interested in understanding what it is unique about these behaviors, the context in which they occur, and the people that perform them.

In addition, this undertaking expands my methodological approach, as it is particularly well suited to examination through secondary research. A previous meta-analysis of studies on habits in nutrition and physical activity (Gardner, de Bruijn, & Lally, 2011) estimated a mean habit-behavior correlation of .46 across 22 papers. In the present research, I aim to update Gardner and colleagues' meta-analysis, expand it to other behaviors, and leverage the literature's variety toward decoding the factors that determine the habit-behavior relationship. Observing a wide range of behaviors will better support the generalization of the my conclusions beyond habits of flossing in particular. It may be particularly useful in casting light on the interplay between the constructs that contribute to habit. As per my previous hypotheses regarding the nature and formation of habits, I expect to find: (a) main effects of frequency, contextual

stability, and natural reinforcement, (b) an interaction between the effects of these three, (c) main effects of gender and age, and (d) an interaction between the effects of these two.

Method

Literature Search and Study Selection. First, we searched for articles in multiple online electronic databases through April 26, 2015. With Scopus and Web of Science, we used the citation tracking feature to locate studies citing the papers that introduced the SRHI and its derivatives. With PsycINFO, PsycArticles, Academic Search Premier, PubMed, and ProQuest, we searched all fields for the following terms: SRHI, SRBAI, HINT, "A Self-Report Index of Habit Strength," "Self-Report Behavioural Automaticity Index," "Self-Report Behavioral Automaticity Index," "Habit Index of Negative Thinking." Second, after screening articles for inclusion, we searched for additional sources by examining the list of works cited by each article and the list of works citing each article. Third, we searched manually in the past year's records of the three journals in which we found the highest number of relevant results: *Appetite, Psychology and Health*, and *Transportation*.

Three raters evaluated studies for inclusion, and discrepancies were resolved through discussion. Eligible studies measured (a) the strength of habit for the behavior of interest using questions adapted from the SRHI, SRBAI, or HINT, and (b) the performance of the behavior of interest in terms of its frequency (e.g., number of times per week the participant flossed), volume (e.g., total minutes of exercise per week), proportion (e.g., percentage of snacks eaten that were fruits or vegetables), a dichotomous outcome (e.g., whether or not the participant applied sunscreen), or some composite thereof.

Coding. Three raters recorded information from the studies concerning the article, the sample, and the design, and discrepancies were resolved through discussion. Article characteristics included (a) authors, (b) year of data collection, (c) publication status, and (d) behaviors of interest. Sample characteristics included (e) the mean habit strength for this behavior, (f) mean sample age, (g) percent of females in sample, and (h) country of data collection. Design characteristics included (i) the number of items used to measure habit strength, (j) whether behaviors were measured in terms of frequency, volume, proportion, yes/no, or combined index; (k) whether measurement was through self-report or observation, (l) the length of time between the measurement of habit and the measurement of behavior, (M) whether the participants were part of an intervention, and (n) whether the study specifically recruited participants who were already trying to change the behavior of interest (e.g., dieters).

Questionnaire for Additional Moderators. In addition, we sought to capture a fuller picture of the relevant behaviors and gather information that was of theoretical interest to my analysis but that did not appear in my sample of studies. To this end, we conducted my own survey; 104 participants recruited from Mechanical Turk rated the 20 behaviors that appeared most frequently in the literature: (a) exercise, (b) active commuting, (c) traveling by car, (d) eating fruits and vegetables, (e) eating unhealthy snacks, (f) eating seafood, (g) observing safety precautions while preparing food, (h) hand washing, (i) using sunscreen, (j) using condoms, (k) flossing, (l) taking prescription medication, (M) recycling, (n) depositing in savings, (o) utilizing IT support, (p) casual internet use, (q) drinking alcohol, (r) smoking, (s) texting while driving, and (t) sitting for prolonged periods. Participants rated each behavior in terms of frequency (1 item), contextual stability (8 items), and natural reinforcement (8 items) using the same scales as described in Study 1. Table 9 displays scale reliabilities.

Table 9: Reliability (Cronbach's α) of scales for moderator variables from external survey.

Behavior	Contextual Stability	Natural Reinforcement
Exercise	.821	.663
Fruits & Vegetables	.809	.601
Unhealthy Snacking	.791	.508
Alcohol Consumption	.881	.467
Internet Use	.727	.523
Smoking	.894	.834
Seafood Consumption	.827	.765
Food Safety Practices	.856	.678
Active Commuting	.924	.462
Hand Washing	.672	.672
IT Assistance Use	.798	.712
Car Use	.876	.587
Sunscreen Use	.935	.515
Prolonged Sitting	.784	.713
Flossing	.692	.654
Recycling	.816	.672
Savings Deposits	.797	.661
Condom Use	.899	.605
Medication Adherence	.889	.581
Texting & Driving	.866	.727

Analyses

Calculation of effect size and moderators. We chose to represent the main study outcomes in terms of Pearson's *r*, such that a more positive value indicates a stronger positive relationship between habit and behavior. We selected this effect size index because the scales predominantly used for both habits and behaviors are inherently continuous, and because nearly all of the studies in my sample reported the habit-behavior relationship in terms of *r*. Two studies reported odds ratios, for which we calculated Cohen's *d,* and then converted to *r*, following the steps described by Borenstein and colleagues (2009). One study reported a Spearman's rank-order correlation, which we transformed using Walker's (2003) formula for converting between

tau, *r*, and rho. In all cases, we performed Fisher's *z* transformation before analysis in order to stabilize the variance and correct for small sample sizes. We weighted all effect sizes by the inverse variance of the resulting *z*. Results were transformed back to *r* for display purposes.

For some studies, we were unable to calculate an effect size from the information in the published report. This occurred most commonly when the habit-behavior relationship was described as part of a multiple regression or structural equation model without reporting the full correlation matrix. In these cases, there was some indication of the habit-behavior relationship (e.g., a regression weight or path coefficient), but we had no way to separate it out from the particulars of the model (e.g., other independent variables, multi-level structure) so that it would correspond with the other effect sizes in my sample. We contacted the authors of 61 studies for which we were unable to calculate an effect size. For 21 studies, the authors provided sufficient information to calculate effect sizes. For four studies, the authors indicated that there were no usable statistics available. We were unable to reach the authors for 36 studies, which we excluded after multiple failed attempts.

We did not contact authors for further information about sample or design characteristics. In some instances, we were sometimes able to estimate a missing value, such as by using 20.5 as the mean age for a sample of otherwise unspecified university undergraduates. Otherwise, studies with missing moderator values were excluded listwise from relevant moderator analyses.

Random-Effects Model. Effect sizes were modeled under the assumption of random effects, a choice that suits the goals of the meta-analysis because random effects assumptions (a) better support the generalization of the findings beyond my sample of studies, (b) better accommodate a large amount of heterogeneity that is not explained by sampling error, and (c) better minimize the outlier effects of studies that have much larger samples than the others (Card,

2012). For this model, we estimated the weighted mean effect size with a 95% confidence interval (CI), and calculated the lack of homogeneity in terms of I^2. We evaluated publication bias by creating a contour-enhanced funnel plot (Peters et al., 2008) and by performing Egger's (1997) regression test. We also used the trim and fill technique (Duval & Tweedie, 2000a; 2000b) to estimate the number of missing studies.

Mixed-effects models. In parallel, we used weighted multiple-regression under mixed-effects assumptions to model the effects of my moderator variables. Because some of the effect sizes pertained to behaviors that we could not include in the external survey, my first mixed-effects model included only moderator variables coded from the published reports: Mean sample age, percent female, length of habit strength scale, mean sample habit strength, time lag between habit strength and behavior measurement, whether the study was an intervention, whether the study recruited a sample that was already trying to modify the behavior, and dummy coded variables to indicate the study's type of behavioral measure (observation or self-report) as well as its units (frequency, volume, proportion, dichotomous outcome, or composite). Also, as in Studies 1 and 2, we tested for an interaction between the effects of age and gender. The second mixed-effects model tested the moderator variables derived from my external survey, including typical behavioral frequency, contextual stability, and natural reinforcement. We also controlled for all predictors that demonstrated a statistically significant effect in the first mixed-effects model.

For both mixed-effects models, we calculated a regression weight and 95% CI for each moderator, and we calculated the remaining, unexplained heterogeneity in terms of I^2. We illustrated all significant continuous predictors using Johnson and Huedo-Medina's (2011) moving constant technique, plotting the estimated mean effect size across various levels of the

moderator. This plot also demonstrates the moderator's relationship with the estimate's precision, and points to the value of the moderator at which the confidence interval crosses the x-axis and the effect thus no longer reaches statistical significance. In addition, a moving constant plot allows the examination of the effect in question at levels of moderator variables extrapolated beyond the range of values that are present in the sample of effect sizes. All analyses were conducted in R using the metafor package (Viechtbauer, 2010).

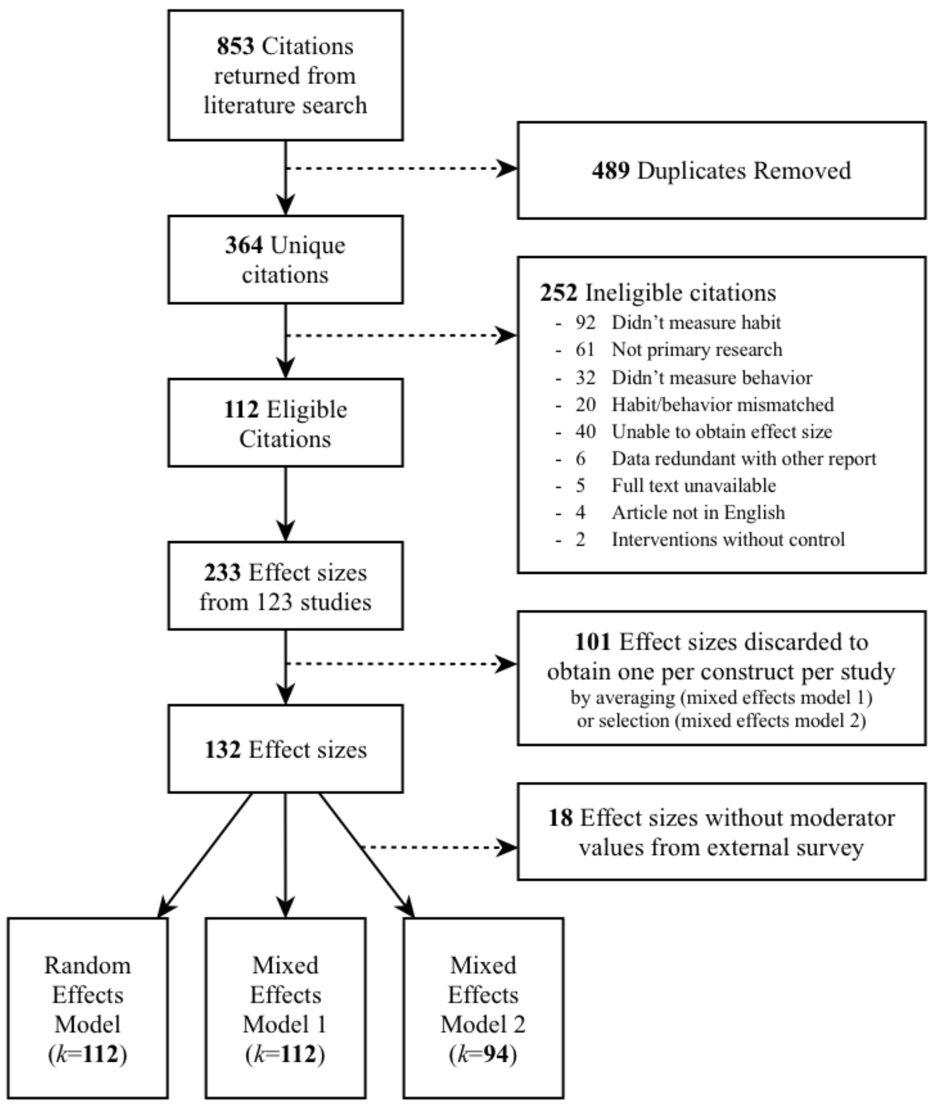
Results and Discussion

Descriptive Statistics. *Effect sizes.* After evaluating the 364 unique citations returned by my literature search, we were able to calculate 233 effect sizes from 123 studies in 112 original reports (see Figure 2). Before performing any meta-analyses, we generated a smaller set, such that there was only one effect size per construct per study. For studies that contained effect sizes for multiple behaviors, we collapsed across variants of the same behavior, but did not across behaviors of different categories. For instance, for Gardner et al.'s (2013) study, we collapsed "drinking alcohol" with "having a second drink," but NOT with "snacking" or "active commuting."

For the random effects model, we collapsed multiple effect sizes by using the mean of each study's relevant correlations. For the mixed effects model and meta-analytic regressions, we selected the effect size that was most unique in terms of its moderator values. For instance, since most studies measured behavior using self-report, we prioritized effect sizes drawn from behaviors measured using observation. Similarly, we selected effect sizes that were farthest from the norm in terms of the sample's mean habit strength or the lag time between habit and behavior measurement. This procedure allowed us to maximize the variance available for the predictor

variables in our meta-analytic regressions. For both the random and mixed effects models, the final sample included 132 effect sizes (see Figure 2).

Figure 2: Flow chart of studies through the meta-analysis.



Participants. The set of effect sizes represented data collected from 53,262 participants. Studies' sample sizes ranged from 13 to 11,390 (*M*=414.30, *SD*=1,034.29). These samples were collected from participants in Australia (*k*=7), Belgium (*k*=3), Canada (*k*=4), China (*k*=1), Denmark (*k*=1), Finland (*k*=3), Germany (*k*=6), Greece (*k*=1), Ireland (*k*=1), Italy (*k*=1), Japan

(*k*=1), Kenya (*k*=1), Korea (*k*=2), the Netherlands (*k*=42), Norway (*k*=8), Poland (*k*=1), Portugal (*k*=1), Romania (*k*=1), Sweden (*k*=2), the UK (*k*=29), and the United States (*k*=21). Weighting by sample size, the mean sample gender was 61% female (*SD*=17%), and the mean sample age was 28.40 years (*SD*=15.93).

Behaviors. The effect sizes were mostly drawn from behaviors among the 20 that we had used in my external survey: physical activity (*k*=26), unhealthy snacking (*k*=17), fruit and vegetable consumption (*k*=13), alcohol consumption (*k*=7), active commuting (*k*=6), internet use (*k*=6), smoking (*k*=5), flossing (*k*=4), car use (*k*=3), IT assistance utilization (*k*=3), food safety practices (*k*=3), seafood consumption (*k*=3), medication adherence (*k*=2), prolonged sitting (*k*=2), sunscreen use (*k*=2), hand washing (*k*=2), condom use (*k*=1), recycling (*k*=1), depositing in savings (*k*=1), and texting while driving (*k*=1). In addition, there were 24 effect sizes from other behaviors, which tended to be specific to a particular population (e.g., using protective motorcycle gear or watching a popular Swedish soap opera).

Measurement of behavior. The methods of behavioral measurement included self-report (*k*=121) and experimenter observation (*k*=17), either in person or electronically. The units of behavioral measurement included frequency (*k*=64), volume (*k*=52), a frequency/volume composite (*k*=12), proportion (*k*=10), or single dichotomous performance (*k*=6). There were 17 effect sizes calculated from the control conditions of intervention studies, and 11 effect sizes from samples that were already attempting to modify their behavior before recruitment.

Measurement of habit. On average, studies measured habit 20.97 days before measuring behavior (*SD*=89.64), using 8.63 items (*SD*=3.47), yielding a habit strength score of 50% of the maximum possible (*SD*=20%).

Overall Effect Size Results. First, in order to paint a general picture of the literature, we modeled weighted mean effect sizes under random-effects assumptions. Overall, the mean habit-behavior effect size was 0.531 (95% *CI* = 0.461, 0.565), which reached statistical significance. There was significant heterogeneity of the effect sizes, I^2=96.72% (95% *CI* = 95.85, 97.55). Because much of this heterogeneity is likely due to my drawing the effect sizes from different behaviors, we also calculated mean effect sizes by behavior type (see Table 10 for estimates, and figures 3-8 for forest plots). When we included the moderator variables coded from each study (see next section), the heterogeneity reduced slightly to I^2=96.22% (95% *CI* = 95.05, 97.26). When we included the moderator variables drawn from the external survey (see next section), the heterogeneity reduced to I^2=95.20% (95% *CI* = 93.50, 96.72).

Table 10: Summary of overall results for each behavior type, random effects assumptions, ordered by magnitude of estimated effect size.

Behavior	k	Estimated Effect (r)	SE	95% CI Lower	95% CI Upper	I^2	
Sunscreen Use	2	1.3327	0.5056	0.3417	2.3237	98%	**
Flossing	4	0.9965	0.1915	0.6211	1.3718	95%	**
Car Use	3	0.8139	0.2725	0.2797	1.3480	96%	**
Fruits & Vegetables	13	0.6315	0.0636	0.5070	0.7561	92%	**
Internet Use	6	0.6029	0.1273	0.3534	0.8524	94%	**
Medication Adherence	2	0.5984	0.1763	0.2529	0.9439	80%	*
Active Commuting	6	0.5702	0.2402	0.0995	1.0409	98%	**
Alcohol	7	0.5278	0.0602	0.4098	0.6459	75%	**
Miscellaneous[a]	24	0.5159	0.0520	0.4140	0.6178	93%	**
Recycling	1	0.4730	0.0402	0.3941	0.5519	*NA*[b]	
Food Safety Practices	3	0.4641	0.1623	0.1461	0.7822	81%	**
IT Assistance Use	3	0.4617	0.0876	0.2900	0.6333	76%	*
Exercise	26	0.4418	0.0435	0.3565	0.5272	93%	**
Seafood Consumption	3	0.4202	0.1293	0.1667	0.6737	98%	**
Smoking	5	0.4166	0.1157	0.1899	0.6432	93%	**
Unhealthy Snacking	17	0.3867	0.0493	0.2900	0.4834	91%	**
Savings Deposits	1	0.3490	0.0918	0.1690	0.5290	*NA*[b]	
Condom Use	1	0.2930	0.1379	0.0227	0.5633	*NA*[b]	
Texting & Driving	1	0.2690	0.0486	0.1738	0.3642	*NA*[b]	
Prolonged Sitting	2	0.2510	0.0875	0.0794	0.4226	56%	
Hand Washing	2	0.0264	0.0429	-0.0576	0.1105	76%	*

a. Behaviors not included in the external survey.
b Sub-samples with only 1 effect size have no I^2 value.
**p<.05, **p<.01*

Figure 3: Forest plots for behaviors included in external survey.

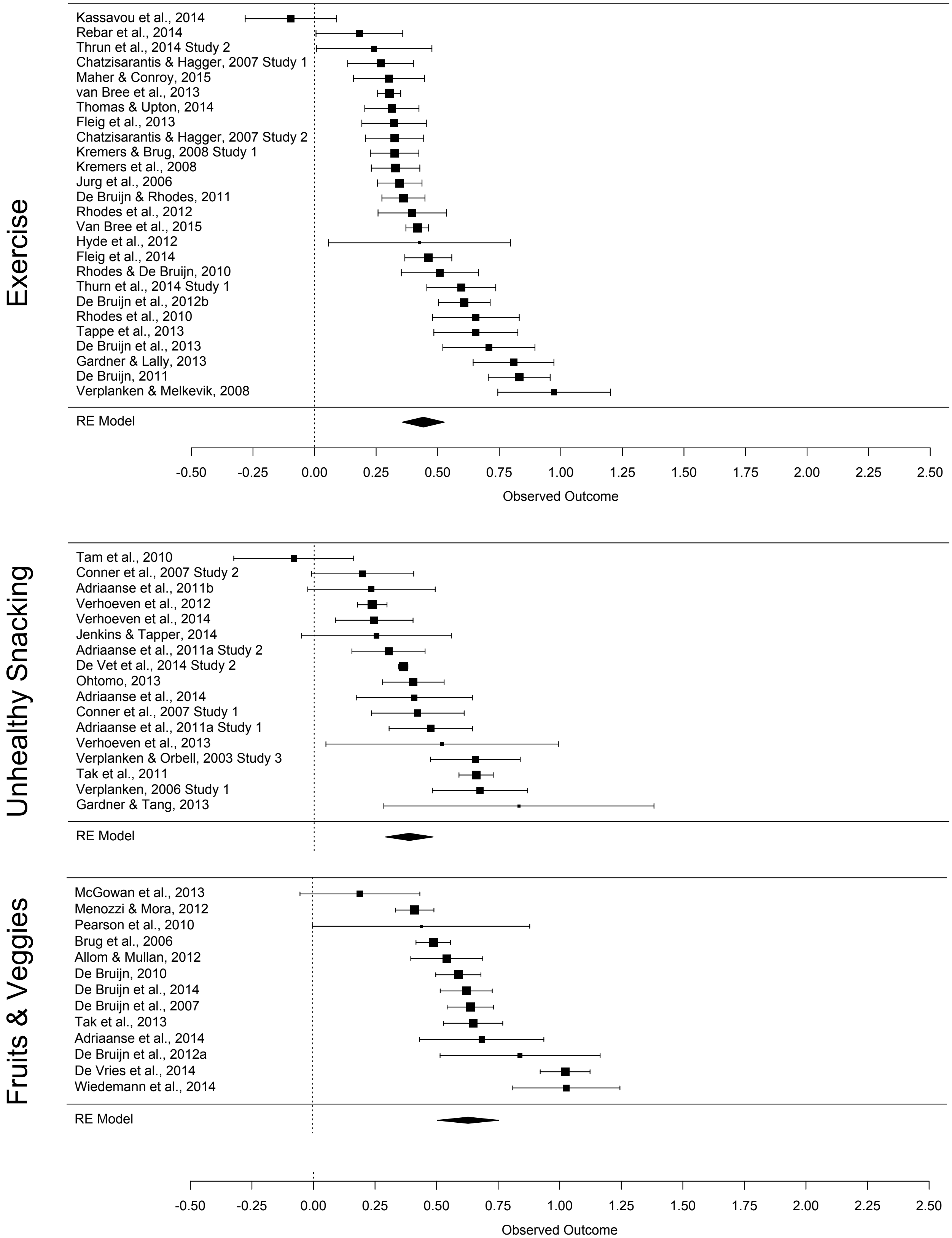


Figure 4: Forest plots for behaviors included in external survey, continued.

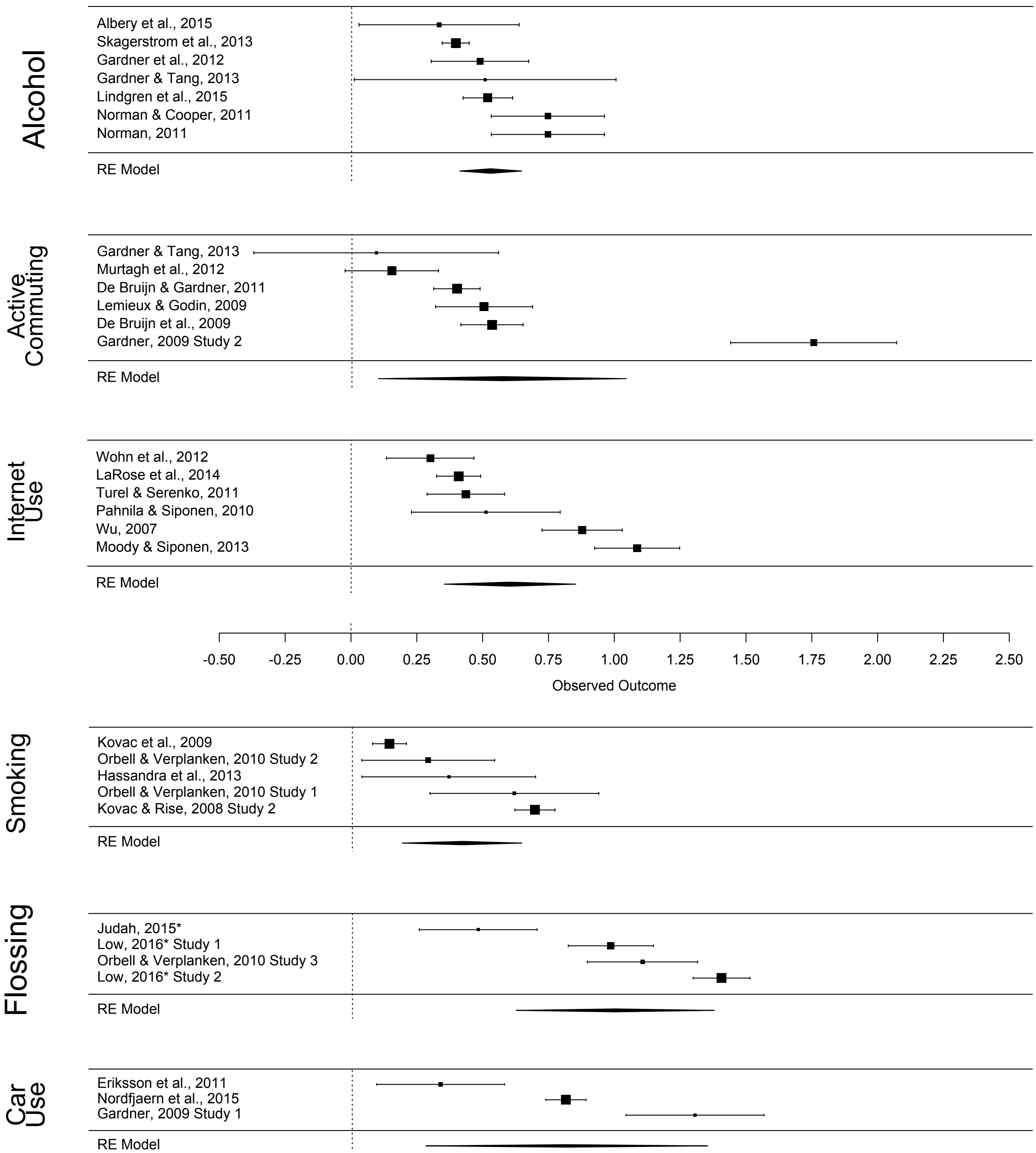


Figure 5: Forest plots for behaviors included in external survey, continued.

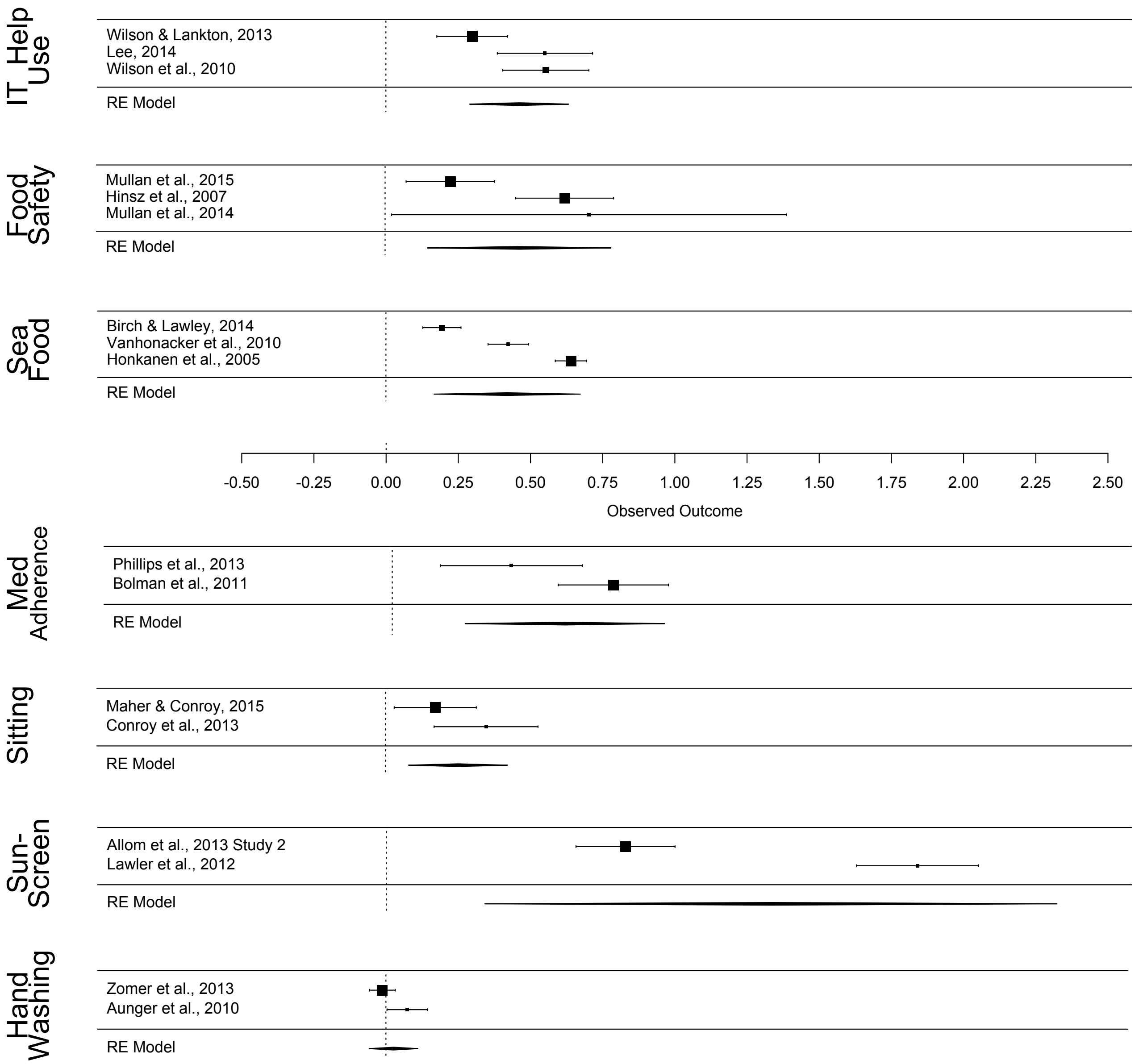


Figure 6: Behaviors included in external survey, but with only one effect size in final sample.

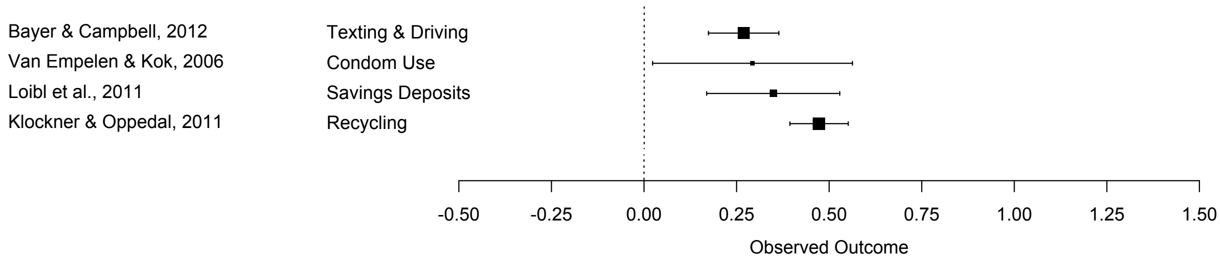
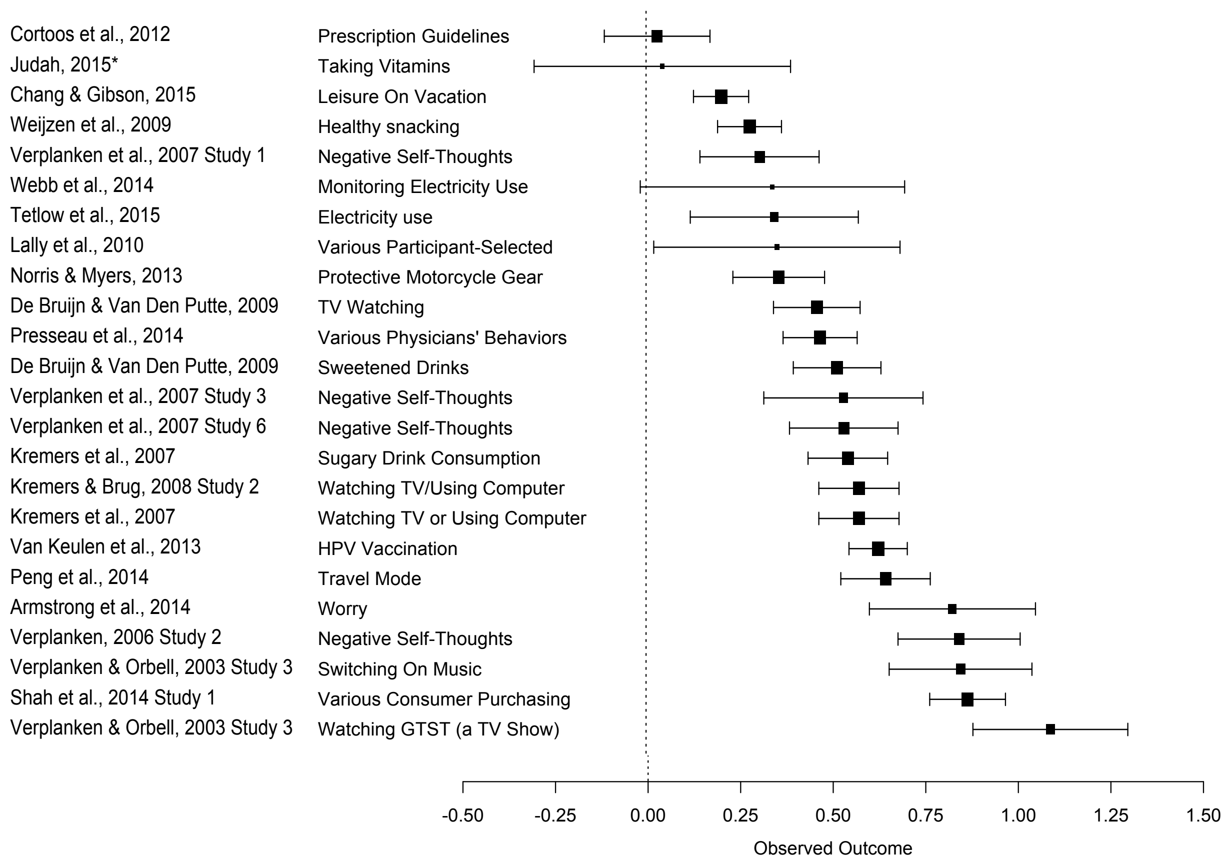
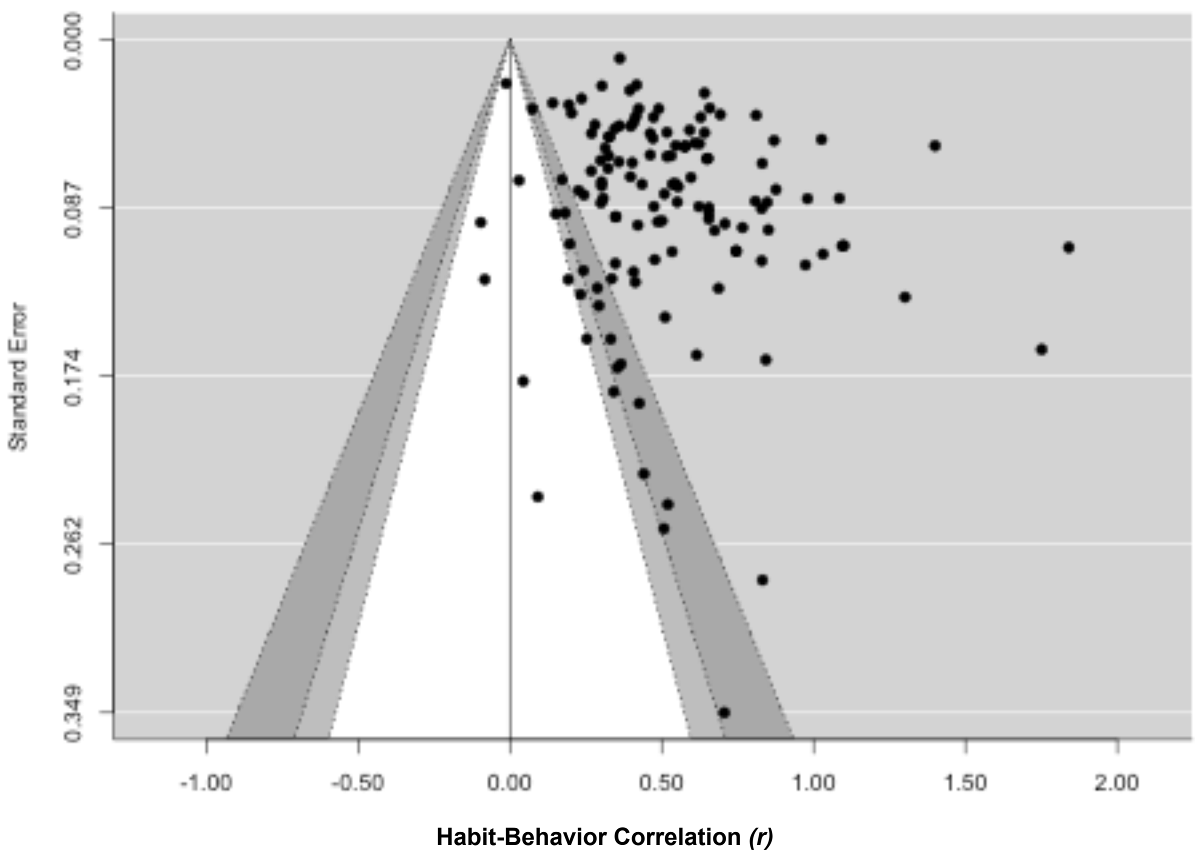


Figure 7: Behaviors not included in the external survey



There was some asymmetry visible in the contour-enhanced funnel plot (Figure 8), which tends to indicate the presence of publication bias. Nonetheless, the regression test found no significant funnel asymmetry, z=1.258, p=.21, and the trim-and-fill technique estimated the number of missing studies at 0. My inferences about publication bias are limited, as the high degree of heterogeneity implies the existence of multiple population effect sizes among the sample effect sizes.

Figure 8: Funnel plot of effect sizes included in random effects model. The angled white, light grey, and dark grey bands indicate $p > .1$, $p<.05$, and $p>.01$, respectively; in all other areas, p<.01.



Moderator Model 1: Variables Coded from Each Study (*k*=112). To examine the effects of my moderator variables on the habit-behavior relationship, we created two models with assumptions of mixed effects. Because external survey moderators were not available for all of the behaviors in my sample, we did not test those moderators in Model 1. Instead, we included as predictors: sample age, sample gender, habit measure length, mean habit strength, habit-behavior measure lag, the mode of behavior measurement (self-report vs. observation), the units of behavioral measurement (frequency vs. volume, proportion, dichotomous, and composite), whether the sample was already trying to modify the behavior before recruitment, and whether the study was an intervention. Finally, as in Studies 1 and 2, we tested for the Age × Gender interaction.

This model indicated the sample heterogeneity as I^2=96.22% (95% *CI* = 95.05, 97.26), which reflects a significant lack of homogeneity. A larger habit-behavior effect size was associated with non-intervention studies, the use of longer habit-strength measures, the use of self-reported measures of behavior, and a shorter time period elapsed between the measurement of habit and the measurement of behavior (see Table 11). We illustrated the effects for continuous moderator variables using Johnson and Huedo-Medina's (2011) moving constant technique, examining habit measure length (Figure 9) and habit-behavior measurement temporal lag (Figure 10). We also found that effect sizes from the control groups of intervention studies were significantly larger than effect sizes from non-intervention studies.

Table 11: Meta-analytic regression, mixed-effects assumptions, Model 1.

	b	SE(b)	z	p
Sample Age	0.0000	0.0022	0.010	.992
Sample % Female	-0.0004	0.0019	-0.230	.818
Sample is Intervention Control Group	-0.2485	0.0830	-2.995	.003
Sample Was Already Modifying Behavior	0.1304	0.1230	1.060	.289
Habit: Measure Length	0.0191	0.0062	3.083	.002
Habit: Measure Mean Score	-0.0007	0.0014	-0.499	.618
Behavior: Measure is Self-Reported[a]	0.4031	0.0687	5.871	.000
Behavior: Measure units are Volume[b]	-0.0023	0.0580	-0.040	.968
Behavior: Measure Units are a Proportion[b]	0.1625	0.1261	1.288	.198
Behavior: Measure Units are Dichotomous[b]	0.0048	0.1395	0.035	.972
Behavior: Measure Units are a Composite[b]	0.0779	0.0998	0.780	.436
Habit-Behavior Measurement Lag	-0.0015	0.0006	-2.369	.018
Interaction: Sample Age x % Female	-0.0001	0.0002	-0.487	.626
Intercept[c]	0.4852	0.0249	19.460	.000

Note: Regression coefficient *(b)* describes relationship between moderator variable and effect size; positive *b* indicates that greater moderator value predicts a stronger habit-behavior relationship.
a. Dummy coded, comparison is "Behavior: Measurement is Observation"
b. Dummy coded, comparison is "Behavior: Measurement Units are Frequency"
c. Calculated with each moderator entered in its mean-centered form.

Figure 9: Moving constant plot of the habit-behavior relationship by length of habit strength measure, with other moderators controlled at their mean values (Mixed-effects Model 1).

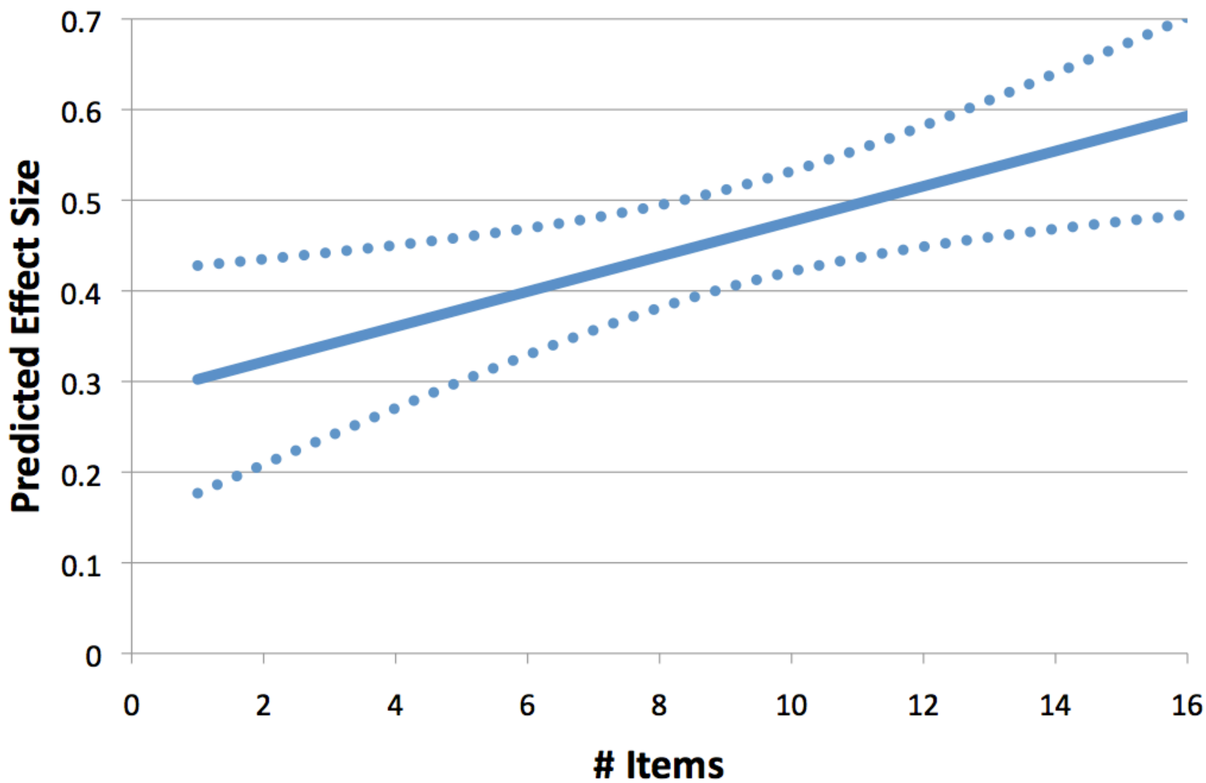
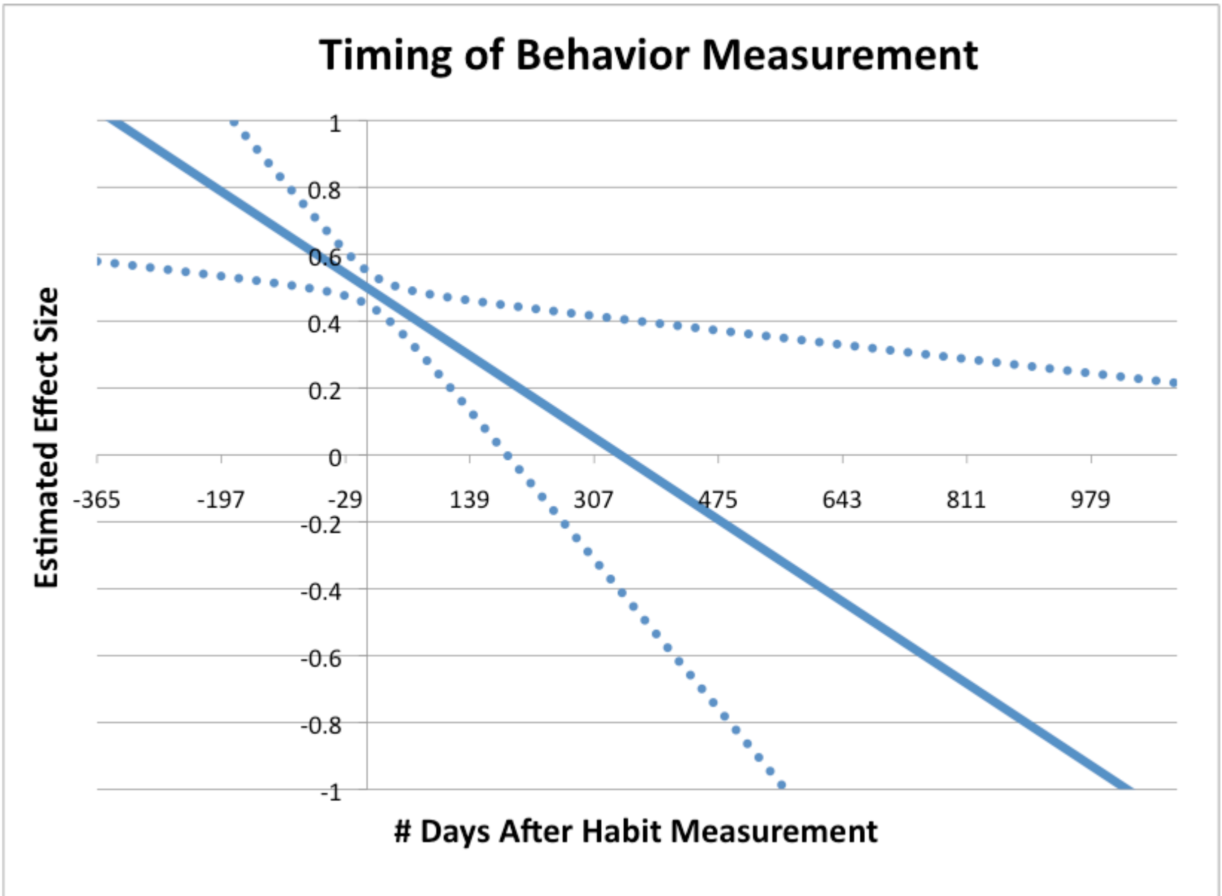


Figure 10: Moving constant plot of the habit-behavior relationship by length of time in between measurement of habit strength and measurement of behavior (Mixed-effects Model 1).



Model 2: All Moderators (*k*=94). We also conducted a second mixed effects model in order to test the moderating roles of the variables gained from my external survey. Please see the included tables for the descriptive statistics and correlations between behaviors in terms of frequency (Table 12), contextual stability (Table 13), and natural reinforcement (Table 14), as well as the within-behavior correlations for the three constructs (Table 15).

Table 12: Correlations and Descriptive Statistics for Behavioral Frequency Variables, Study 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Exercise																				
2. Fruit & Vegetables	.15																			
3. Unhealthy Snacking	-.09	.10																		
4. Alcohol	.12	-.07	.10																	
5. Internet	-.01	.18	.01	-.03																
6. Smoking	.05	-.07	.10	.09	.08															
7. Seafood	.10	.14	-.08	-.04	-.01	-.03														
8. Food Safety	-.01	.31**	.22*	-.05	.18	-.12	.09													
9. Active Commuting	.11	.13	-.04	-.05	-.07	.03	-.05	-.05												
10. Handwashing	.13	.30**	.01	-.09	.30**	.06	-.06	.15	-.04											
11. IT Use	.01	-.04	.11	.00	.04	-.03	-.07	.05	.04	.22*										
12. Car Use	.15	.10	.36**	.02	.13	.49**	.10	.08	-.03	.13	-.04									
13. Sunscreen	.34**	.22*	.03	.14	-.06	-.07	.02	-.02	.14	.07	.12	.13								
14. Sitting	-.09	.19	.11	.02	.16	-.05	.12	.32**	-.22*	.24*	-.08	.19	-.11							
15. Flossing	.15	.31**	.05	.01	-.02	.13	.11	-.06	.25*	.03	-.06	.16	.29**	-.11						
16. Recycling	.14	.26*	.16	.08	.03	.01	.15	.14	-.01	.05	-.02	.14	.09	.16	.06					
17. Savings	.28**	-.11	.13	.03	-.12	.09	-.06	-.17	-.03	-.05	.01	.13	.08	-.07	-.02	-.02				
18. Condom Use	.05	.09	.19	.13	-.10	.07	.03	-.02	-.05	.00	-.05	.09	.05	.18	.10	.04	.05			
19. Medication	-.07	-.08	.21*	-.01	-.01	.00	.14	-.05	.01	.03	.07	.08	.12	.21*	.03	.06	.02	.03		
20. Texting & Driving	.05	-.10	.23*	-.05	-.02	.38**	-.12	-.06	.21*	-.01	-.05	.48**	-.10	-.17	.01	-.03	.01	-.01	-.02	
m	3.03	11.04	5.88	1.24	41.10	8.38	0.84	13.29	2.47	34.59	0.38	8.74	0.67	25.02	4.39	4.77	0.72	0.34	2.81	0.74
sd	2.51	7.23	4.28	1.97	57.71	27.73	1.31	10.68	4.54	29.23	1.64	8.28	1.91	21.93	4.26	6.42	0.90	0.89	4.51	2.43

*p<.05, **p<.01

Table 13: Correlations and Descriptive Statistics for Contextual Stability Variables, Study 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Exercise																				
2. Fruit & Vegetables	.28*																			
3. Unhealthy Snacking	.34**	.41**																		
4. Alcohol	.56**	.52**	.43**																	
5. Internet	.27*	.22*	.36**	.44**																
6. Smoking	.52*	.57**	.35	.67**	.55**															
7. Seafood	.43**	.66**	.31*	.60**	.29*	.77**														
8. Food Safety	.23	.48**	.38**	.59**	.43**	.30	.33*													
9. Active Commuting	.30	.37*	.05	.64**	.32*	.67**	.45*	.27												
10. Handwashing	.33**	.44**	.41**	.46**	.44**	.70**	.60**	.48**	.17											
11. IT Use	.42	.38	-.04	.57*	.39	.96**	.84**	.25	.73*	.47*										
12. Car Use	.29*	.39**	.24*	.47**	.23*	.69**	.52**	.38**	.39*	.38**	.48*									
13. Sunscreen	.56**	.31	.19	.74**	.21	.57	.76**	.23	.64**	.64**	.81**	.57**								
14. Sitting	.46**	.29**	.34**	.72**	.41**	.45*	.53**	.34**	.37*	.42**	.46*	.35**	.58**							
15. Flossing	.33*	.19	-.02	.29	-.11	.59**	.47**	.03	.37*	.22	.47*	.33**	.71**	.01						
16. Recycling	.34**	.41**	.16	.58**	.38**	.47*	.52**	.29*	.50**	.28*	.44*	.07	.33	.33**	.11					
17. Savings	.34*	.30*	.16	.55**	.28*	.23	.36	.28*	.26	.28*	.40	.17	.36	.38**	.04	.50**				
18. Condom Use	.46	.77**	.25	.68*	.22	.82*	.84**	.51*	.88*	.63**	.89	.52*	.89*	.26	.50	.67*	.57			
19. Medication	.14	.19	.27	.06	.18	.18	.29	.01	.41	.31	.13	-.14	.46	.02	.39*	.16	-.04	.27		
20. Texting & Driving	.66**	.62**	.62**	.65**	.12	.86**	.71**	.39	.41	.83**	.91**	.49*	.83*	.62**	.73**	.11	.07	.73	.45	
m	71.00	57.95	48.01	66.27	65.02	59.27	51.49	66.69	69.00	68.17	33.33	65.16	64.24	68.84	81.71	68.83	66.14	64.46	80.23	38.68
sd	19.69	18.76	18.44	21.87	16.99	27.57	23.09	19.81	27.60	15.60	20.43	19.74	34.20	15.93	17.31	20.89	22.56	23.03	23.06	25.13

*p<.05, **p<.01

Table 14: Correlations and Descriptive Statistics for Natural Reward Variables, Study 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Exercise																				
2. Fruit & Vegetables	.40**																			
3. Unhealthy Snacking	-.22*	-.30**																		
4. Alcohol	.17	-.07	.07																	
5. Internet	-.12	-.01	.20	-.12																
6. Smoking	.04	-.21	.25*	.41**	-.18															
7. Seafood	.07	.04	-.09	.02	-.03	.33**														
8. Food Safety	.10	.37**	-.27**	-.22*	.09	-.44**	.01													
9. Active Commuting	.09	.34**	-.06	.10	-.03	.16	.24*	-.06												
10. Handwashing	.38**	.39**	-.38**	.06	.06	-.18	.06	.51**	.05											
11. IT Use	-.03	-.10	.20	.03	-.06	.19	.19	-.20	.07	-.30*										
12. Car Use	-.05	.01	.21*	.23*	.06	.05	-.11	.03	-.20	.13	-.04									
13. Sunscreen	.43**	.57**	-.24*	.01	.15	-.15	-.05	.33**	.00	.37**	-.26*	.05								
14. Sitting	-.33**	-.51**	.22*	.08	.22*	.08	-.03	-.04	-.24*	-.11	.12	.21*	-.44**							
15. Flossing	.34**	.42**	-.15	.09	.02	-.07	.10	.23*	.29*	.51**	-.15	.07	.29*	-.19						
16. Recycling	.38**	.50**	-.34**	.10	.08	-.28*	-.12	.43**	.22	.42**	-.19	-.14	.34**	-.22*	.36**					
17. Savings	.31**	.39**	-.38**	-.11	-.06	-.29*	-.02	.23*	.01	.51**	-.23	.09	.35**	-.17	.34**	.26*				
18. Condom Use	.01	-.02	.19	.25*	.11	.21	-.18	-.09	-.04	-.06	.22	.12	.07	.15	-.08	-.09	.08			
19. Medication	.16	.03	.02	-.10	.32**	-.21	.09	.08	-.08	.10	.14	-.03	.16	.14	.02	.25*	.15	.08		
20. Texting & Driving	-.07	-.38**	.16	.09	-.03	.41**	.19	-.32**	.01	-.29*	.29*	-.21	-.21	.18	-.15	-.35**	-.39**	.07	-.03	
m	2.18	2.66	-0.46	-0.15	1.73	-1.62	0.40	2.83	0.44	2.88	-1.15	0.81	0.87	-0.62	1.80	2.64	2.88	0.04	0.65	-2.69
sd	1.90	1.53	1.55	1.77	1.57	3.16	2.50	1.84	1.63	1.80	2.12	1.56	1.50	1.93	1.91	1.78	1.90	2.29	1.75	2.32

*p<.05, **p<.01

Table 15: Within-behavior correlations between frequency, stability, and reward, study 3.

	Frequency & Stability	Frequency & Reward	Stability & Reward
1. Exercise	.05	.61 **	.05
2. Fruit & Vegetables	.20	.50 **	.15
3. Unhealthy Snacking	.34 **	.18	.23 *
4. Alcohol	.14	.21	.08
5. Internet	- .10	- .11	.17
6. Smoking	.36	.39 **	.62 **
7. Seafood	.24	.49 **	.28
8. Food Safety	.33 **	.40 **	.29 **
9. Active Commuting	.29	.08	- .04
10. Handwashing	- .06	.14	.37 **
11. IT Use	.23	- .10	- .35
12. Car Use	.27 *	.11	.02
13. Sunscreen	.53 **	.60 **	.47 *
14. Sitting	- .08	.09	- .18
15. Flossing	.47 **	.57 **	.27 *
16. Recycling	.16	.40 **	.42 **
17. Savings	.16	.24 *	.14
18. Condom Use	.41	.42 **	.42
19. Medication	.60 **	.55 **	.22
20. Texting & Driving	.27	.09	.23

*p<.05, **p<.01

This model is based on the first one, but in order to limit the number of predictors and avoid depleting the available degrees of freedom, we kept only the variables that demonstrated a statistically significant effect (habit measure length, use of self-reported behavioral measure, habit-behavior measurement lag, intervention). To these, we added the moderator variables describing the behavior from which the effect size was drawn—namely, the behavior's average frequency, the stability of its context, and its tendency to provide natural reinforcement. We also included the interaction terms resulting from all combinations of these three variables.

Model 2 again found significant heterogeneity, I^2=95.20% (95% *CI* = 93.50, 96.72). Like Model 1, larger habit-behavior effect sizes were associated with non-intervention samples, longer habit strength measures, the use of self-report measures of behavior instead of observation, and a shorter lag between the measurement of habit and the measurement of behavior (see Table 16). Among the moderators drawn from the external survey, contextual stability demonstrated a marginally significant positive relationship with effect size (see Figure 11). There was also a marginally significant interaction between the effects of frequency and natural reinforcement. Finally, there was a significant three-way interaction between the effects of frequency, contextual stability, and natural reinforcement.

We have illustrated this 3-way interaction in Figure 12 by creating subsamples using median splits. High and low frequency behaviors are represented on plots 1 and 2, respectively. High and low natural reinforcement are illustrated in each plot by separate lines. The lines correspond to the effect of contextual stability (x-axis) on the estimated mean habit-behavior effect size (y axis). As this Figure shows, the generally positive effect of contextual stability on the habit-behavior relationship is reduced in cases of low-frequency behaviors, and entirely

reversed in cases of behaviors that are low in frequency and low or negative in natural reinforcement.

Table 16: Meta-analytic regression, mixed effects model 2.

	b	***SE(b)***	***z***	***p***
Sample is Intervention Control[a]	-0.2457	0.0808	-3.042	**.002**
Habit: Measure Length	0.0147	0.0057	2.584	**.010**
Behavior: Measure is Self-Reported[b]	0.4225	0.0623	6.781	**<.001**
Habit-Behavior Measurement Lag	-0.0012	0.0006	-2.032	**.042**
Typical Behavioral Frequency	0.0055	0.0050	1.096	.273
Typical Contextual Stability	0.0065	0.0039	1.656	.098
Typical Natural Reinforcement	-0.0149	0.0243	-0.614	.539
Interaction: Frequency × Stability	-0.0011	0.0011	-1.051	.293
Interaction: Frequency × Reinforcement	0.0063	0.0038	1.683	.092
Interaction: Stability × Reinforcement	-0.0032	0.0030	-1.071	.284
Interaction: Frequency × Stability × Reinforcement	-0.0010	0.0005	-2.041	**.041**
Intercept[c]	0.4812	0.0253	19.0198	**<.001**

Note: Regression coefficient *(b)* describes relationship between moderator variable and effect size; positive *b* indicates that greater moderator value predicts a stronger habit-behavior relationship. *p* values in **boldface reached conventional levels of significance (*p*<.05).**

a. Dummy coded, comparison is "Sample is from non-intervention study"

b. Dummy coded, comparison is "Behavior: Measurement is Observation"

c. Calculated with each moderator entered in its mean-centered form.

Figure 11: Moving constant plot of the habit-behavior relationship by contextual stability, with other moderators controlled at their mean values (Mixed-effects model 2).

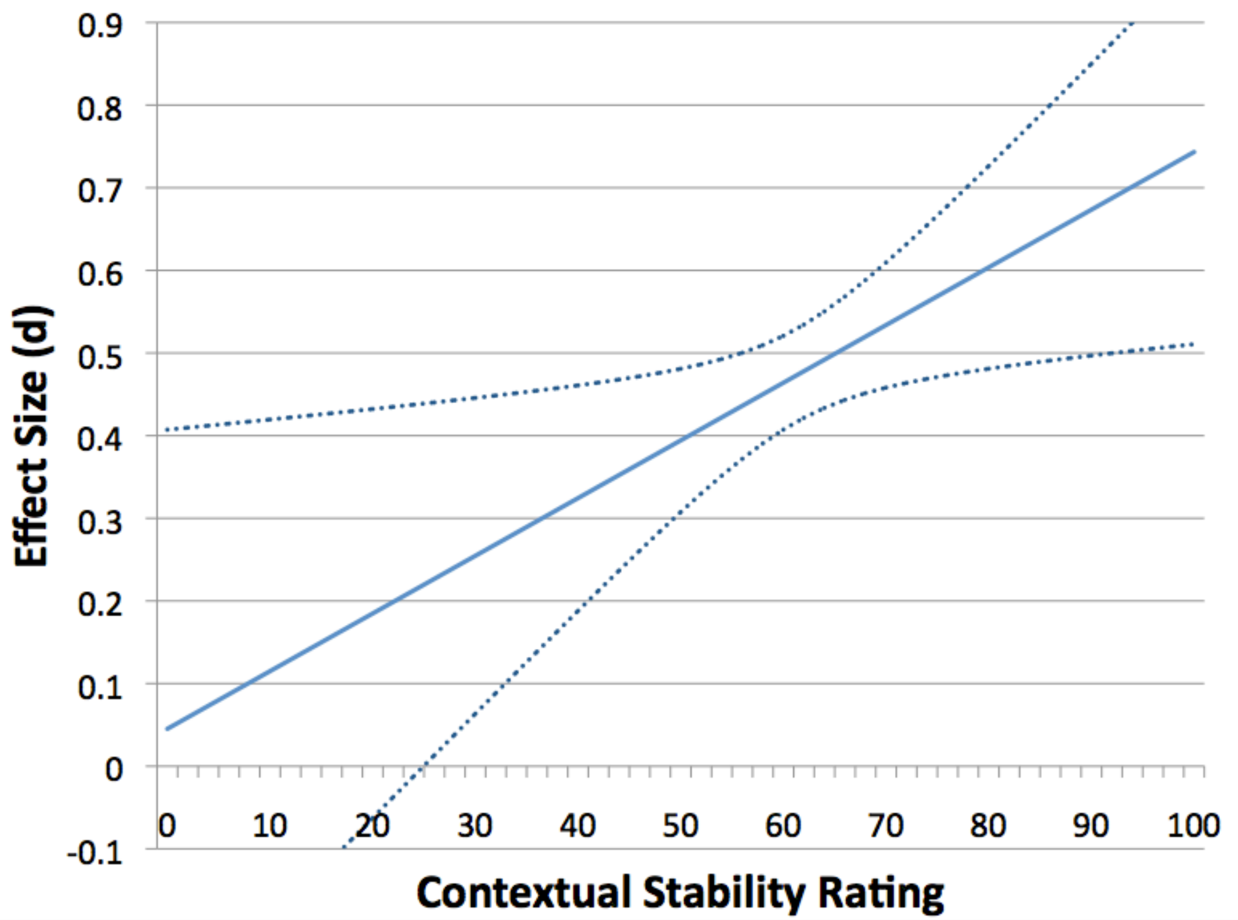
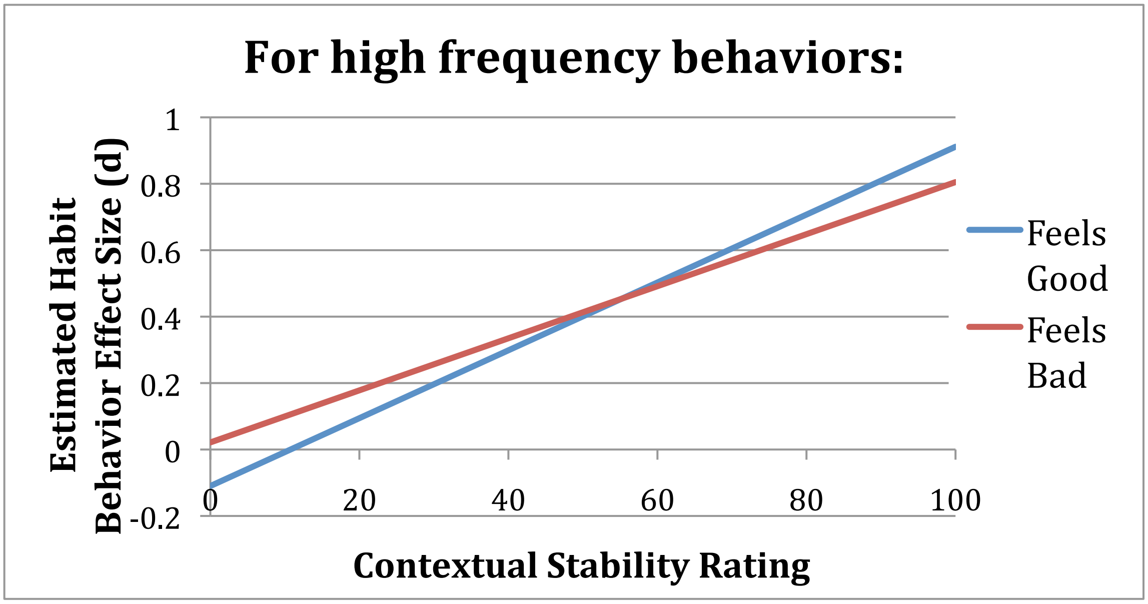
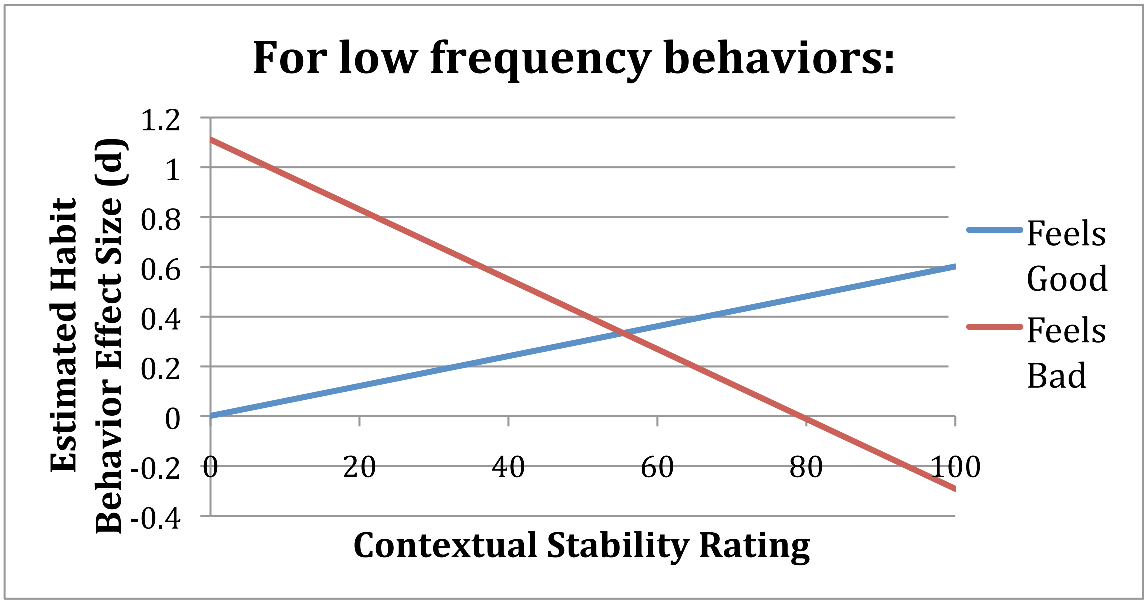


Figure 12: Plot of the 3-way interaction between contextual stability, behavioral frequency, and natural reward on the estimated habit-behavior relationship, all other moderators controlled at their mean values (Mixed-effects model 2).





General Discussion

Overview

Habits are an important psychological construct because they exert a powerful influence on behavior and because they are ubiquitous in daily life. Psychological theory tends to define habits as patterns of frequent behavior that are triggered automatically by cues in the environment. The contributions of frequency and automaticity have been very well demonstrated in the empirical literature. Less is known about the mental association that links environmental cues with the performance of behavioral, even though the assumption of such an association forms the basis of habit theory and of my most commonly used methods. In the present research, we aimed to catch a glimpse of the association and to evaluate a selection of ideas that are implicit in an association-based view of habits. To this end, this dissertation reported three studies: an experiment, a test of a new measurement tool, and a meta-analysis.

In Study 1, we looked for evidence of the cue-behavior association, using a word-completion task to prime experimental participants with features of a bathroom environment and test whether this brought flossing to mind. We also measured their flossing habits in terms of frequency, automaticity, and two new constructs: contextual stability and natural reinforcement. In Study 2, we attempted to measure participants' flossing habits in terms of their mental associations between flossing and features of the environment in which they floss. We created three versions of a new Implicit Association Test that allowed participants to populate the task stimuli with objects in their bathrooms, sounds in the bathrooms, and activities in their nightly routines. In Study 3, we aggregated studies on habit strength across a wide spectrum of behaviors to gain insight on the general structure of habits as a psychological construct. We also performed a new survey in order to describe each behavior in terms of its typical frequency, contextual

stability, and natural reward, and attempted to use these aspects to interpret the various habit-behavior relationships represented in my sample of effect sizes. Each of these studies contributed to an understanding of habit in multiple ways.

Detecting the cue-behavior association. Studies 1 and 2 used computer-based tasks intended to detect and measure the mental cue-behavior association that is thought to underlie habits. In Study 1's word-completion task, priming participants with bathroom-related concepts did not appear to bring flossing to mind, no matter the strength of their flossing habits. In Study 2's Implicit Association Test, the strength of participants' flossing habits seemingly had no effect on the degree to which they associated flossing with the features of their flossing environment. Ultimately, we remain without any direct way to measure the cue-behavior association, and further, without any direct evidence that it is truly the mechanism by which habits operate.

Nonetheless, we suggest that the cue-behavior association is still worth pursuing. In particular, it appears that the specific nature and action of the association deserves further theoretical development and empirical exploration. The results of my studies call into question my assumption that the association is semantic in nature—that it is mediated by activation passing through networks of general concepts such as "bathroom" and "flossing." Instead, future research might investigate the possibility of an association that connects the perception of environmental cues directly to behavioral schema. Studies in kinesiology and sports psychology have observed specific patterns of brain activation in trained athletes while visualizing the performance of their sport. Could we use this methodology to develop profiles of neural activation corresponding to habitual actions, such as flossing? Would we find that objects from the flossing environment elicit this profile more strongly in those who have a stronger flossing habit? Might this effect persist even if word association tests of the same people revealed no

difference? Such a procedure would not make for a feasible measure of habit strength in most habit studies, of course, but it might point us toward the constructs that we ought to target with new measures.

Contextual stability and natural reinforcement. In my push to explore beyond frequency and automaticity, we set out to test two classic hypotheses of habit theory: that behaviors should form into the strongest habits when they (a) occur in a consistent context, and (b) feel good. We hoped to demonstrate these effects in various behavioral realms, and to introduce tools to aid in their further exploration. Study 1 deployed two new scales: The first, a measure of contextual stability, specified to fully describe a behavior in terms of Ajzen and Fishbein's (1977) TACT concepts; the second, a new measure of the pleasant and unpleasant sensations and feelings that people experience as a result of doing and not a behavior. We found that my measure of stability was reliable, and that it predicted flossing habit strength in tandem with natural reinforcement. Study 3 found that, across 20 different behaviors, a high degree of contextual stability predicts a strong relationship between habit strength and behavior. Also, the effect of contextual stability interacts with both natural reward and frequency.

Overall, my studies seem to have supported the idea that both contextual stability and natural reinforcement are at work in basic habit processes. These concepts are not new to habit theory, but they have been rather under-utilized in an empirical literature that is focused mainly on the automaticity component of habit. In future research, these constructs or some version of them deserve consideration and may well enter into common use alongside the SRHI, and that the literature will see a renewed vigor in the effort to identify and develop new and promising habit constructs.

For instance, although Study 2 included “other people” in its measure of contextual stability, we have not even scratched the surface of the vast, unexplored realm of social perception and influence in habit theory. Because people, as social animals, are naturally attuned to other people, it would follow that habits and all of their supporting processes are tightly woven into the fabric of interactions with family, friends, coworkers, neighbors, and so on. Perhaps next we will delve into the psychological processes involved in the transmission of habits through normative perception in dyads. Or, as one of the participants in Study X phrased it in the comments section, “my girlfriend and I both floss, but only when we’re around each other.”

Age and gender. We examined the roles of age and gender throughout the present research, hypothesizing that (a) women would report stronger flossing habits than men, (b) flossing habits would increase in strength with age, (c) the latter effect would be more pronounced in men than in women. Results yielded some evidence for all of these hypotheses, but each was only supported in a different one out of the three studies. We found an age effect only in Study 2, wherein older participants reported flossing more frequently than younger participants. We found a gender effect only in Study 3, wherein samples that had more women yielded stronger habit-behavior correlations. We found an age-gender interaction only in Study 1, wherein flossing habit strength increased with age more for male than for female participants.

Overall, evidence concerning age and gender in habits is mixed. It seems to suggest that both are indeed important considerations in habit research, but does not conclusively enumerate what specific roles they play. One likely implication is that age and gender play many different roles. Especially when considering a variety of behaviors as we did in my meta-analysis, future research should accommodate the possibility a wide range of gender and age differences, not

only in the overall habit but in its contributing factors as well. Even considering a single construct and behavior—the natural reinforcement in exercise habits, for example—a multitude of possible effects spring readily to mind.

The good and bad physical sensations that follow a hearty run are likely to differ between a child and a grandparent. The emotional consequences of skipping a workout are likely experienced in terms of oft-gendered values and beliefs, such as those deriving from an environment that scrutinizes weight and appearance, or those deriving from an environment that reveres competitive achievement. Hopefully, the self-relevant implications of joining a sports team will differ less for boys and girls born in the last 10 years than for men and women raised in a time when female physicality was discouraged. Each story told by future habit research will require research methods tuned to different sensitivities, and each promises to contribute to habit theory in a different way.

Strengths

Although the three studies in this dissertation leave the bulk of its original questions unanswered, they do offer a number of features that are not commonly found in the relevant literatures. For one, as observed in the meta-analysis, the number of studies on flossing in habit research is still small, and we are happy to contribute to the body of findings in this area. Studies 1 and 2, though they did not reveal significant effects, stand out in a habit literature that remains mostly correlational. Study 2's use of the IAT, though it did prove to be an effective measure, is among a very small number of studies that have employed non self-report gauges of habit strength. Perhaps most importantly, my proposal and investigation of contextual stability and natural reinforcement add attention to the set of theoretical habit constructs, which has been largely dominated by frequency and automaticity. In addition, the broad scope of my meta-

analysis affords a unique advantage. Few previous studies have included multiple behaviors, and fewer still have drawn on the differences between behaviors to produce new insights into habit as a general construct. Further, if the use of SRHI-based measures continues to grow at its current pace, this may well be the last time that it is feasible to fit the entire literature into a single meta-analysis.

Limitations

Although we did make use of experimental methods, my only findings of interest are based on data that are correlational in nature. Consequently, there is no evidence concerning causality or developmental factors. Although experimental and longitudinal designs are rare in the current body of habit research, they are of vital importance in bringing habit theory to its full potential. Health psychologists' most pressing questions often revolve around how habits form over time, and how one might design techniques to build up healthy ones and break down unhealthy ones.

Similarly, the current studies did not include the measurement of specific instances of behavior. We relied on self-reported recall of past behavior, whereas there are considerably more advanced methods of behavioral measurement available in the habit literature. For instance, many of the effect sizes in my meta-analysis were derived from indices of daily diary entries. Some studies even used the direct observation of participants' behavior in the lab setting. Others made clever use of strategies to indirectly observe behavior, such as by using electronic monitoring caps on bottles of vitamins or measuring the weight of used packets of floss (Judah, 2015). Methods such as these will be important to future research, especially in an area dedicated to decoding behavior that by definition is often done without conscious intent or awareness.

In addition, although my studies were set up to test for gender and age effects, my selection of measures does not allow us to evaluate the ideas that led us to hypothesize these effects in the first place. We cannot interpret what it means for habit theory that older people have stronger flossing habits than younger people unless we can find a clearer picture of *why* this is the case. Ultimately, habit theory will not advance so much from the mere detection of gender and age effects as from the empirical explanation thereof, and the resulting discovery of constructs that influence, interact with, and even constitute habits.

Conclusions

Habit research has enjoyed a gold rush of sorts with the introduction of valid and easily deployed tools for measuring behavioral automaticity. While these tools have produced many rich returns and found fertile ground in a wide variety of behaviors, we feel there are still myriad untapped veins waiting for the curious souls who would venture yet further afield. Perhaps the richest strike of all will be the element at the very core of habit, the cue-behavior association. Though it remains for now a mythic treasure, its secrets promise to increase not only my knowledge about habits, but also my very capacity for gathering new knowledge about habits.

Appendix A: A review of conceptualizations of habits in previous research, including definition, recurring themes, and specific meaning of the term "habit"

Paper	Definition of Habit	Key Features	A "Habit" is
Triandis, 1980	"Situation-specific sequences that are or have become automatic, so that they occur without self-instruction"	Context, automaticity	A behavioral sequences
Ouellette & Wood, 1998	"tendencies to repeat responses given a stable supporting context"	Repetition, context	A behavioral tendency
Verplanken & Aarts, 1999	"Learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states"	Learning, automaticity, goals	A behavioral sequence
Aarts & Dijksterhuis, 2000	"we conceive of habits as a form of goal-directed automatic behavior," "...habits are represented as links between a goal and actions that are instrumental in attaining this goal. The strength of such links is dependent on frequent co-activation of the goal and the relevant actions in the past," "...habits can be seen as hierarchical mental representations in which activation of a goal leads to activation of a number of associated behaviors lower in the hierarchy."	Association, goals, repetition, learning	A behavior; a mental representation
Wood, Quinn, & Kashy, 2002	"habit performance reflects the routine repetition of past acts that is cued by stable features of the environment"	Repetition, automaticity, context	A behavioral tendency
Haddock & Maio, ???	"Habits also possess the characteristics of automaticity... developed as a result of repeated behavioral responses to a particular environmental cue"	Automaticity, learning, repetition, context	A behavior
Verplanken & Orbell, 2003	"features of a habit... a history of repetition, automaticity lack of control and awareness, efficiency, and expressing identity	Repetition, automaticity, identity	
Strack & Deutsch, 2004	"Behavioral schemata and their links to other contents in the impulsive system can be understood as habits "	Automaticity, association	A behavioral schema; a mental association
Ajzen & Fishbein, 2005	"with repeated performance, behavior is assumed to come under the control of stimulus cues, bypassing intentions and perceptions of behavioral control"	Repetition, learning, context, automaticity	A series of past behaviors

Wood, Tam, & Witt, 2005	"Behavioral dispositions to repeat well-practiced actions given recurring circumstances."	Repetition, learning, context	A behavioral tendency
Neal, Wood, & Quinn, 2006	"response dispositions that are activated automatically by the context cues that co-occurred with responses during past performance"	Repetition, automaticity, context, association, learning	A response tendency
Verplanken, 2006	"When a person repeatedly faces the same behavioural choice in the same situation, and thus repeats his or her previous response, associations build up between the cues that define the context and this person's response. Given that the context remains stable and the response is satisfactory, these associations then acquire a degree of automaticity"	Repetition, association, context, automaticity	A response tendency
Verplanken & Wood, 2006	"Habits are a form of automaticity in responding that develops as people repeat actions in stable circumstances"	Automaticity, learning, repetition, context	Automaticity in responding
Webb & Sheeran, 2006	"Behaviors that are performed frequently in stable contexts support the development of habits"	Repetition, context, learning	A behavior
Wood & Neal, 2007	"Habits are learned dispositions to repeat past responses. They are triggered by features of the context that have covaried frequently with past performance, including performance locations, preceding actions in a sequence, and particular people. Contexts activate habitual responses directly, without the mediation of goal states."	Learning, context, repetition, automaticity	A behavioral tendency
Verplanken, 2007	"Habit is behavior that has a history of repetition, is characterized by a lack of awareness and conscious intent, is mentally efficient, and is sometimes difficult to control"	Repetition, automaticity	A behavior
Verplanken, 2008	"repeated behavior that has gained a degree of automaticity, and is executed in stable contexts"	Repetition, automaticity, context	A behavior
Gardner, 2009	"automatic responses to everyday contexts, learned through repeated performance in those contexts"	Automaticity, context, learning, repetition, association	A response

Tobias 2009	"Habits are defined as slowly developing associations between situational cues and repeatedly performed behavior options"	Learning, association, context, repetition	A mental association
Webb, Sheeran, & Luszczynska, 2009	"a history of reinforcement means that the learned response is elicited relatively automatically when the associated cue is encountered"	Learning, automaticity, association, context	
Collins & Mullan, 2010	"predispositions to act without conscious intention... likely when behaviors are performed with high frequency in stable situational contexts"	Automaticity, repetition, context	A behavioral tendency
Lally, van Jaarsveld, Potts, & Wardle, 2010	"As behaviours are repeated in consistent settings they then begin to proceed more efficiently and with less thought as control of the behaviour transfers to cues in the environment that activate an automatic response: a habit"	Repetition, learning, automaticity, context, automaticity	
Gardner, 2011	"behavioural patterns learned through context-dependent repetition: repeated performance in unvarying settings reinforces context-behaviour associations such that, subsequently, encountering the context is sufficient to automatically cue the habitual response"	Learning, context, repetition, association, automaticity	A behavioral tendency
Orbell & Verplanken, 2011	"Habit might be usefully characterized as a form of automaticity that involves the association of a cue and a response."	Automaticity, association	Automaticity
Judah, Gardner, & Aunger, 2012	"The formation of habit – that is, a learnt automatic response to contextual cues – requires initiation of a behaviour and repetition in a constant context"	Learning, automaticity, context, repetition, association	A response
Nilsen, Roback, Broström, & Ellström, 2012	"Habit is behaviour that has been repeated until it has become more or less automatic, enacted without purposeful thinking, largely without any sense of awareness"	Repetition, learning, automaticity	A behavior

Appendix B: The Self-Report Habit-Strength Index (Verplanken & Orbell, 2003)

Please rate each of the following statements from 1-5 in terms of how much you agree or disagree with them:

1	**2**	**3**	**4**	**5***
Disagree Strongly	Disagree somewhat	Neither Agree nor Disagree	Agree Somewhat	Agree Strongly

(Behavior)___is something that...

___ 1. I do frequently.
___ 2. I do automatically.
___ 3. I do without having to consciously remember.
___ 4. that makes me feel weird if I do not do it.
___ 5. I do without thinking.
___ 6. that would require effort not to do it.
___ 7. that belongs to my (daily, weekly, monthly) routine.
___ 8. I start doing before I realize I'm doing it.
___ 9. I would find hard not to do.
___ 10. I have no need to think about doing.
___ 11. that's typically "me."
___ 12. I have been doing for a long time.
**

*The items are accompanied by response scales anchored by agree/disagree and preferably should contain five or more response categories.

**Some items may have to be reworded in line with the behavior under study.

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