RUNNING HEAD: Habitual Instigation and Execution

Habitual Instigation and Habitual Execution:

Definition, Measurement, and Effects on Behaviour Frequency

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Statement of contribution

What is already known?

- Habit is often used to understand, explain and change health behaviour
- Making behaviour habitual has been proposed as a means of maintaining behaviour change
- Concerns have been raised about the extent to which health behaviour can be habitual

What does this study add?

- A conceptual and empirical rationale for discerning habitually instigated and habitually executed behaviour
- Results show habit-behaviour effects are mostly attributable to habitual instigation, not execution
- The most common habit measure, the Self-Report Habit Index, measures habitual instigation, not execution

Abstract

Objectives. 'Habit' is a process whereby situational cues generate behaviour automatically, via activation of cue-behaviour associations developed through past performance. This paper presents a conceptual and empirical rationale for distinguishing between two manifestations of habit in health behaviour, triggering selection and initiation of an action ('habitual instigation'), or automating progression through sub-actions required to complete action ('habitual execution'). We propose that habitual instigation accounts for habit-action relationships, and is the manifestation captured by the Self-Report Habit Index (SRHI), the dominant measure in health psychology.

Design. Conceptual analysis, and prospective survey.

Methods. Student participants (N = 229) completed measures of intentions, the original, non-specific SRHI, an instigation-specific SRHI variant, an execution-specific variant, and, one week later, behaviour, in three health domains (flossing, snacking, breakfast consumption). Effects of habitual instigation and execution on behaviour were modelled using regression analyses, with simple slopes analysis to test habit-intention interactions. Relationships between instigation, execution, and non-specific SRHI variants were assessed via correlations and factor analyses.

Results. The instigation SRHI was uniformly more predictive of behaviour frequency than the execution SRHI, and corresponded more closely with the original SRHI in correlation and factor analyses.

Conclusions. Further, experimental work is needed to separate the impact of the two habit manifestations more rigorously. Nonetheless, findings qualify calls for habit-based interventions by suggesting that behavior maintenance may be better served by habitual instigation, and that disrupting habitual behavior may depend on overriding habits of instigation. Greater precision of measurement may help to minimise confusion between habitual instigation and execution.

KEYWORDS:

Habit; automaticity; theory; behaviour

Introduction

Many health-related behaviours are performed repeatedly, with minimal conscious awareness or prior deliberation (Wood, Quinn, & Kashy, 2002). The concept of 'habit' – whereby behaviour is automatically elicited by cues that have consistently preceded previous performances (Verplanken & Aarts, 1999) – is often used to predict and explain recurrent health behaviours (e.g. Nilsen, Roback, Broström, & Ellström, 2012; van't Riet, Sijtsema, Dagevos, & De Bruijn, 2011). Repetition in consistent contexts reinforces mental context-behaviour associations, such that the context acquires the potential to automatically trigger the behaviour, and alternatives become less mentally accessible (Danner, Aarts, & de Vries, 2007). Unlike intentional action, generated through effortful deliberative processing, habitual action is activated via an impulsive processing system, whereby cues trigger stored context-behaviour associations, which subsequently guide responses rapidly, with minimal effort, awareness, control or intention (Strack & Deutsch, 2004). As habit forms, action control is transferred to the impulsive system, so that initially intentional actions become automatic, freeing cognitive resources for other tasks (Wood et al, 2002). Theory predicts that, in associated contexts, habit will consistently elicit behaviour, and diminish the influence of intention on action, such that behaviour may proceed even where conscious motivation is low (Triandis, 1977). Evidence of these effects has prompted interest in habit formation as a mechanism for health behaviour maintenance (Gardner, de Bruijn & Lally, 2011; but see Gardner, Corbridge & McGowan, 2015), and habit disruption for modifying ingrained unhealthy behaviours (Rothman, Sheeran & Wood, 2009). Some commentators have however questioned the extent to which health behaviour can be habitual (Maddux, 1997), as few actions are experienced as fully automated. This criticism depends on a conceptualization of 'habitual behaviour' as action that is, without conscious oversight, both selected from available options and performed to completion. This paper has two aims: first, we present a conceptual analysis of 'habitual behaviour', which proposes a distinction between two manifestations of habit within behaviour; and second, we present new empirical evidence as proof of principle of the utility of this distinction for enhancing behaviour prediction and habit measurement.

What is 'habitual behaviour'? A conceptual analysis

Deconstructing 'habitual behaviour' requires a coherent definition of 'habit'. Portraying habit as a *form* of behaviour is incompatible with theoretical accounts of habit as a *determinant* of behaviour; 'habit cannot be both the behaviour and the cause of the behaviour' (Maddux, 1997, p336). Additionally, people can identify and block unwanted habitual actions (Quinn, Pascoe, Wood, & Neal, 2010), suggesting that habit does not directly generate behaviour, but rather activates an impulse which, unless frustrated, guides action (Gardner, 2015a, 2015b). Gardner (2015a) thus defined habit as '*a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations'* (p4). Within this definition, an 'impulse' is a mental action representation (or action schema) which, unless opposed by stronger competing impulses, guides behaviour effortlessly, bypassing awareness (West & Brown, 2013). A distinction is thus achieved between *habit*, which describes a process, and *habitual behaviour*, which denotes a manifestation of that process in action. Gardner's (2015a) definition portrays habit as conceptually distinct from behaviour, and as a potential determinant of behaviour, so is consistent with theories of habitual action (e.g., Triandis, 1977).

Understanding 'habitual behaviour' also depends on understanding how 'behaviour' may be facilitated by habit. All actions can be broken down into sub-components. Action-phase models deconstruct action into sequential phases, originating in a phase prior to selecting an action and concluding in the completion of action or reflection on its outcomes (e.g. Heckhausen & Kuhl, 1985). The Rubicon model, for example, depicts phases of predecision (characterized by deliberating over which action to pursue, and culminating in deciding to act), postdecision (characterized by deliberation over when, where and how to enact an action, culminating in action initiation), and action (Heckhausen & Kuhl, 1985). Models of the cognitive structures underpinning behaviour portray action hierarchically, such that all actions are composed of discrete lower-level sub-actions that serve to complete the higher-order action (for examples, see Botvinick, Niv, & Barto, 2009; Cooper & Shallice, 2000, 2006). For example, 'going for a run' may be decomposed into sub-actions such as 'putting on sneakers' and 'leaving the house', each of which can be decomposed further (e.g. 'putting on left sneaker', 'tieing sneaker laces', 'putting on right sneaker')[1]. People often do not consciously attend to lower-level actions: we tend to mentally represent actions at high levels of abstraction, according to reasons for or likely consequences of performance (e.g. 'visiting a friend'), rather than lower-level procedural intricacies (e.g. 'pressing the doorbell') (Vallacher & Wegner, 1987; Zacks & Swallow, 2007). These perspectives may be reconciled by recognizing that action involves at least two stages: *selecting an action,* which in action-phase terminology entails the decision to act and, in

[1] Viewing behaviour as a fractal creates an infinite regress, avoidance of which requires the assumption that there is a base level at which action should be conceived, such that analysis at a yet finer level is no longer directly relevant to understanding meaningful behaviour (e.g. patterns of muscle activation). The cognitive modelling approach views the basic level of analysis as that of purposeful physical movements. For example, Cooper and Shallice (2000) decompose the discrete behavioural steps involved in 'preparing instant coffee' no further than the level of 'pick up', 'put down', 'tear', 'unscrew', and so on. This level of analysis is sufficient for the purposes of this paper.

cognitive terminology, activation of a high-level action schema; and *performing the action*, involving successful completion and termination of the action phase, or the concatenated discharge of lower-level sub-actions that comprise the higher-level.

Two corresponding accounts of the role of habit in action can be inferred from existing treatments of 'habitual behaviour'. The first describes habitual selection and initiation of behaviour (e.g., Verplanken & Melkevik, 2008; Wood & Rünger, 2016): encountering a context (e.g. arriving home) automatically triggers a stored mental representation (or action schema) of an associated and perceptually unitary action (e.g. going for a run), which, unless sufficiently opposed, translates directly into action initiation (e.g. changing into running clothes). From this perspective, 'going for a run', for example, is habitual to the extent that, upon encountering associated cues, the actor is automatically prompted to select the 'going for a run' action unit, and so begins enacting the sub-actions required to 'go for a run' (e.g. 'put on sneakers'). Indeed, one study found that, when primed with the contexts in which they run, habitual runners were quicker to recognize the word 'running' than those not primed (Neal, Wood, Labrecque, & Lally, 2012), indicating that context exposure activated a 'running' schema. Within this account, the habit process guides selection of *which* behaviour to pursue, and usually mobilises the first sub-action required to pursue it. From an action-phase perspective, habit facilitates movement from predecision into action, automatically generating a commitment to immediately pursue the habitual behaviour, so bypassing preactional deliberation (cf Verplanken, Aarts & van Knippenberg, 1997). We term this *'habitual instigation'* of behaviour, whereby *the habit process generates selection of a behavioural target, which, unless frustrated, instigates its realization into* *action* (see too Gardner, 2015a; Phillips & Gardner, 2015)[2]. Completion of the action subsequently proceeds via the (habitual or non-habitual) activation of lower-level sub-actions. Potentially, any internal or external event may trigger habitual instigation (Verplanken, 2005), though studies of what we deem habitual instigation have focused on location, social environment, time, mood, and preceding actions (Judah, Gardner, & Aunger, 2013; Wood et al, 2002).

A second account portrays habit as a facilitator of progression through an action sequence such that, after an action has been selected, its performance proceeds to completion through habitual activation of its sub-components (e.g. Graybiel, 1998; Verplanken & Aarts, 1999). This form of habitual behaviour is akin to skill (Anderson, 1982): through repeated practice, sub-actions required to complete a higher-level action become perceptually 'chunked' into automated sequences which, after instigation, are discharged without conscious oversight (Graybiel, 1998; Vallacher & Wegner, 1987). These sequences are 'habitual' in that, within a higher-order sequence (e.g. 'going for a run'), completion of a sub-action (e.g. 'put on sneakers'), or attainment of its consequences (e.g. sneakers are on), automatically activates a subsequent sub-action (e.g. 'leave the house'). In hierarchical terms, this manifestation of habit operates at a more fine-grained level of action than that of the triggered mental action representation (Vallacher & Wegner, 1987). 'Going for a run', for example, would be habitual in this respect to the extent that progression through the sub-actions required to perform what the actor views as 'going for a run' is facilitated by habit. This

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[2] We have previously termed this a 'habit of initiation' (Gardner, 2015a). We have revised our terminology to avoid confusion, as 'initiation' is often used to describe adoption of a new behaviour within a long-term account of behaviour change, which canould incorporate multiple instances of behavioural enactment (Rothman, 2000). We use 'instigation' here to refer to the momentary activation of a single instance of behaviour.

manifestation locates habit within the Rubicon model's action phase and facilitates movement towards termination of action. We term this *'habitual execution'* of behaviour, whereby *the habit process activates lower-level sub-actions subservient to a higher-order behavioural target, and so, unless enactment of any lower-level actions is frustrated, facilitates completion of the higher-order behaviour*[3].

FIGURE 1 HERE

Figure 1 depicts the two hypothesized manifestations as applied to 'going for a run'. Both phenomena are underpinned by the same psychological process (i.e., habit). However, habitual instigation of 'going for a run', prompted by potentially any internal or external cue, operates by committing the actor to an action, and typically instigating the first sub-action within the sequence (e.g. 'put on sneakers'). By contrast, habitual execution occurs after the actor has committed to the action. It denotes progression through subsequent sub-actions (which may include yet lower-level sub-actions necessary to complete 'putting on sneakers'), whereby attainment of a sub-action or its consequences automatically cues the following sub-action in the sequence.

The distinction between habitual instigation and execution is implicit in extant empirical and theoretical work, but often obfuscated in explicit conceptualisations of 'habitual behaviour'. Neuroimaging has shown that two sites are involved in habit formation, the infralimbic cortex being implicated in routine action selection (i.e. instigation), and the sensorimotor striatum in representation of the steps required to discharge routine actions (execution; Smith & Graybiel, 2014). The Norman-Shallice model describes the 'horizontal' triggering of high-level action schemas (instigation),

[3] We have previously termed this a 'habit of performance' (Gardner, 2015a). We now prefer the term 'habitual execution', to more clearly specify behavioural enactment and achieve a clearer distinction with from behavioural instigation (Phillips & Gardner, in press).

and subsequent 'vertical' (i.e. top-down) excitation of subservient lower-level schemas (execution) (Norman & Shallice, 1986). Yet, Graybiel (2008, p361) defines habitual behaviour as *both* automatically triggered (habitual instigation) *and* automatically proceeding to completion (habitual execution). Aarts, Paulussen and Schaalma (1997) describe 'genuine habit formation' as involving both 'automatic decisions on courses of action *and* their subsequent execution' (p369, emphasis added). Two recent exercise habit measures incorporate both activation in response to external triggers (instigation), and invariance of subsequent exercise performance (execution) (Grove, Zillich, & Medic, 2014; Tappe & Glanz, 2013).

A distinction between habitual instigation and execution would have important theoretical and practical implications. Habitual instigation does not necessitate habitual execution, nor vice versa. One person may habitually opt to 'go for a run' (habitual instigation), yet complete the run mindfully, varying elements of performance (e.g. route taken) to avoid boredom (non-habitual execution). Conversely, another may deliberate over whether to go running (non-habitual instigation), but automatically enact the run, paying little attention to the unfolding sequence (habitual execution). The distinction may be less practically relevant for simpler health behaviours, composed of fewer observable sub-components, for which instigation and execution are less discernible (e.g. drinking water; Lally, van Jaarsveld, Potts, & Wardle, 2010). However, many health behaviours to which habit is applied, such as physical activity (e.g. Grove et al, 2014), are complex and rarely experienced as wholly automated (Maddux, 1997). Restricting 'habitual behaviour' to actions that are automatically instigated *and* executed limits its explanatory value for complex actions. Defining 'habitual behaviour' as *either* habitually instigated *or* executed recognizes both as potentially independent manifestations of habit in behaviour. It also allows for behaviour to be both habitual and mindful (e.g. deliberatively instigated, habitually executed).

We hypothesise that habitual instigation and execution reduce the cognitive demands of action, but in different ways. Habitual instigation operates analogous to an automated reminder to act, alleviating the mental burden of deliberative decision-making. Imposing the distinction retrospectively on previous studies, this concurs with research indicating that, with context-dependent performance, activation of action becomes less reliant on external reminders (Tobias, 2009). By contrast, habitual execution makes procedural enactment smooth and efficient, so it can proceed with minimal cognitive oversight. This corresponds with evidence that people can better attend to matters unrelated to ongoing actions executed mindlessly (Wood et al, 2002).

Habitual instigation and habitual execution in action: An empirical study

We have proposed that the same underlying cognitive process (i.e. habit) may instigate and/or facilitate the execution of health behaviour. An empirical study was undertaken to provide proof-of-principle of the distinction, and demonstrate its relevance for developing understanding of the extant empirical literature around habitual health behaviour, using the behaviour-prediction survey design that dominates this literature (Gardner, 2015a). Predictive studies have typically assessed two hypothesized effects of habit on action: a positive correlation between habit strength and behaviour frequency, and an interaction between habit and intention, such that intentions are less predictive of behaviour frequency as habit strengthens (Labrecque & Wood, 2015). We predict that these effects are likely to be attributable to habitual instigation, not execution. For example, habitual gym-goers repeatedly attend the gym because they are automatically cued to do so, not because they follow the same exercise routine while in the gym (Phillips & Gardner, 2015). Conversely, one may habitually execute the same routine in the gym yet attend the gym infrequently (see Gardner, 2012). Habitual execution will likely correlate with behaviour frequency in unvarying contexts because execution patterns develop through repetition (Anderson, 1982; Kaushal & Rhodes, 2015; Lally et al., 2010). Habitual execution is however unlikely to directly *determine* behaviour frequency (Phillips & Gardner, 2015). We also expect that any moderating effect of habit on the intention-behaviour relationship – whereby habit activates behaviour more rapidly and efficiently than do conscious intentions (Labrecque & Wood, 2015) – should be attributable to habitual instigation, not execution. For example, those with weak intentions to go to the gym may be more likely to attend where they are automatically cued to do so.

Existing habit measures do not discern instigation and execution. The only study of the two habit manifestations to date adapted non-specific item stems from the Self-Report Habit Index (SRHI, Verplanken & Orbell, 2003; 'Exercise…' [e.g. '…is something I do automatically']) to specify instigation ('*Deciding to* exercise*…*') or execution (e.g. '*Once I am exercising, going through the steps of my routine…*'; Phillips & Gardner, 2015). Phillips and Gardner (2015) showed that instigation and execution loaded on discrete factors, and only instigation predicted exercise frequency, though measurement incompatibility arising from differently worded behaviours ('going through the steps of my routine' vs 'exercise') may have diminished execution-behaviour associations (Ajzen, 1988). Although the authors did not employ the originally-formulated SRHI for comparison, these findings suggest that the characteristic effects of habit on action frequency, which are typically shown by the SRHI (Gardner et al., 2011), may be attributable more to habitual instigation than execution. This is also supported by evidence showing that forming detailed plans of the contexts in which an action will be enacted (i.e., instigated) can strengthen SRHI scores (e.g. Fleig et al, 2013; Orbell &

Verplanken, 2010, Study 3). It is important to know which manifestation is captured by the SRHI, so as to fully understand findings from previous studies of health habits.

This study was undertaken to address two research questions arising from the hypothesized distinction between habitual instigation and execution. First, is habitual instigation a stronger predictor of behaviour frequency than is habitual execution? Second, which of the two habit types is assessed by the SRHI, the most commonly used measure within health psychology (Gardner, 2015a)? This study investigated whether effects of habit on behaviour frequency can be attributed to habitual instigation rather than execution, and whether the SRHI captures instigation, execution, or some combination of both. Three health behaviours were studied, to ensure findings were not behaviour-specific. These were: breakfast consumption, as skipping breakfast has been associated with increased obesity and greater engagement in other health-compromising behaviours (e.g. Keski-Rahkonen, Kaprio, Rissnane, Virkkunen, & Rose, 2003); flossing, which combats bacteria build-up, which can otherwise cause cavities and gum disease (Bader, 1998), and has been linked to cardiovascular disease (El Fadi et al., 2011); and high-calorie snacking, which may contribute to weight gain and obesity (Forslund, Torgerson, Sjöström, & Lindroos, 2005).

To permit comparisons of our results with previous studies of habitual health behaviour, we adopted a prospective (one-week) questionnaire survey design with correlational analysis, which are the methods most commonly used in those studies (Gardner, 2015a). Undergraduate students were recruited, because we sought to model effects within an educated sample likely to recognise the distinction between instigation and execution. Additionally, emerging adulthood is characterized for many by engagement in health-risk behaviours (e.g., Nelson Laska, Pasch, Lust, Story, & Ehlinger, 2009), making variation in health behaviours and habit strength likely in this sample.

Hypotheses

Predicting behaviour frequency. Habit has been hypothesized to have two effects on behaviour frequency, such that, where habit is strong, behaviour will be more frequently elicited, and intentions will have less predictive impact. We expected these effects to be attributable to habitual instigation. Thus:

Hypothesis 1: An instigation-specific SRHI variant ('instigation-SRHI') will correlate more strongly with behaviour frequency than will an execution-SRHI.

Hypothesis 2a: Instigation-SRHI will predict behaviour frequency when controlling for intention.

Hypothesis 2b: Adding an execution-SRHI over and above instigation-SRHI and intentions will not improve the predictive utility of the model.

Hypothesis 3a. Instigation-SRHI will interact with intention in predicting behaviour, such that, as habit strength increases, the relationship between intention and behaviour will diminish.

Hypothesis 3b: Execution-SRHI will *not* interact with intention in predicting behaviour.

Assessing the SRHI. We expected the non-specific SRHI to reflect habitual instigation, not execution. Thus, we predicted the non-specific SRHI would replicate instigation-SRHI effects, and show closer convergence with the instigation-SRHI:

Hypothesis 3c: The non-specific SRHI will interact with intention in predicting behaviour frequency, such that, as habit strength increases, the relationship between intention and behaviour will be attenuated.

Hypothesis 4: Instigation-SRHI will correlate more strongly with the non-specific SRHI than will execution-SRHI.

Hypothesis 5: Instigation-SRHI items will load predominantly on the same factor as non-specific SRHI items, whereas the Execution-SRHI items will load predominantly on a different factor to non-specific SRHI items.

Method

Participants, design and procedure

Psychology undergraduate students aged 18 or above were recruited, via a US college participant pool website, to an online survey, for which they received course credits. At Time 1 (T1), they completed intention, and instigation, execution, and non-specific habit measures[4]. One week later (T2), they completed behaviour measures. Data were collected in February-April 2014, with recruitment interrupted for two weeks during Spring Break, when typical behaviour would likely be disrupted (Wood, Tam, & Guerrero Witt, 2005). Data collection was preplanned to run for one semester in duration, to maximize the chances of recruiting a sample sufficient to power analyses. Institutional ethical approval was obtained for all procedures detailed below (#011412).

Three hundred and nine participants were recorded at T1, of whom 296 (96%) responded at T2. Thirteen non-responders to T2 did not differ on any of the measured variables from those who completed both time points ($p \geq .46$). Given the similar wording of items, we included six items testing attention ('Please mark [e.g. strongly agree] as your answer to this question') (see Maniaci & Rogge, 2014). Of 296 who completed T2, 67 (22.6%) were excluded for answering incorrectly at least one of the

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[4] Past behaviour was also assessed at baseline, using the same measure detailed below (number of days breakfast eaten: M = 5.91, SD = 2.18, observed range 0-7; days flossed: M = 3.22, SD = 2.53, observed range 0-7; days high-calorie snacks eaten: M = 4.79, SD = 1.87, observed range = 0-7) Patterns of results from correlation and regression analyses reported below were identical where past behaviour was the dependent variable.

six items. The final sample comprised 229 participants (193 [84%] female; age range 18-36y, mean = 19.7y, SD = 1.9).

Questionnaire

The questionnaire had two sections, in both of which items were presented for breakfast, snacking, and flossing sequentially. The first featured intention and non-specific SRHI items, and the second Instigation and Execution SRHI items. To ensure attention to item wording variations, participants were randomly allocated, with 50% probability, to receive instructions between the sections that either drew explicit attention to the instigation-execution distinction, or informed them to expect alike items (for wording, see Supporting Information). Instruction condition (hereafter, 'condition') had negligible impact on instigation and execution SRHI responses; correlations with condition were found for only three of 48 possible items (2 habit types x 8 items x 3 behaviours; maximum $r = .19$, $p=.004$). Condition was nonetheless controlled in all analyses.

Measures

Data were self-reported. Unless otherwise stated, response options ranged from 'strongly disagree' (1) to 'strongly agree' (7). True habit-intention-behaviour relationships may be inflated by measuring prointentional habits (Gardner et al, 2015), and so, while prointentional habits were measured for eating breakfast and flossing (e.g. flossing habit, intention to floss), habit measures were counterintentional for snacking (snacking habit, intention *to avoid* snacking). 'High-calorie snacks' were defined as 'high in fat or sugar, such as candy, sugar-sweetened beverages (e.g. soda, frappuccino), cookies, donuts, fries, and chips'. 'Eating breakfast' and 'flossing' were not explicitly defined.

Each *habit* variant (non-specific, instigation, execution) was measured by eight SRHI items ('[Behaviour X is something …] I do automatically', '…I do without having to consciously remember', 'I do without thinking', 'that makes me feel weird if I do not do it', 'that would require effort not to do', 'I would find hard not to do', 'I have no need to think about doing', 'I do before I realize I'm doing it')[5]. The latter item was amended from its original wording ('…I *start doing* before I realize I'm doing it'; Verplanken & Orbell, 2003, p1329) to permit a habitual execution adaptation. Four SRHI items relating more to frequency and self-identity were excluded from our measure (Gardner, Abraham et al, 2012; Orbell & Verplanken, 2015). Instigation and execution stems were selected following pilot work, conducted by Phillips and Gardner (2015), among an independent group of 124 undergraduate students to identify face-valid indicators of the two habit types. Four SRHI items relating more to frequency and self-identity were excluded from our measure (Gardner, Abraham et al, 2012; Orbell & Verplanken, 2015).

Non-specific SRHI item stems took the form '[flossing/eating breakfast/eating high-calorie snacks] is something…'. *Instigation-SRHI* stems were: 'Deciding to [floss/eat breakfast/eat high-calorie snacks] is something…'. We chose the word 'deciding' as a lay-friendly alternative to 'instigation', based on Phillips and Gardner's (2015) pilot work showing college students to fully understand the term 'deciding' to be distinct from 'doing' (i.e. execution). *Execution-SRHI* stems were: 'Once I have decided to [floss/eat breakfast/eat high-calorie snacks], the act of [flossing/eating breakfast/eating high-calorie snacks] is something…'. All indices were reliable ($\alpha \geq .90$).

[5] The former four items comprise the 'Self-Report Behavioural Automaticity Index' (SRBAI), a reliable automaticity SRHI subscale (Gardner, Abraham et al, 2012). Patterns of results reported below did not change when analyses were run using the SRBAI in place of the SRHI.

Following Ajzen (2006), two items measured *intention* ('I [intend to/plan to] [floss/eat breakfast/eat high-calorie snacks] on most days over the next 7 days'; α ≥ .93). *Behaviour frequency* was measured by a single-item: 'Over the last 7 days, on how many days did you [floss/eat breakfast/eat high-calorie snacks]?' [None – 7 days]).

Analysis

Analyses were run for each behaviour in turn. Normality of data was checked. Negatively skewed breakfast frequency ($z = -4.17$, $p<.001$), and positively skewed flossing frequency scores ($z = 4.69$, $p<.001$), were log-10 transformed (using reverse-ordered breakfast frequency values, and re-reversed transformed values to ensure appropriate interpretation; Tabachnick & Fidell, 2007). Transformed values were less skewed (breakfast: $z = -1.20$, $p=.12$; flossing: $z = 2.73$, $p=.003$), and correlated highly with untransformed scores (r's = .97, $p<.001$), so were entered into analyses.

Comparison of correlation coefficients. Correlations, adjusted for condition, between SRHI variants and behaviour frequency (Hypothesis 1), and between each SRHI variant (Hypothesis 4), were statistically compared using Meng, Rosenthal and Rubin's (1992) formulae. . Adjusted and unadjusted correlation coefficients differed by a maximum of ±.01, indicating that condition had no impact on the magnitude of coefficients, or comparisons between them.

SRHI variants as predictors of behaviour frequency. Hypotheses 2a and 2b were tested in regression models, in which condition, intention and instigation-SRHI were entered at the first step, and execution-SRHI at the second step. Condition did not predict behaviour in any model ($p≥.29$).

For each habit type, an additional model was run entering condition and intention at the first step, and the SRHI variant at the second step, to estimate variance explained by each SRHI variant when unadjusted for other variants. Hypotheses 3a, 3b and 3c were tested by adding, at a third step, an interaction term representing the product of means-centred SRHI and intention scores. Predictive interaction terms were deconstructed using simple slope analysis, to model intention effects at one standard deviation (SD) below the mean SRHI variant score (weak habit), at the mean (moderate habit), and one SD above the mean (strong habit). To assess the validity of observed interactions, the sample was deconstructed based on habit and intention scores, with those ≥1 SD below, within ±1 SD of, and ≥1 SD above the mean of each variable respectively treated as 'low', 'moderate', and 'high', generating nine (3 x 3) profiles.

Factor analysis of SRHI variants. Hypothesis 5 was tested in exploratory factor analyses using maximum likelihood extraction and direct oblimin rotation, to determine the factor structure underlying the 24 items (8 items x 3 SRHI variants). Exploratory factor analysis was used because we expected strong patterns of cross-loadings, which would violate the independent cluster assumption of confirmatory factor analysis (Schmitt, 2011). All analyses met sampling adequacy and sphericity assumptions. Factor extraction was informed by parallel analysis (Horn, 1965), which establishes 'significant' factor eigenvalues by comparison to randomly generated threshold values (O'Connor, 2000). Factor loadings were extracted from the pattern matrix. (The structure matrix is reported in Supplementary Table 1.)

Power analysis

Power analyses were run for hypotheses 1-4, with power set at .80 and p<.05, using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2009). The largest required sample for comparing correlation coefficients (hypotheses 1 and 4) was N = 130, based on assumed correlations of $r_{\text{instigation SRHI,execution SRHI}}$ = .85, $r_{\text{instigation SRHI,behaviour}}$ = .70, and $r_{\text{execution SRHI,behaviour}}$ = .50. For regression models (hypotheses 2a, 2b, 3a, 3b, 3c), assuming medium effects for four predictors, N = 85 was required. We expected a two-factor structure (hypothesis 5), each with at least four item loadings greater than .60, for which analysis N=100 is sufficient (Guadagnoli & Velicer, 1988).

Results

Is habitual instigation a stronger predictor of behaviour frequency than habitual execution?

The instigation-SRHI consistently correlated more strongly with behaviour frequency ($r \geq .51$) than did execution-SRHI ($r \geq .32$; $Z \geq .3.79$, p's<.001; Table 1), supporting Hypothesis 1.

TABLE 1 HERE

As Table 2 shows, for each behaviour, within models at the first step (Model F ≥33.38, $R^2 \geq .31$, p's<.001), instigation-SRHI predicted behaviour ($\beta \geq .32$, p's<.001), as did intention ($\beta \geq .|25$, p's<.001). Adding execution-SRHI did not alter any model ($\Delta R^2 \leq .01$, $\Delta F \leq 0.09$, $p \geq .77$), nor did execution-SRHI predict behaviour (β's = -|.02). Hypotheses 2a and 2b were supported.

TABLE 2 HERE

After controlling for intention, with the exception of flossing execution SRHI ($\beta = .08$, $p = .18$), each SRHI variant was predictive ($\beta \geq .19$, $p \leq .001$; Table 3, Step 2, all models), though instigation-SRHI models (Model F ≥ 33.38, $R^2 \geq .31$, p's<.001) appeared to explain more variance than execution-SRHI models (Model F ≥ 19.73, $R^2 \geq .21$, p's<.001).

TABLE 3 HERE

None of the SRHI variants interacted with snacking intention (Model F ≥14.75, $R^2 \geq .21$, p's <.001; Table 3, Step 3, all models). For eating breakfast and flossing, only the execution SRHI variant interacted with intention (Model F ≥65.86, $R^2 \geq .54$, all p's <.001; $\beta = .13$, $p \leq .009$), such that habitual execution *strengthened* the intention-behaviour relation. Intention had greater impact on behaviour where habit was strong, rather than moderate or weak (respectively, breakfast: βs = .79, .68, .56; flossing: βs = .77, .64, .51; all p's<.001). Profiling showed that, while there was minimal variation in breakfast consumption intention, with 73% of the sample reporting intentions within ±1 SD of the mean, there was greater variation in flossing profiles, suggesting statistical effects were valid (see Supplementary Table 2). Hypotheses 3a, 3b and 3c were not supported.

Does the non-specific SRHI assess instigation or execution?

The non-specific SRHI consistently correlated more strongly with instigation-SRHI ($r \geq .84$) than with execution-SRHI ($r \geq .57$; $Z \geq 7.53$, p's<.001), supporting Hypothesis 4.

For eating breakfast and flossing, two intercorrelated factors were generated ($r \geq .65$; Table 4). While three factors emerged for snacking, items predominantly loaded on the first two. For all behaviours, non-specific and instigation items consistently loaded on the first factor only, and execution on the second only, supporting Hypothesis 5.

TABLE 4 HERE

Discussion

A conceptual analysis of 'habitual behaviour' generates predictions that habit may manifest in health behaviour in two ways: by automatically triggering selection of a behaviour, which, unless controlled, will initiate behaviour (habitual instigation), or by automating progression through the sub-actions required to complete a behaviour, ensuring efficient performance (habitual execution). An empirical study was conducted to explore which manifestation better accounts for habit-behaviour effects, and which is captured by the dominant habit measure in health psychology (the Self-Report Habit Index; SRHI). Across three health behaviours, direct associations between the SRHI and action frequency were more attributable to habitual instigation than execution, though habitual execution was unexpectedly found to strengthen intention-behaviour relations where habitual instigation did not. Item response patterns suggested that the SRHI primarily captured habitual instigation, though the predictive utility of an instigation-specific measure illustrates the feasibility of employing a conceptually more coherent index of habitual triggering of action selection. All measures were worded compatibly, eliminating the possibility of measurement error influencing execution-action relationships. More rigorous research, using experimental and longitudinal designs, is needed to demonstrate more compellingly the distinction between the two habit manifestations and their implications for understanding health behaviour. Nonetheless, our findings support our call for greater conceptual clarity in understanding habitual health behaviour, and for more precise measurement.

As a process that directs behaviour automatically (Aarts et al, 1997), habit has been theorized to have two effects on behaviour: a positive correlation with frequency, and an interaction with intention, such that intentions have less impact on behaviour where habit is strong (Triandis, 1977). We expected these findings to be attributable to habitual instigation, and indeed, found stronger associations with behaviour for an instigation-specific SRHI variant than an execution variant. Our findings echo work showing habitual instigation to better predict exercise frequency (Phillips & Gardner, 2015). No moderation was found using any variant for high-calorie snacking, and for breakfast consumption and flossing, moderation was observed using the execution index only, and in the opposite direction to that predicted by theory (Triandis, 1977), with intentions becoming *more* predictive of behaviour where habit was strong. We propose that habitual instigation acts as an automated contextual reminder to perform an intended action (cf Tobias, 2009). Our findings thus failed to confirm our predictions that habitual instigation would operate as a mechanism for overriding intentional tendencies in regulating action, in line with effects demonstrated in most previous studies (Gardner, 2015a). While unexpected, these results are not however unprecedented: a growing number of SRHI-based tests have, in line with the present findings, either not shown moderation, or shown habit to *reinforce* the link between intention and action (for a review, see Gardner, 2015a). Our findings offer a potential explanation for inconsistent habit-intention effects in previous studies, in that habitual execution may enable acting on intention where habitual instigation does not. ‘Chunking’ sub-actions together into an automated chain of procedural elements makes performance easier (Anderson, 1982; Graybiel, 1998), so bolstering self-efficacy (Bandura, 1977), which in turn facilitates acting on intention (Conner & McMillan, 1999). While our findings suggested that the SRHI mostly taps instigation, strong intercorrelations between factors could also imply that the SRHI captures elements of habitual execution. If this were so, then previous SRHI studies that observed habit to strengthen intention-behaviour relationships may have captured effects of habitual execution rather than instigation. Importantly however, we observed interactions only between prointentional habits and intentions (e.g. habitual flossing, intention to floss), and not between counterintentional snacking habits and intentions. Interactions are typically not found where intentions and habits conflict (Gardner et al, 2015). Previously observed interactions may represent methodological artifice arising from strong positive intention-habit correlations (Gardner, 2015a). Caution must therefore be exercised in interpreting the observed interplay between habitual execution and intention; replication in settings where habits and intention conflict is warranted.

Habit has been proposed as a mechanism for promoting maintenance of newly adopted health behaviours (Rothman et al, 2009), because habitual actions are frequently and consistently enacted in associated contexts (Wood & Neal, 2007). Our results suggest that the habit-behaviour relationship may be attributable more to automatically cued activation of behaviour, not to the automaticity with which an action sequence unfolds. Although for simple behaviours comprised of fewer sub-actions, instigation and execution may be less empirically and phenomenologically discernable, for more complex behaviours, our findings have important practical implications. From a behaviour change perspective, behaviour maintenance may be facilitated through development of habitual instigation (e.g., Kaushal & Rhodes, 2015), and need not involve automation of procedures of sub-actions. Forming both habitually instigated and executed responses may maximize the likelihood of maintenance (Aarts et al, 1997), but this may be an unrealistic target for many health behaviours. Even among regular exercisers, for example, physical activity is rarely wholly automated (Hagger et al, 2015). Our findings question the interpretation by some commentators of evidence of habit-action relationships as indicating the importance of both habitual instigation *and* execution in sustaining frequent health behaviour (e.g. Gardner, Lally, & Wardle, 2012). This is not, however, to argue that habitual execution does not support action. Constructing an automated chain of procedural elements is important for mastery (Anderson, 1982), which may make behaviour more attractive, increasing the likelihood of subsequent performance (Bandura, 1977; McAuley, Pena, & Jerome, 2001). Building a habitually executed sequence could therefore have an indirect positive effect on behaviour maintenance, albeit mediated by deliberative mechanisms such as self-efficacy enhancement and intention formation. Conversely, targeting habitual execution could be fruitful for stopping unwanted unhealthy actions. Disruption of an ongoing chunked action raises lower-level procedural sub-components into conscious awareness (Vallacher & Wegner, 1987), allowing an actor to consciously terminate the sequence, and so minimize any negative consequences. For example, a habitual smoker may be interrupted after activating their 'smoking' routine but prior to lighting a cigarette (Orbell & Verplanken, 2010), and a habitual snacker impeded prior to overeating (Neal, Wood, Wu, & Kurlander, 2011). Disruption of this kind may prevent completion of behaviour, but, for behaviours that are both habitually instigated and executed, would presumably not address its instigation. That is, the snacker that interrupts execution in one context may succumb to temptation in subsequent contexts, due to habitual instigation. Lasting habit discontinuation may be better facilitated by dismantling the cue-behaviour association that habitually activates pursuit of behaviour, rather than blocking its execution.

Relative to an execution-specific SRHI variant, an instigation SRHI variant was more strongly correlated with, and loaded most highly on the same factor as, the original, non-specific SRHI. Notably, correlations between factors were strong. This is unsurprising, because where behaviour is both instigated and executed consistently, the two habitual responses will develop in concert (Smith & Graybiel, 2014). However, strong intercorrelations could also reflect participants' confusion about the proposed distinction. Participants' comprehension of the items was not explicitly evaluated, but rather inferred from patterns of factor loadings, and so potential noise within the measures cannot be estimated. Nonetheless, given the predictive utility of the instigation-specific SRHI, we would recommend that researchers using the SRHI adopt our items to achieve more conceptually precise measures of habitual instigation or execution. In these instances, we suggest that habitual instigation and execution may respectively be captured by asking participants to what extent 'deciding' to do a behaviour, and 'having decided, actually doing' a behaviour, are habitual.

Our study sought to illustrate the potential utility of discerning between habitual instigation and execution in explaining health behaviour, using a behaviour-prediction design among a student sample. The limitations of self-report-based correlational designs for observing habit are well-documented (e.g. Gardner, 2015a; Hagger et al, 2015; Sniehotta & Presseau, 2012). In line with traditional operationalisations of the SRHI (Verplanken & Orbell, 2003), our measures specified only the behavioural component of a habit response ('Behaviour X'), not the context that habitually triggers the response (Sniehotta & Presseau, 2012). Our instigation and execution measures could however easily be augmented to incorporate contextual elements in the same way as can the generic SRHI ('Behaviour X in Context Y'; Sniehotta & Presseau, 2012). More fundamentally, the validity of self-reported habit has been questioned, as people cannot reliably reflect on non-reflective processes (Hagger et al, 2015; Labrecque & Wood, 2015). Self-report may also be differentially sensitive to the two habit manifestations; people pay little conscious attention to procedural elements of chunked actions (Vallacher & Wegner, 1987), so it is possible that habitual execution may be less reliably self-reported than instigation. These problems may have been compounded by use of a highly-educated sample, who may be better able to comprehend the distinction between behavioural instigation and execution processes; indeed, we purposefully recruited students on this assumption. Future work however, ideally conducted among non-student samples, might compare our item wordings against less subjective habit measures, such as 'script elicitation' methods, involving detailed recall of sequential procedures (Judah et al, 2013), or tests of mental cue-behaviour associations (Labrecque & Wood, 2015). Alternatively, 'think aloud' methods may be employed to assess whether participants' comprehension matches that of researchers interpreting the data (Gardner & Tang, 2014). An additional problem inherent to self-report is that of careless or inattentive responding, which can distort effects (Maniaci & Rogge, 2014). Our participants were required to discern between subtly different wordings of similar SRHI items, so we excluded those who responded inaccurately to at least one of six attention-testing items. Whilst this conservative approach is likely to have minimized contamination of effects, the exclusion of nearly a quarter of our sample for this reason illustrates the potential magnitude of this problem within self-report survey data.

Further investigations of the proposed instigation-execution distinction will require more sophisticated and rigorous methods than were used in the present study. Lab-based experimental designs, in which novel habits can be created or otherwise manipulated within tightly controlled conditions, may more reliably empirically separate instigation of a sequence of action from execution of the action. Longitudinal studies, in which changes in behaviour reliably temporally precede the development or disruption of habit, may also offer opportunities to explore whether differences may be observed in rates of formation or disruption of habitual instigation versus execution patterns (cf Judah et al, 2013). While the present study achieved its purpose of illustrating empirically the potential to discern the two habit types within the most popular research design, further theory development will require moving beyond the correlational, self-report survey model.

Habit has traditionally been studied in relation to simple and relatively indivisible actions, such as pulling strings and pressing levers (Watson, 1913). Many of the behaviours studied within health psychology are considerably more complex, being comprised of multiple sub-components. For such behaviours, a distinction can be made between the automatic activation of an action schema that, unless opposed, initiates an action sequence (habitual instigation), and automatic discharging of the lower-level actions within an action sequence after it has been initiated (habitual execution). We have presented empirical evidence, albeit correlational and self-report-based, that supports our predictions that effects of habit on action frequency can be attributed more to habitual instigation than execution, and that habitual behaviour can be more precisely captured by specifying either instigation or execution as the object of measurement. This qualifies previous guidance on harnessing habit to change health behaviour. While habitual execution may be important for generating fluid and efficient performance, repetition of health-promoting behaviour may be better facilitated by formation of a habitual instigation response. Additionally, dismantling cue-response associations underlying habitual instigation may most effectively discontinue unhealthy behaviours.

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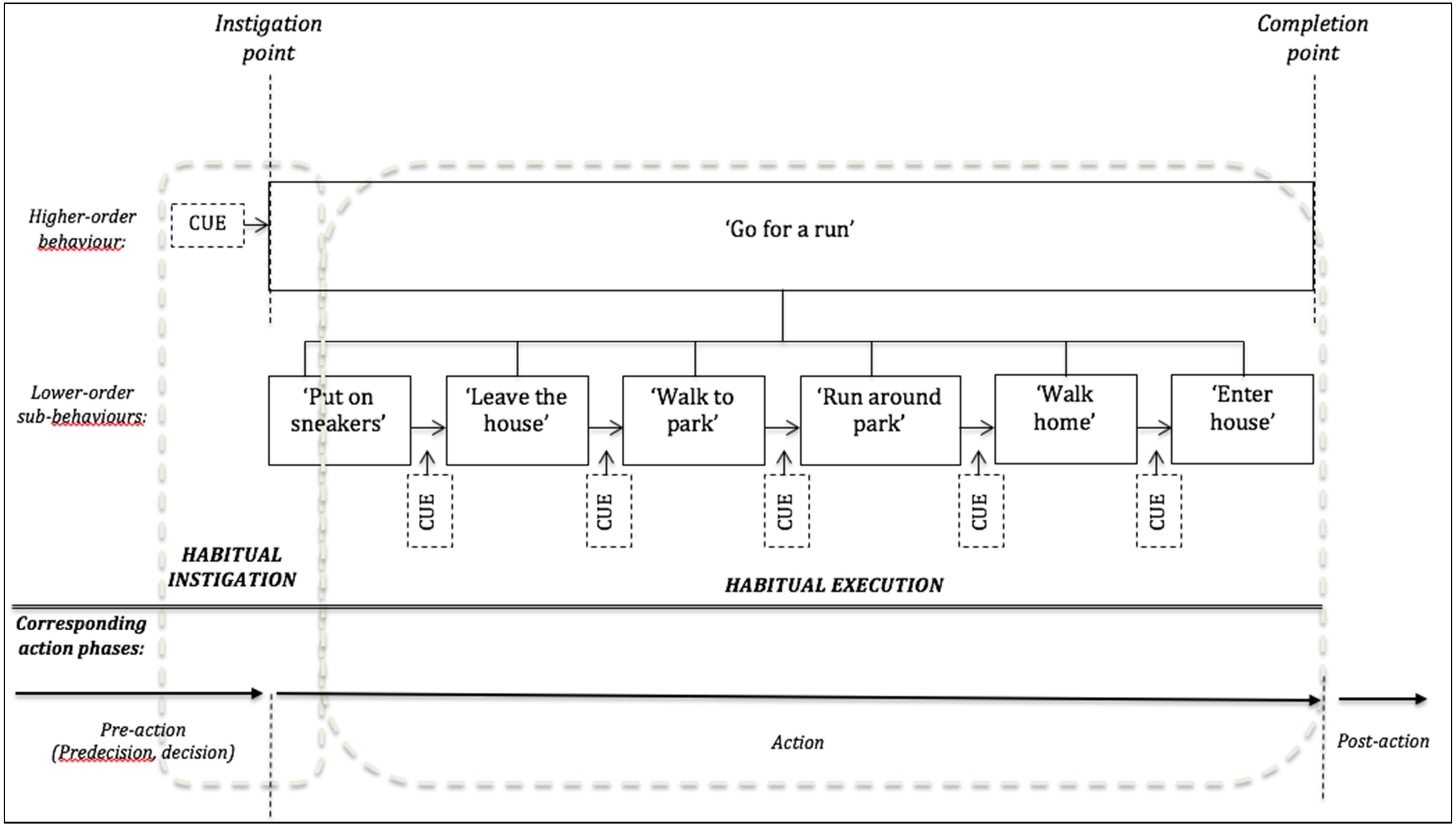
Figure 1. Habitual instigation versus execution for 'going for a run'



NB: Instigation and completion points refer to instigation and completion of ‘going for a run’, not of its sub-behaviours. Incorporation of only part of the ‘put on sneakers’ sub-behaviour within Habitual Instigation indicates that only initiation of ‘putting on sneakers’, and not necessarily its completion, may be enacted as part of the Habitual Instigation.

Table 1. Descriptives and correlations

	2.	*3.*	*4.*	*5.*	*Observed range*	*Mean*	*SD*	*α*
Eating breakfast (n = 229)								
1. Behaviour frequency (no. days on which breakfast eaten) (T2) †	.75	.72	.55	.73	0-7	5.92	2.14	-
2. Non-specific SRHI (T1)		.90	.70	.75	1-7	4.00	1.81	.95
3. Instigation SRHI (T1)			.73	.75	1-7	4.33	1.81	.96
4. Execution SRHI (T1)				.58	1-7	5.14	1.45	.94
5. Intention (T1)					1-7	5.32	2.02	.98
Flossing (n = 228)								
1. Behaviour frequency (no. days on which flossed) (T2) †	.69	.68	.49	.72	0-7	3.19	2.43	-
2. Non-specific SRHI (T1)		.94	.64	.77	1-7	2.59	1.70	.96
3. Instigation SRHI (T1)			.64	.73	1-7	2.68	1.74	.97
4. Execution SRHI (T1)				.61	1-7	4.24	1.67	.96
5. Intention (T1)					1-7	3.88	2.11	.97
Eating high-calorie snacks (n = 228)								
1. Behaviour frequency (no. days on which high-calorie snacks eaten) (T2)	.57	.51	.32	-.42	0-7	4.68	1.80	-
2. Non-specific SRHI (T1)		.84	.57	-.52	1-6.5	3.35	1.36	.90
3. Instigation SRHI (T1)			.61	-.39	1-7	3.58	1.48	.93
4. Execution SRHI (T1)				-.26	1-7	4.35	1.47	.93
5. Intention (T1) ‡					1-7	4.69	1.78	.93

NB: Correlations are adjusted for group allocation. All coefficients significant at p<.001. † For breakfast and flossing behaviour frequency, correlation coefficients are reported for transformed values, and means and SDs reported for untransformed values. ‡ For high-calorie snacking, intention refers to intending *to avoid* high-calorie snacking. SRHI = Self-Report Habit Index. T1, T2 = Time 1, Time 2.

Table 2. Instigation and execution SRHIs as predictors of behaviour frequency

Step	*Eating breakfast (n = 229)*		*Flossing (n = 228)*		*Eating high-calorie snacks (n = 228)*	
	Step 1 Beta	*Step 2 Beta*	*Step 1 Beta*	*Step 2 Beta*	*Step 1 Beta*	*Step 2 Beta*
1. Intention	.42***	.42***	.49***	.49***	-.25***	-.25***
Instigation SRHI	.41***	.40***	.32***	.33***	.41***	.42***
2. Execution SRHI		.01		-.02		-.02
R^2	.60	.60	.57	.57	.31	.31
Model F	114.53***	85.52***	98.85***	73.86***	33.38***	24.95***
R^2 *change*		.00		.00		.00

NB: All models control for group allocation, which had no relationship with behaviour (p’s ≥.29). *** p<.001. All other p’s>.05. SRHI = Self-Report Habit Index.

Table 3. Non-specific, Instigation and Execution SRHIs as moderators of intention-behaviour frequency relationship**.**

	All models	*Non-specific SRHI*		*Instigation SRHI*		*Execution S*	
Step	*Step 1 Beta*	*Step 2 Beta*	*Step 3 Beta*	*Step 2 Beta*	*Step 3 Beta*	*Step 2 Beta*	
Eating breakfast (n = 229)							
1. Intention	.73***	.38***	.41***	.42***	.50***	.62***	
2. Habit		.46***	.45***	.41***	.39***	.19***	
3. Habit x intention			.04		.10		
R^2	.53	.63	.63	.60	.61	.55	
Model F	128.51***	124.85***	93.54***	114.53***	87.86***	93.43***	7
R^2 change		.05***	.00	.07***	.01	.02***	
Flossing (n = 228)							
1. Intention	.72***	.47***	.50***	.49***	.52***	.67***	
2. Habit		.33***	.27**	.32***	.25**	.08	
3. Habit x intention			.06		.07		
R^2	.52	.57	.57	.57	.57	.53	
Model F	123.08***	98.39***	73.91***	98.85***	74.70***	82.98***	6
R^2 change		.05***	.00	.05***	.00	.00	
Eating high-calorie snacks (n = 228)							
1. Intention	-.41***	-.16*	-.17*	-.25***	-.25***	-.35***	-
2. Habit		.48***	.48***	.41***	.41***	.21***	
3. Habit x intention			.03		.04		
R^2	.17	.33	.33	.31	.31	.21	
Model F	22.85***	37.33***	27.96***	33.38***	24.94***	19.73***	1
R^2 change		.16***	.00	.14***	.00	.04***	

NB: All models control for group allocation, which had no relationship with behaviour frequency (minimum p = .29).
*** p<.001, **≤p.01, *p≤.05. All other p's>.05. SRHI = Self-Report Habit Index.

Table 4. Exploratory factor analyses of non-specific, Instigation and Execution SRHIs

	Eating breakfast (n = 229)		*Flossing (n = 229)*	
	Factor 1	*Factor 2*	*Factor 1*	*Factor 2*
Non-specific SRHI ('Behaviour X is something…')				
'I do automatically'	.92		.94	
'I do without having to consciously remember'	.87		.97	
'that makes me feel weird if I do not do it'	.93		.85	
'I do without thinking'	.89		.95	
'that would require effort not to do'	.88		.77	
'I do before I realize I'm doing it'	.66		.88	
'I would find hard not to do'	.81		.85	
'I have no need to think about doing'	.71		.72	

Instigation SRHI *('Deciding to do Behaviour X is something…')*				
'I do automatically'	.90		.96	
'I do without having to consciously remember'	.86		.97	
'that makes me feel weird if I do not do it'	.89		.87	
'I do without thinking'	.88		.94	
'that would require effort not to do'	.79		.83	
'I do before I realize I'm doing it'	.78		.90	
'I would find hard not to do'	.85		.86	
'I have no need to think about doing'	.66		.80	
Execution SRHI *('Once I have decided to do Behaviour X, the act of Behaviour X is something…')*				
'I do automatically'		.84		.91
'I do without having to consciously remember'		.87		.93
'that makes me feel weird if I do not do it'		.66		.82
'I do without thinking'		1.04		.98
'that would require effort not to do'		.78		.80
'I do before I realize I'm doing it'		.65		.84
'I would find hard not to do'		.70		.76
'I have no need to think about doing'		.81		.82
Eigenvalue	15.42	2.06	16.03	2.95
% variance explained	64.25%	8.60%	66.80%	12.31%
Correlation between Factors 1 & 2	.74		.65	

Emphasis added to higher loadings. Loadings extracted from pattern matrix. Loadings <.40 not reported. All extracted factor eigenvalues exceeded those randomly generated by parallel analysis (Factor 1 [F1]: 1.28; F2: 1.18, F3: 1.15). SRHI = Self-Report Habit Index.

Supplementary Table 1a. Sample profiles underpinning habitual execution x intention interaction, breakfast consumption (N = 229)

		Intention		
		≥1 SD below mean N (%)	*Mean N (%)*	*≥1 SD above mean N (%)*
Habitual execution	*≥1 SD below mean N (%)*	19 (8%)	12 (5%)	0 (0%)
	Mean N (%)	33 (14%)	118 (52%)	0 (0%)
	≥1 SD above mean N (%)	0 (0%)	47 (21%)	0 (0%)
Column total		*52 (23%)*	*177 (73%)*	*0 (0%)*

Supplementary Table 1b. Sample profiles underpinning habitual execution x intention interaction, flossing (N = 229)

		Intention		
		≥1 SD below mean N (%)	*Mean N (%)*	*≥1 SD above mean N (%)*
Habitual execution	*≥1 SD below mean N (%)*	20 (9%)	15 (7%)	0 (0%)
	Mean N (%)	19 (8%)	98 (43%)	36 (16%)
	≥1 SD above mean N (%)	4 (2%)	11 (5%)	26 (11%)
Column total		*43 (19%)*	*124 (54%)*	*62 (27%)*

Supplementary Table 2. Structure matrix from exploratory factor analyses of non-specific, Instigation and Execution SRHIs

	Eating breakfast (n = 229)		*Flossing (n = 229)*	
	Factor 1	*Factor 2*	*Factor 1*	*Factor 2*
Non-specific SRHI (‘Behaviour X is something…’)				
‘I do automatically’	**.86**	.60	**.93**	.60
‘I do without having to consciously remember’	**.88**	.66	**.94**	.59
‘that makes me feel weird if I do not do it’	**.86**	.59	**.87**	.59
‘I do without thinking’	**.90**	.67	**.94**	.61
‘that would require effort not to do’	**.84**	.60	**.77**	.50
‘I do before I realize I’m doing it’	**.72**	.56	**.90**	.60
‘I would find hard not to do’	**.79**	.57	**.86**	.57
‘I have no need to think about doing’	**.73**	.54	**.74**	.49
Instigation SRHI (‘Deciding to do Behaviour X is something…’)				
‘I do automatically’	**.90**	.66	**.95**	.60
‘I do without having to consciously remember’	**.90**	.69	**.94**	.59
‘that makes me feel weird if I do not do it’	**.89**	.65	**.90**	.61
‘I do without thinking’	**.91**	.69	**.93**	.59
‘that would require effort not to do’	**.85**	.66	**.83**	.54
‘I do before I realize I’m doing it’	**.82**	.63	**.90**	.58
‘I would find hard not to do’	**.84**	.62	**.88**	.59
‘I have no need to think about doing’	**.77**	.63	**.80**	.52

Execution SRHI (‘Having decided to do Behaviour X, the act of Behaviour X is something…’)				
‘I do automatically’	.63	**.85**	.51	**.86**
‘I do without having to consciously remember’	.64	**.87**	.56	**.90**
‘that makes me feel weird if I do not do it’	.63	**.77**	.57	**.84**
‘I do without thinking’	.59	**.91**	.56	**.93**
‘that would require effort not to do’	.65	**.84**	.59	**.84**
‘I do before I realize I’m doing it’	.59	**.73**	.60	**.87**
‘I would find hard not to do’	.65	**.80**	.61	**.84**
‘I have no need to think about doing’	.60	**.81**	.57	**.85**
Eigenvalue	15.42	2.06	16.03	2.95
% variance explained	64.25%	8.60%	66.80%	12.31%
Correlation between Factors 1 & 2	.74		.65	

Emphasis added to higher loadings. Loadings extracted from structure matrix. Loadings <.40 not reported. All extracted factor eigenvalues exceeded those randomly generated by parallel analysis (Factor 1 [F1]: 1.28; F2: 1.18, F3: 1.15).

Supporting information:

Instructions given within questionnaire, prior to Instigation and Execution SRHI items

Condition 1 (explicit attention drawn to instigation-execution distinction):
“The following questions distinguish between deciding to do an action and actually doing that action. For example, 'drinking coffee' involves first deciding to drink coffee, and then actually consuming the coffee. 'Eating a candy bar' requires deciding to eat a candy bar, and then actually eating the candy bar. Please read each question carefully before answering.”

Condition 2 (participants informed to expect alike items):
“You may find some of the following questions to be similar. However, please read each question carefully before answering.”