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Developing habit-based health behaviour change interventions: twenty-one questions to guide future research

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ABSTRACT

Objective: Habitual behaviours are triggered automatically, with little conscious forethought. Theory suggests that making healthy behaviours habitual, and breaking the habits that underpin many ingrained unhealthy behaviours, promotes long-term behaviour change. This has prompted interest in incorporating habit formation and disruption strategies into behaviour change interventions. Yet, notable research gaps limit understanding of how to harness habit to change real-world behaviours.

Methods: Discussions among health psychology researchers and practitioners, at the 2019 European Health Psychology Society 'Synergy Expert Meeting', generated pertinent questions to guide further research into habit and health behaviour.

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Results: In line with the four topics discussed at the meeting, 21 questions were identified, concerning: how habit manifests in health behaviour (3 questions); how to form healthy habits (5 questions); how to break unhealthy habits (4 questions); and how to develop and evaluate habit-based behaviour change interventions (9 questions).
Conclusions: While our questions transcend research contexts, accumulating knowledge across studies of specific health behaviours, settings, and populations will build a broader understanding of habit change principles and how they may be embedded into interventions. We encourage researchers and practitioners to prioritise these questions, to further theory and evidence around how to create long-lasting health behaviour change.

Many health-promoting behaviours must be repeated over the long-term to have a meaningful impact on health. For example, successful management of long-term conditions relies on sustained medication adherence (Ho et al., 2009). Conversely, lasting health effects of discontinuing previously ingrained, repetitive health-risk behaviours arise from maintaining cessation (Hill et al., 2005). Yet, many behaviour change interventions have only short-term effects, which erode as people disengage from health-promoting behaviours, or lapse into old behavioural patterns that undermine maintenance of health-promoting behaviour (Kwasnicka et al., 2016). Engendering lasting change requires understanding how to sustain health-conducive behaviours, and prevent re-emergence of old, unwanted actions.

Habit is a key concept in behaviour maintenance (Rothman et al., 2009). Habitual behaviour is prompted when encountering a situation automatically triggers impulses to act, via the activation of situation-behaviour associations learned through consistent performance (Gardner, 2015). Unlike behaviour effortfully generated by reflective processes that require memory, attention, and conscious motivation, habitual behaviour is triggered relatively effortlessly and rapidly by nonconscious processes that can operate without awareness or intention (Orbell & Verplanken, 2010). In associated situations, habitual behaviours are not only more likely to be enacted, but also proceed where people might otherwise forget or lack the momentary intention strength to act, and potentially even when they intend not to do them (Gardner, Lally, et al., 2020; Wood et al., 2021). These effects have been shown across various health behaviours, including physical activity, sedentary behaviour, dietary consumption, alcohol consumption, medication adherence, and virus transmission behaviours (Aunger et al., 2010; Conroy et al., 2013; Gardner et al., 2012; Hagger, 2019; Hagger et al., 2020; Lin et al., 2016; Mullan et al., 2021; Phillips et al., 2013).

Commentators have argued that making health-promoting behaviours habitual will shield against potential motivation losses, and disrupting cue–response links will permanently discontinue many health-risk behaviours (Conn & Ruppar, 2017; Orbell & Verplanken, 2020). Health psychologists have been at the forefront of efforts to embed habit principles in behaviour change interventions (Mullan & Novoradovskaya, 2018). Yet, knowledge gaps limit understanding of how to use habit to support lasting behaviour change. This paper sets out research questions that emerged from discussions at the 'Synergy Expert Meeting' at the 2019 European Health Psychology Society (EHPS) conference, held in Dubrovnik, Croatia.

The meeting was advertised via the EHPS website (EHPS, 2019) and email lists, and social media (e.g. Twitter). The advertised aim of the meeting, as written by the meeting organisers and facilitators (authors BG and PL), was to 'stimulate discussion around the implications and applications of state-of-the-art habit theory for health psychology research and practice' (EHPS, 2019). Objectives were to 'identify, and achieve consensus around, the most pertinent research questions and strategies for developing and applying habit theory to health psychology domains' (EHPS, 2019). Potential meeting attendees were required to apply, providing statements of their relevant experience, expectations of the meeting and likely contribution, and a list of relevant scientific outputs. While formally designated an 'expert meeting' in accordance with EHPS branding, facilitators accepted all 22 applications, including from doctoral students. Of the 22, five did not attend, leaving a group of 17 attendees and two facilitators. The collective expertise of attendees encapsulated research and practice in habit theory and application, and understanding and changing a range of potentially habitual behaviours. In the meeting, four topics, pre-determined by the facilitators, were covered: (a) how habit manifests in health behaviour, (b) how to make and (c) break health-related habits, and (d) how to develop habit-based health behaviour interventions.

At the meeting, attendees brainstormed pertinent unanswered questions that may hinder design of optimal real-world habit-based interventions. Immediately after the meeting, BG and PL organised the questions into a preliminary thematic structure. The questions and structure were subsequently iteratively refined by BG. Six months after the meeting, the structured list of questions was shared via a cloud-based service with all authors, who were asked to indicate to which points they wished to contribute written material. Further iteration of questions, contributions and structure was undertaken by BG and PL, until a set of coherently organised, mutually exclusive questions and discussion points remained. Contributions were incorporated by BG into a draft, which was refined following co-author feedback. At all stages of review, questions were revised or removed according to inductively identified criteria, which excluded those deemed too general (e.g. 'how can we break habits?'), insufficiently related to intervention development or implementation ('how should we measure habit?'), or superseded by other questions. A full account of deviations from the original questions and structure was shared with co-authors, all of whom were satisfied that the final draft captured all key questions and discussion points. The final set of questions is presented in Table 1.

Understanding 'habit' and 'habitual behaviour'

While there is no consensually agreed definition, habit cannot be meaningfully defined as both a type of behaviour and a cause of behaviour (Maddux, 1997). Recent definitions portray habit as a learned cue–response association which, when activated by exposure to the cue, automatically generates non-conscious impulses to act (Fleetwood, 2021), or the overarching process by which cuing these associations generate action impulses (Gardner, 2015). Importantly, these definitions differentiate between *habit* as a cognitive construct that generates behaviour, and *habitual behaviour* as the action generated by habit. Habitual behaviour is triggered automatically and

Table 1. Twenty-one questions to guide future research, organised into domains.

Domain	Research question
Understanding 'habit' and 'habitual behaviour'	1. Which cues, or clusters of cues, most commonly support real-world habitual behaviours, and why?
	2. How, and to what extent, does behavioural complexity influence the formation of habits for instigating real-world behaviour?
	3. How, and in what role(s), can habit be used to promote complex real-world health behaviours?
Understanding habit formation	4. What is the typical 'shape' of within-person real-world habit growth with repetition over the long-term, and what determines the fit of this 'shape' to individual trajectories?
	5. What level of habit strength is required to sustain real-world behaviour over time?
	6. Which personality and individual difference factors influence real-world habit formation, and how?
	7. What makes the most effective reward(s) for quickening or heightening real-world habit formation, and why?
	8. What is the optimal position within an existing routine to insert a new behaviour in order to promote real-world habit formation?
Understanding habit disruption	9. To what extent, and in what real-world conditions, does inhibiting an unwanted habit, or avoiding exposure to cues, lead to degradation of underlying cue-response associations?
	10. To what extent must a cue-response association be degraded for habitual cuing of a real-world behaviour to be discontinued?
	11. What factors hasten the degradation of real-world habit associations?
	12. Do degraded real-world habits reform more quickly, or more strongly, than do wholly new real-world habits?
Designing and evaluating habit-based behaviour change interventions	13. Which behaviour change techniques are most conducive to reinforcing the cue-response associations needed for real-world habit to form?
	14. Does forming a 'higher-order habit' promote greater uptake of more specific target behaviours than does forming a habit for a more specific behaviour?
	15. Which behaviour change techniques are most conducive to disrupting unwanted habit associations or habitual behaviours in real-world contexts?
	16. How feasible is it to substitute an unwanted habit with a less-rewarding alternative habit in the real-world?
	17. What factors influence the extent to which habit substitution will lead to lasting behaviour change, and how?
	18. Are habit-based interventions that explain the concept of habit to participants more effective for forming or disrupting habits, or promoting lasting behaviour change, than those that do not?
	19. To what extent, and in what conditions, is advice regarding which specific behaviours to perform in which specific settings more or less conducive to real-world habit formation than training people to set their own personalised habit plans?
	20. How effective are interventions that create new cue-response associations or disrupt old cue-response associations for bringing about lasting real-world behaviour change?
	21. Through which mechanisms of action do habit-based interventions bring about real-world behaviour change?

efficiently in response to cues, potentially without conscious intention, awareness, or control (Bargh, 1994). Harnessing this process to change behaviour requires understanding cues and the responses that they generate.

Understanding cues to habitual behaviour

Habits are inherently idiosyncratic, based on person-specific cue–response associations acquired through repetition of a specific behaviour in a specific context, so cues to

specific habits will vary between individuals. Nonetheless, identifying common cues to common habitual behaviours would guide population-level health behaviour intervention design, by highlighting settings that may be practically or theoretically most supportive of habit.

Research on habit cues has tended to focus on cue type (but see Keller et al., 2021). In theory, any contextual feature consistently present immediately prior to action enactment can become a habit cue, but social and health psychologists have tended to focus on location, presence of others, time of day, and prior events as likely cues to real-world health behaviours (see Wood et al., 2021; Wood & Rünger, 2016). Theorists have proposed that some environmental features are inherently more or less conducive to habits than others. For example, time-based cues require monitoring so are, in principle, less suited to supporting action outside of awareness than event-based cues, which are inherently more salient (McDaniel & Einstein, 2000). Indeed, a study of pre-existing physical activity habits found that the consistency of prior events (e.g. 'after breakfast') was related to habit strength, but engaging in activity at a consistent time of day was not (Pimm et al., 2016; see also Phillips et al., 2021). However, a study of formation of dietary consumption habits found that recommending use of event-based or of time-based cues was equally supportive of habit development (Keller et al., 2021). More work is needed to identify the characteristics of cues that are most conducive to sustaining health-promoting habit associations, and those that often support common unwanted habits.

Research is lacking regarding which aspects of a given real-world setting serve to cue habits. This may be due in part to the difficulty of defining cues. Although sometimes used interchangeably, a 'context' tends to be used to denote real-world settings that incorporate multiple cues, while a 'cue' is typically used to denote a specific stimulus representing one of many potential lower-order fragments within a higher-order 'context'. For example, a person with a habit for eating high-calorie snacks while watching TV at home may enact their habit in the home environment *context*, but in response to the specific *cue* of watching TV. A cue may therefore be defined as the smallest possible 'active ingredient' sufficient to activate a given habit association.

Practically, however, the attempted separation of cues and contexts is problematic, for two reasons. First, cues are often inseparable. The workplace, for example, can represent a location cue, a time cue (i.e. the time at which a person arrives or departs), or a social cue (i.e. the presence of colleagues). Real-world cues have fuzzy boundaries. Second, it is difficult to distinguish a 'context' from a 'cue'. Even seemingly simple cues consist of smaller components. 'Taking a cigarette break with a colleague' involves, for example, taking a break, and a colleague, which may be separate cues, such that 'taking a cigarette break with a colleague' more accurately represents a context. Alternatively, both may be required, such that habit is prompted by a configuration of cues, of which none is sufficient but all are necessary to activate habit impulses. Even when a purported cue supports habit, there may be practical value in identifying whether all components of the cue are necessary to support habitual responses – and conversely, whether unidentified elements that co-occur with the proposed cue are also required.

Cue effects may also be subjective. Cues must be perceived to generate action, yet little research has focussed on how cues are mentally represented, or how such

representations may mediate between cue exposure and response elicitation (see Papies et al., 2020; Qin et al, 2021). For example, although research on cue types has implicitly focussed on verifiable environmental features (e.g. locations), ostensibly different cues may be perceived as sufficiently similar to generate the same action. For example, a person who habitually flosses after toothbrushing is likely to continue to do so after replacing an old toothbrush with a new one (Judah et al., 2013), despite the physical properties of the stimulus having changed. Further work on common cues, and perceptions of such cues, will aid understanding of whether and how specific habits may generalise across contexts, due to the consistent presence of triggering cues in seemingly different contexts.

Research question (RQ) 1: *Which cues, or clusters of cues, most commonly support real-world habitual behaviours, and why?*

Understanding habitual responses

Commentators have argued that real-world health behaviours are often too complex to be generated by cue–response mechanisms (Kruglanski & Szumowska, 2020; Marien et al., 2019). This raises the question of what, for any given behaviour, constitutes the 'response' generated by habit, and how complex the 'response' can be.

The complexity of any given behaviour is commonly, albeit implicitly, conceived of according to the number of 'steps', or sub-actions, required to complete that behaviour (Lally et al., 2010). For example, drinking a glass of water is seen as 'simple', as it involves only filling a glass, putting in to the mouth, and swallowing water, whereas 'going for a run' involves many sub-actions – e.g. changing into running clothes, leaving the house, and running – so is seen as 'complex' (Lally et al., 2010; but see Rodger et al., 2021). This account of complexity is rooted in hierarchical depictions of behaviour, which propose that all actions can be broken down into lower-order sub-actions. Activation of a mental representation of a higher-level act – for example, deciding to 'go for a run' – in turn triggers the representation and subsequent performance of the first lower-level sub-actions required to complete the act of 'going for a run' (e.g. 'change into running clothes'; Cooper & Shallice, 2006). Completion of a sub-action in turn activates the next sub-action in the sequence (e.g. 'leave the house'), until the higher-level act is completed.

Mullan and Novoradovskaya (2018) argue that complexity should be conceived of according not only to the number of sub-actions, but also the nature of action outcomes. They distinguish between 'one-step' actions, which involve a single cluster of lower-level sub-actions (e.g. brushing teeth), and 'multi-step' actions, which require more elaborate sequences of sub-actions (e.g. physical activity). Based on theory suggesting that rewarding an action reinforces the impact of repetition on habit formation (de Wit & Dickinson, 2009), Mullan and Novoradovskaya also differentiate between actions that offer immediate hedonic rewards (e.g. unhealthy snacking, which rapidly delivers pleasure) and those that provide only more distal benefits (e.g. eating fruit and vegetables, which offers longer-term health rewards). Mullan and Novoradovskaya propose that habit plays different roles according to these two

determinants. Specifically, one-step/hedonic and one-step/distal benefit behaviours become habitual more quickly, and habit is the sole determinant of familiar one-step/hedonic behaviours. However, for one-step/distal benefit actions, and all multistep actions, habits operate alongside conscious intentions in generating action.

Gardner et al. (2016) offer an alternative depiction of habit in complex behaviours, distinguishing between two manifestations of habit in action. 'Habitual instigation' refers to the automatic selection of and commitment to perform an action from an array of alternatives (e.g. 'going for a run'). 'Habitual execution' describes habit facilitating fluid performance, whereby completing one sub-action ('changing into running clothes') habitually cues the next ('leave the house'). Although less practically significant for behaviours with few sub-actions, for complex actions like physical activity, participants can distinguish between 'habitually deciding' (instigation) and 'habitually doing' (execution) (Phillips & Gardner, 2016).

Gardner, Lally, et al. (2020) argue that the instigation–execution distinction renders the issue of behavioural complexity largely redundant, because the characteristic influence of habit on behaviour relates to instigation, not execution (Hardwick et al., 2019). By extension, the process by which habit triggers action should operate equally for all actions, regardless of execution complexity. This explains how people can form 'higher-order habits', whereby they habitually instigate actions for which execution is complex and requires conscious oversight (Phillips et al., 2019). For example, recipients of an intervention designed to promote habitually 'filling half of the dinner plate with fruits and vegetables' in meal contexts reported increases in habit strength, despite choosing different fruits and vegetables on different occasions (Phillips et al., 2019). Other interventions have promoted habitual instigation of flexibly executed actions, such as walking 10,000 steps (Beeken et al., 2017).

Both Gardner et al.'s and Mullan and Novoradovskaya's perspectives are theoretically problematic. If all actions can be deconstructed into sub-actions ad infinitum, the number of sub-actions involved in an action cannot be objectively identified. Additionally, whether an action is 'higher-level' or 'lower-level' is relative, not absolute. Habitually triggered water consumption, for example, can equally be deemed habitual instigation of 'drinking water', or habitual execution within a higher-order sequence (e.g. 'having a meal').

From a practical perspective, however, conceiving of actions according to discrete 'steps' highlights the importance of specifying how habit is expected to support health-related behaviours. At very low levels of analysis, all action is likely to be habitual (Cooper & Shallice, 2006); the muscle movements involved in walking, for example, are executed automatically. Researchers should therefore ask not *whether* an action is habitual, but rather *what is the role* of habit in the action (Gardner et al., 2019). Developers of habit-forming toothbrushing interventions, for example, should clarify whether the aim is to create habits to engage in a toothbrushing episode, so promoting frequent toothbrushing, or to support consistent brushing technique, so facilitating high-quality performance (Raison et al., 2020). If the aim is to promote habitual performance, intervention developers must identify which 'step(s)' in performance are expected to become facilitated by habit.

Notwithstanding the need for agreement on how best to operationalise behavioural complexity, more research is needed to test hypotheses about how habit affects

complex actions, and how these may translate into effective behaviour change intervention design. For example, the instigation–execution distinction has been supported mostly by studies of existing habits (Hoo et al., 2017; Raison et al., 2020), rather than in formation contexts.

RQ2: *How, and to what extent, does behavioural complexity influence the formation of habits for instigating real-world behaviour?*

RQ3: *How, and in what role(s), can habit be used to promote complex real-world health behaviours?*

Understanding habit formation

Habit formation is a process of strengthening a cue–response association, typically from a base point of a weak or no association, and ideally such that the cue comes to prompt action without conscious deliberation (Kaushal & Rhodes, 2015; Lally et al., 2010). Development of effective habit-formation interventions will be aided by understanding how habit develops with repetition, and factors that may enhance the impact of repetition on habit strength (see Gardner & Lally, 2018).

Understanding habit formation trajectories

Enactment of new or unfamiliar behaviours requires conscious processing, but as habit strengthens, regulation of action instigation transfers to environmental cues and becomes less cognitively effortful (Lally et al., 2011). Understanding the 'shape' of the within-person relationship between context-dependent repetition and habit formation can help intervention developers to provide behaviour change support when it is most needed. Among 96 participants performing a self-chosen dietary or physical activity behaviour in response to a self-chosen once-daily cue, an asymptotic curve – characterised by initial rapid gains that decelerate as a plateau is reached – provided a good fit to the data for many, and fitted best for those who most consistently performed the behaviour daily (Lally et al, 2010). An alternative asymptotic curve, depicting slower formation at the outset, fitted participants consistently performing a stretching exercise in the morning or evening (Fournier et al., 2017; see too Tobias, 2009). These findings imply that habit-forming interventions should provide most support at the early stages to maintain repetition before automaticity peaks, and that support may then be lessened, because habit alone should sustain action.

Other studies have questioned whether habit necessarily forms asymptotically. In a study of 117 participants forming healthy drinking or eating habits in response to once-daily cues, 56% experienced quadratic habit trajectories, with rapid early habit gains peaking then declining, albeit to a level higher than baseline (Keller et al., 2021; see too van der Weiden et al., 2020). Habit formed asymptotically for only 38% of the sample (Keller et al., 2021). This suggests that habit formation curves may differ between individuals such that, while for some people peak habit strength may be maintained, for others, habit will erode from this peak. Interventions may therefore need to provide support not only before habit is established, but also at later points, to counteract waning habit strength.

Attempts to understand how repetition translates into habit will depend on how repetition is assessed and for how long. Most studies have modelled the impact of time, not repetition, on habit development (e.g. Lally et al., 2010). Using time to capture repetition is unlikely to be problematic where context-consistent performance reliably occurs only once over the specified timeframe. For example, among participants successfully acting once daily, habit strength at day 10 will reliably reflect ten repetitions. However, where behaviours are performed more or less frequently than the habit measurement timeframe, time offers an inadequate proxy measure. Habit strength at day 10 will not reflect actual number of repetitions where behaviour has consistently been performed in response to cues occurring more than once-daily (e.g. 'after eating a meal'), or if participants fail to act on one or more days. More work is needed to establish the shape of habit formation trajectories with repetition, and whether and why these differ across actors, behaviours, or cues.

RQ4: *What is the typical 'shape' of within-person real-world habit growth with repetition over the long-term, and what determines the fit of this 'shape' to individual trajectories?*

Understanding the conduciveness of habit to behaviour maintenance

While many studies show stronger habit is associated with more frequent performance (Gardner, 2015), surprisingly little work has tested whether habit formation leads to persistent action upon exposure to cues (Triandis, 1977). Habit is most usefully portrayed on a continuum of strength, rather than a habit/no-habit dichotomy, which renders this hypothesis problematic. Some participants report habit gains peaking at low levels, such that the associated behaviour becomes less deliberative, but not meaningfully automatic (Lally et al., 2010). It seems unlikely that shifting from 'strongly' to 'moderately' disagreeing that a behaviour is automatic reflects formation of a habit sufficient to sustain behaviour. People describe new behaviours performed daily becoming 'second nature' within 1–2 weeks (Lally et al., 2011, p. 487; Gardner et al., 2014), implying both habit formation and maintenance. To our knowledge, only one study has shown the impact of habit formation on behaviour over time. Among new gym members, habit typically plateaued after 6 weeks of attendance, and those surpassing a score of 2.8 on a 1–5 self-report scale – where 1 denotes weak and 5 strong habit – were more likely to continue attending (Kaushal & Rhodes, 2015). More work is needed in this area.

RQ5: *What level of habit strength is required to sustain real-world behaviour over time?*

Understanding facilitators of habit formation

Leaving aside factors that promote enactment of behaviour more generally, facilitators of the growth of cue–response associations can be roughly organised into those pertaining to the actor, behaviour, or cues. These facilitators may potentially hasten habit formation, such that fewer repetitions are needed, or heighten the level at which habit peaks.

Actor-related facilitators

Work in this area has focussed on personality and individual differences (e.g. McCloskey & Johnson, 2019; Ramakrishnan et al., 2021). A cross-sectional survey of conscientiousness, neuroticism, and habit among 459 participants showed that higher conscientiousness was associated with weaker habit for health-risk behaviours (e.g. unhealthy snacking; McCloskey & Johnson, 2021), and neuroticism was associated with stronger habits. Notwithstanding limitations of the cross-sectional design, these results suggest the formation of health-conducive habits may be inhibited by conscientiousness but facilitated by neuroticism. Conscientiousness associations may perhaps reflect trait self-control: people higher in conscientiousness tend to show greater self-control (O'Gorman & Baxter, 2002), so may be more likely to maintain non-automatic regulation of their actions (Moran & Mullan, 2021). Yet, this conflicts with evidence suggesting that people with greater trait self-control may act *more* habitually. Galla and Duckworth (2015) showed that people higher in self-control report stronger habits for actions that help them to act according to their goals, effectively habitually shielding their behaviour (e.g. eating a healthy diet) against unwanted temptations (e.g. snacking).

A preference for routine has been linked to stronger habit (Ersche et al., 2017) and conversely, 'life chaos' – i.e. an absence of structure – is associated with weaker habit (Hoo et al., 2017). This may indicate that, perhaps owing to a preference for regularity or aversion to novelty (Ramakrishnan et al., 2021), people with more structured lives purposely plan responses to cues or encounter potential habit cues more consistently. Qualitative data suggest that people tend to find it more difficult to maintain context-dependent repetition of actions during weekends or while on holiday, because daily activities are less structured, making it harder to adhere to habit formation plans (Lally et al., 2011). Routinisation is thought to be particularly important in medication adherence. Stronger habit is associated with greater adherence among adults with cystic fibrosis (Hoo et al., 2017), and lower adherers often report lacking routine (Arden et al., 2019).

Research exploring actor-related facilitators has been limited by its focus on predicting ongoing habits. Correlates of between-person variation in pre-existing habits do not reliably represent determinants of within-person formation of new habits. For example, while Galla and Duckworth's (2015) study of ongoing habits suggested that people higher in self-control have stronger existing habits, another found that self-control capacity had no impact on the formation of new 'good' habits (van der Weiden et al., 2020).

RQ6: *Which personality and individual difference factors influence real-world habit formation, and how?*

Behaviour-related facilitators

Actions that are ideally performed rigidly in unvarying contexts – for example, hand hygiene among healthcare professionals following patient contact (Potthoff et al., 2018) – are naturally the most appropriate targets for habit-forming interventions. Research into behaviour-related facilitators is needed to understand how best to

promote context-dependent repetition, or to reinforce the impact of each repetition on habit development. There is disagreement around whether people can form 'habits of omission'; theory dictates that people cannot form cue–response associations that specify no response (Lally & Gardner, 2013). However, in practice people can form habits for acting in a way that inhibits unwanted responses. For example, people who made coping plans specifying that they would 'do something else instead' of smoking in response to smoking cues were more likely to avoid smoking over the following four weeks than those who did not form such plans (Armitage, 2008). Conversely, 'preparation habits' can facilitate later, wanted behaviours; gym-goers who formed habits for placing a packed gym bag by the door were more likely to exercise over a subsequent 6-week period than those who did not (Kaushal et al., 2018).

In theory, any repeated behaviour can become habitually triggered, but in practice, the reward value of action will likely dictate the likelihood of repetition, and the reinforcing impact of each repetition on habit strengthening (de Wit & Dickinson, 2009). Questions have been raised around which reward types are most effective (Lally & Gardner, 2013), and evidence is mixed around whether such reinforcement hastens habit formation or increases the level at which habit strength peaks. Studies of physical activity, dietary consumption, flossing and vitamin adherence interventions have shown that, for behaviours that yield intrinsic rewards such as pleasure or satisfaction, fewer repetitions are typically required for habit to peak (Judah et al., 2018; Kaushal & Rhodes, 2015; Keller et al., 2021; but see Phillips et al., 2019). Hedonic rewards, based on positive sensory experiences, are also thought to be more reinforcing than rewards based on expected future benefits (Mullan & Novoradovskaya, 2018). Judah et al. (2020) showed that people formed stronger habits for consuming low-sugar drinks that they rated as more pleasurable. Lastly, reward immediacy is important, with delayed rewards (e.g. long-term health benefits) having less overall reinforcement value. There is relatively little real-world research into the impact of rewards on the repetition-habit relationship. Studying the impact of rewards is challenging because reward value may fluctuate across performances and may change over time, as initial rewards lose their appeal. It can also be difficult to isolate the impact of concurrent rewards; for example, a planned bout of exercise may bring mood benefits, alongside the satisfaction of plan enactment. Reward value is also subjective. It may be fruitful to examine within-person factors that affect the value of potential rewards. For example, outcomes that affirm preferred self-identities – e.g. 'I am the type of person who eats healthy snacks' – may be rewarding (Verplanken & Sui, 2019).

RQ7: *What makes the most effective reward(s) for quickening or heightening real-world habit formation, and why?*

Cue-related facilitators

Cue effectiveness depends at least partly on cue salience (McDaniel & Einstein, 2000). One study showed that people were more likely to floss, and formed stronger flossing habits, when cued to do so after rather than before toothbrushing (Judah et al., 2013). This suggests that people are more likely to attend to cues within an ongoing

routine (e.g. 'oral hygiene'), rather than cues situated at the end of a preceding routine (e.g. 'having a shower'; Judah et al., 2013). While 'piggybacking' a new habit (flossing) on to an existing one (toothbrushing) in this way exploits the cue–response architecture that supports existing habits, it may be difficult to remember to consistently insert a new behaviour into a habitually executed routine. There may, however, be practical advantages to inserting habits at the end of preceding routines; for example, where a new medication needs to be taken after a meal, completion of a 'mealtime' routine may be a more functional cue than completing the act of 'taking pre-existing medication'.

RQ8: *What is the optimal position within an existing routine to insert a new behaviour in order to promote real-world habit formation?*

Understanding habit disruption

Understanding how habit disruption relates to behaviour cessation

Gaps in understanding how habits are 'broken' can be attributed to the multifaceted nature of habit disruption, which encompasses four discrete ways of preventing habitual action (Gardner, Rebar, et al., 2020). 'Habit inhibition' refers to wilfully frustrating enactment of an activated habit impulse; for example, thinking 'don't do it!' on encountering cues to habitual snacking (Quinn et al., 2010). 'Habit discontinuation' refers to the avoidance of habit cues, either purposefully – e.g. avoiding stressful situations that prompt habitual snacking – or due to naturally occurring disruption – e.g. loss of employment resulting in removal of cues to desk-based snacking (Verplanken et al., 2018). 'Habit degradation' refers to purposeful or natural decaying of cue–response associations, and 'habit substitution' denotes the supplanting of an old, unwanted response to a cue (e.g. unhealthy snacking at 2 pm) with a new, wanted alternative response (e.g. eating fruit at 2 pm). Inhibition and discontinuation block enactment of habit impulses but do not directly address the associations that generate such impulses; they target *habitual behaviour*, not habit (Gardner et al., 2021).

The impact of disrupting health-related habitual *behaviours* on habit *associations* has received little empirical attention. Some have hypothesised that continued non-performance of a habitual behaviour in associated settings will lead to habit degradation (Tobias, 2009). Others propose that associations will persist despite disruption of habitual behaviour (Gardner et al., 2021). This has important implications for behaviour change because, in theory, persistent habits retain the potential to be reactivated when an actor returns to a triggering context following non-exposure, or loses the self-regulatory capacity to continue to inhibit unwanted impulses (e.g. when under stress; Gardner et al., 2021). For example, despite successful initial diet and activity changes, many people report difficulty in maintaining weight loss because they struggle to continually inhibit unwanted impulses (Gardner et al., 2021). Others have predicted that habit will degrade only where an old habitual behaviour is consistently and rigidly supplanted with an alternative response; that is, habit degradation occurs via habit substitution (Mercuur et al., 2021). For example, consistently

substituting habitual unhealthy snacking at 2 pm with eating fruit at 2 pm should develop a new, competing association that will dominate over and degrade the old association (Wood et al., 2021). If multiple alternative responses are performed (e.g. eating fruit, drinking water, going for a walk), no new habit will form, so the snacking habit will not decay (Mercuur et al., 2021). Further empirical evidence is required to test these predictions.

RQ9: *To what extent, and in what real-world conditions, does inhibiting an unwanted habit, or avoiding exposure to cues, lead to degradation of underlying cue-response associations?*

Some researchers have portrayed habit associations as indelible memory traces, such that, while one habit can be supplanted by another, habit associations can never truly be 'broken' (Graybiel & Smith, 2014). The possibility that habits may persist indefinitely raises questions regarding the optimal level of habit degradation for behavioural cessation, and factors that may contribute to degradation. For example, occasional lapses into unwanted habitual behaviours would be expected to impede the decaying of habit associations by reinforcing the unwanted association.

RQ10: *To what extent must a cue-response association be degraded for habitual cuing of a real-world behaviour to be discontinued?*

RQ11: *What factors hasten the degradation of real-world habit associations?*

Another question arises regarding 'habit recovery', whereby a degraded habit association is restrengthened through resumption of context-specific performance. For example, a person with a habit for unhealthy snacking each evening may, due to health problems, mindfully develop an evening fruit consumption habit instead, leading to snacking habit decay, but may deliberatively return to unhealthy evening snacking if the health problems are later resolved. Portrayals of habits as indelible imply that the degraded habit trace would facilitate more rapid strengthening of the snacking habit than would be observed for an action for which no prior habit memory exists. In real-world contexts, it may be difficult to distinguish the recovery of old habits due to resumed engagement from alternative processes supporting the re-emergence of non-decayed habitual behaviours, such as returning to associated contexts following temporary discontinuation, or momentary lapses in the self-regulation needed to inhibit behaviour.

RQ12: *Do degraded real-world habits reform more quickly, or more strongly, than do wholly new real-world habits?*

Designing and evaluating habit-based behaviour change interventions

There are various ways in which an intervention can be 'habit-based' (Michie & Prestwich, 2010). We focus only on those that explicitly use techniques expected to form or disrupt habits, and use habit formation or disruption as mechanisms for lasting behaviour change.

Understanding how best to promote habit-based change

Habit formation

Promoting habit formation requires understanding of the behaviour change techniques (BCTs) most conducive to formation[1]. Aside from studies of BCTs that support new behaviours more broadly, surprisingly little empirical research has sought to identify BCTs conducive to context-dependent repetition, or reinforcing the impact of each repetition on the speed or extent of habit formation. Some researchers have sought to identify BCTs most closely aligned with theoretical principles of reinforcing cue–behaviour associations (Gardner, Rebar, et al., 2020; Kok et al., 2016; Mullan & Novoradovskaya, 2018). Others have retrospectively identified common BCTs in real-world formation interventions (Gardner & Rebar, 2019). Conclusions from both approaches overlap, because explicitly habit-based interventions tend to use theory-derived BCTs to strengthen cue–response associations (e.g. Mergelsberg et al, 2021). More prospective work is, however, needed.

RQ13: *Which behaviour change techniques are most conducive to reinforcing the cue-response associations needed for real-world habit to form?*

Questions can also be asked regarding the optimal level at which behaviour can be specified within habit formation interventions. The concept of 'higher-order habits' raises the prospect of creating habit associations supporting a range of behaviours, prompting greater overall behavioural engagement. For example, forming a habit of 'filling half of a plate with fruits and vegetables' should promote consumption of a range of fruits and vegetables (Phillips et al., 2019), compared to forming a habit for eating a banana with breakfast. This may also promote variation, so preventing boredom and disengagement.

RQ14: *Does forming a 'higher-order habit' promote greater uptake of more specific target behaviours than does forming a habit for a more specific behaviour?*

Habit disruption

Similar to formation, BCTs conducive to purposeful habit disruption – i.e. inhibition, discontinuation, and substitution – can be derived from theory (Gardner, Rebar, et al., 2020; Kok et al., 2016). Inhibiting a habit relies on self-regulation at the moment that a habit impulse is activated, so core BCTs will likely include distraction, planning inhibitory responses, and training executive function to facilitate planning and enactment (Adriaanse & Verhoeven, 2018; Kok et al., 2016). Purposeful discontinuation of exposure to cues – as opposed to discontinuation arising from naturalistic context changes (Verplanken et al., 2018) – involves avoiding cues (i.e. 'stimulus control'), or restructuring physical or social environments to minimise exposure (Kok et al., 2016). Habit substitution requires the combination of BCTs conducive to habit formation and inhibition. There may be other BCTs that facilitate forms of habit disruption; for example, attempts to inhibit habits may be aided by prior monitoring of unwanted behaviours and potential cues, to identify which responses must be inhibited and in which contexts (Verhoeven et al., 2014). Empirical work is needed to test the effects of discrete BCTs for disrupting habits or habitual behaviours.

RQ15: *Which behaviour change techniques are most conducive to disrupting unwanted habit associations or habitual behaviours in real-world contexts?*

Habit substitution has been proposed as the optimal strategy for lasting disruption of habits in unchanging contexts (Gardner et al., 2021). Little evidence is available around the feasibility of substitution in many real-world contexts, however. Many 'bad' habits, such as eating high-calorie snacks, develop because they offer immediate, hedonic rewards, which may be more potent reinforcers than the longer-term health benefits arising from eating lower-calorie alternatives (Mullan & Novoradovskaya, 2018). Additionally, little is known about the real-world longevity of health habits that have newly supplanted prior, unhealthy habits, and factors that may influence the recovery of old, unhealthy habitual responses.

RQ16: *How feasible is it to substitute an unwanted habit with a less-rewarding alternative habit in the real-world?*

RQ17: *What factors influence the extent to which habit substitution will lead to lasting behaviour change, and how?*

Giving habit-based advice

Questions remain around whether, in addition to techniques needed to make or break habits, additional strategies may consistently enhance the effectiveness of habit-based interventions. For example, many habit-based interventions seek to explain the habit concept to participants (e.g. Beeken et al., 2017; White et al., 2017), but it is unclear whether this offers advantages over delivering habit change techniques without explaining target mechanisms or outcomes.

RQ18: *Are habit-based interventions that explain the concept of habit to participants more effective for forming or disrupting habits, or promoting lasting behaviour change, than those that do not?*

When habit has been explained to participants, habit formation interventions have differed according to whether they use a 'one size fits all' approach encouraging enactment of specific behaviours in specific contexts among all recipients, or instead seek to equip participants with the skills and knowledge to pursue self-chosen behaviours and settings. In theory, supporting participants to create personally-tailored habits should lead to the formation of more personally-relevant, intrinsically motivated and so stronger habits (Lally & Gardner, 2013). This approach may also be more suited to population-level initiatives when target behaviours and contexts are likely to differ widely among recipients. Yet, a study of parents developing action plans to form healthy child-feeding habits showed that many created suboptimal plans by, for example, failing to specify contexts or setting unmeasurable targets (e.g. 'I will give my child more water'; Gardner et al., 2014). Training participants to set their own habit goals with minimal further support risks loss of fidelity to habit theory.

RQ19: *To what extent, and in what conditions, is advice regarding which specific behaviours to perform in which specific settings more or less conducive to real-world habit formation than training people to set their own personalised habit plans?*

Understanding the mechanisms by which habit-based interventions change behaviour

Surprisingly, the fundamental assumption that making or breaking habits will lead to lasting behaviour change remains largely untested. A systematic review of 15 interventions promoting habit formation found encouraging short-term effects on behaviour, but few assessed behaviour change over the longer-term (Gardner & Rebar, 2019).

RQ20: *How effective are interventions that create new cue-response associations or disrupt old cue-response associations for bringing about lasting real-world behaviour change?*

Even where habit-based interventions have shown promise, researchers have often failed to conclusively demonstrate that changes in behaviour are attributable to habit change (but see Kliemann et al., 2017). Interventions have typically been evaluated using uncontrolled designs, or via comparison against no-treatment controls (Gardner & Rebar, 2019). Assessing the unique contribution of habit-based components requires comparing habit interventions against matched non-habit comparators. Mediation analyses or process evaluations are also needed, because it is possible that a habit-based intervention may yield long-term behaviour change via non-habit mechanisms (Volpp & Loewenstein, 2020). For example, people tend to find advice on consistent repetition simple and easy to follow (e.g. Gardner et al., 2014), making behaviour change more attractive (Volpp & Loewenstein, 2020). Conversely, non-habit-based treatments may prompt habit change. In a physical activity intervention trial, control participants who received non-habit-based guidance reported similar activity habit gains as did a group that received habit-based advice (White et al., 2017). This likely reflects that, when seeking to implement general behaviour change advice, people spontaneously adopt strategies conducive to habit change, such as enacting wanted behaviours in consistent settings, or avoiding triggers to unwanted actions (Quinn et al., 2010). This presents a challenge to evaluating the psychological mechanisms by which habit-based interventions may yield change. Further research is needed to identify the extent to which interventions targeting habit change yield changes in habit or other mechanisms.

RQ21: *Through which mechanisms of action do habit-based interventions bring about real-world behaviour change?*

Discussion

Addressing the questions, we have identified will facilitate development of interventions to promote formation of healthy habits or disruption of unhealthy habits, and so engender lasting real-world behaviour change. Our questions transcend research contexts, such that the 'answers' may differ across behaviours, settings, and populations. Cues to unhealthy eating, for example (Research Question 1; see Table 1), differ from cues to stair climbing, and stair climbing cues for younger adults differ from those for older adults (Eves, 2014). Nonetheless, accumulating and synthesising domain-specific evidence will inform a broader understanding of habit. We encourage all researchers interested in habit or behaviour change to contribute towards efforts to address these questions. Habit specialists should collaborate with intervention

designers and practitioners to embed these questions into broader behaviour change projects. Although habit research within health psychology is predominantly rooted in the traditions and assumptions of social psychology, we encourage health psychologists to work more closely with other disciplines, to enrich understanding of how habit translates into behaviour change.

Rigorous methods are required to comprehensively address our questions. Yet, the adequacy of dominant methods for studying habit within health psychology is questionable. For example, despite the conceptual separation of habit as cognition and habitual behaviour as the product of such cognition (Gardner, 2015), health habit research relies predominantly on self-report measures that assess habit via reflections on behaviour (e.g. Verplanken & Orbell, 2003; Orbell & Verplanken, 2015). These indices are unlikely to be sensitive to underlying habit associations that are not acted upon. True effects of habit on action are obscured by focussing only on the behavioural output of habit (see Luque et al., 2020). Direct measures of cue–response associations (e.g. Danner et al., 2007), or impulses aroused by cuing such associations (e.g. Fidler et al, 2011), may provide more sensitive measures. Inadequate measures, and inconsistencies in sensitivity between measures, present challenges for questions that require monitoring habit change and its relationship with behaviour change. Additionally, while our questions are designed to stimulate research on real-world habits, this is not to imply that all such research must be field-based. Research in controlled settings (e.g. lab-based studies) will aid developing understanding of the determinants, techniques, and mechanisms involved in habit-based behaviour change.

Attempts to track real-world habit change and its facilitators have been limited by design problems, such as using between-person analyses to study a within-person process (Judah et al., 2013). Intensive longitudinal designs, involving frequent momentary assessments, offer promise for modelling within-participant habit trajectories (Bolger & Laurenceau, 2013), and the dynamic interplay between habit formation and its facilitators (Keller et al., 2021). The repeated measurement of habit at micro timescales characteristic of ecological momentary assessment designs also permits insight into momentary fluctuations in habit strength and its impact on behaviour (Rebar et al., 2014). Such insights would provide a useful basis for isolating meaningful habit change from natural fluctuation.

Longer follow-ups are also needed to document habit change. Habit formation studies have tended to use 12-week follow-ups (Keller et al., 2021; Lally et al., 2010), but it is possible that habits may degrade beyond this point (Judah et al., 2013; Tobias, 2009). Assessing habits over short periods risks overlooking dips in newly-formed habits, or the restrengthening of degraded habits, over the longer-term. Similarly, the long-term effect of habit interventions has received little research attention. A review of habit formation interventions found the longest follow-up was 24 months (Beeken et al., 2017), and few tracked habit for more than 12 months (Gardner & Rebar, 2019).

Translating habit theory into interventions conducive to sustainable behaviour change requires understanding how habit affects behaviour, how habit forms and is broken, and how to change habit via interventions. Yet, research gaps exist in each of these areas. Addressing our research questions will further the science of health habits and behaviour change.

Note

1. The Behaviour Change Technique Taxonomy v1 portrays 'habit formation', as defined as 'prompting rehearsal and repetition of the behavior in the same context repeatedly so that the context elicits the behavior', as a standalone technique (Michie et al., 2013, Supplementary Material, p. 11). This is however more accurately labelled 'context-dependent repetition', which separates the process by which behaviour changes (i.e. context-consistent performance) from the outcome of change (i.e. cue-response associations; Gardner & Rebar, 2019).

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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