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Reconceptualizing self-regulation in health behaviors: A dynamic perspective on the PAAM model

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ABSTRACT

Health behavior change and maintenance are essential for preventing chronic diseases and promoting well-being. However, a persistent intention-behavior gap highlights the complexity of sustaining health-promoting behaviors over time. The Physical Activity Adoption and Maintenance (PAAM) model 1.0, based on in dual-process theories, provides a framework for understanding the interaction between explicit (reflective) and implicit (automatic) processes in physical activity (PA) regulation. Recent evidence suggests that PA behaviors and their determinants are more dynamic than previously conceptualized, necessitating an updated framework. This paper introduces the PAAM model 2.0, which expands upon its predecessor by incorporating intraindividual variability in key constructs such as intention and self-control. The revised model also underscores the role of anticipated affect in intention formation and behavior regulation. While originally designed for PA, the PAAM model 2.0 offers a generalized framework applicable to other repetitive health behaviors, including medication adherence, dietary regulation, and sleep routines. The model's implications for research and practice are discussed, emphasizing the need for dynamic assessments and tailored interventions. By integrating state-like fluctuations and integrated regulatory processes, the PAAM model 2.0 advances our understanding of long-term health behavior change and provides a foundation for effective, evidence-based interventions.

Behavior change and behavior maintenance are foundational to health promotion, enabling healthier lifestyles and the prevention of chronic diseases (Cleven et al., 2022; Kwasnicka et al., 2016). Despite widespread awareness of the benefits of engaging in health-promoting behaviors such as regular physical activity (PA), balanced nutrition, and stress management (Jekauc et al., 2015), a significant discrepancy often exists between individuals' intentions and their actual behaviors (Jekauc et al., 2025). This phenomenon, known as the intention-behavior gap, underscores the complexity of sustaining behavior change over time (Conner & Norman, 2022). Addressing this gap is essential for designing interventions and policies that foster long-term adherence to beneficial routines, thereby improving public health outcomes and reducing healthcare costs associated with preventable conditions (Sniehotta, Scholz et al., 2005).

A wide range of theoretical approaches have emphasized that both deliberative (explicit) and automatic (implicit) processes contribute to the adoption and maintenance of health behaviors (Hagger, 2016). On one end of this continuum, deliberate, conscious, and goal-directed regulation involves mechanisms such as intention formation and rational evaluation of behavioral outcomes. At the other end, behavioral regulation can be shaped by automatic, stimulus-driven processes, including habits and affective associations with contextual cues. These regulatory mechanisms interact and co-regulate behavior in dynamic ways, depending on factors such as self-regulation capacity, emotional states, and contextual variables (Metcalfe & Mischel, 1999). This perspective reflects a growing recognition that health behaviors are shaped by the integration of reflective and automatic influences, and that effective prediction and promotion of behavior change requires attention to this interaction (Brand & Ekkekakis, 2018).

The Physical Activity Adoption and Maintenance (PAAM) was developed to explain the dynamic interplay between intention-driven and automatic regulatory mechanisms in the adoption and

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maintenance of PA behavior (Strobach et al., 2020). Within the PAAM framework, intention and habit are considered core constructs that exert complementary influences on behavior. Intentions are particularly critical during the initiation of novel behaviors and are shaped by self-regulatory capacities such as trait self-control and executive functioning (EF) (Pfeffer & Strobach, 2021). As behaviors become repeated and situated within stable contexts, habit strength increases, and behavioral regulation becomes increasingly automatic. Affective experiences, especially positive affect during or after PA, further contribute to this shift by reinforcing behavior patterns and supporting habit development (Weyland et al., 2020).

While the original version of the PAAM model (henceforth labelled as PAAM model 1.0) provides a valuable framework for understanding key regulatory mechanisms governing PA adoption and maintenance, recent empirical evidence suggests that the model requires refinement to account for dynamic aspects of behavior regulation and the expanded role of affect (Jekauc et al., 2024; Maher et al., 2024; Pfeffer & Strobach, 2021; Rodrigues & Teixeira, 2023). The original PAAM model 1.0 conceptualizes key constructs, such as intention and self-control, as relatively stable traits, yet these determinants often fluctuate based on situational and temporal factors (Conroy et al., 2011; Englert et al., 2021). A more dynamic representation of these variables is thus essential to capture the fluid nature of behavior change processes (Maher & Conroy, 2018). Additionally, anticipated affect – the emotional expectations tied to future actions – has emerged as a critical factor in intention formation, influencing decision-making and motivational states (Feil et al., 2023). Notably, our focus on short-term, state-like fluctuations within daily or weekly timescales in the revised PAAM model (henceforth labelled as PAAM model 2.0) is aligned with calls in the literature for explicit theorizing on temporal matters in health psychology (Scholz, 2019), which emphasize the importance of specifying when and across which timespans psychological processes and their relationships unfold. By incorporating these dynamic and anticipatory dimensions, the PAAM model 2.0 could provide a more comprehensive and context-sensitive understanding of PA behaviors, enhancing its predictive power and practical application in interventions aimed at promoting sustained engagement in PA.

The objective of this paper is to provide an extension from the PAAM model 1.0 to the PAAM model 2.0 to address intraindividual variability and to align it with recent advancements in understanding PA behaviors. We do so by providing an overview of the key elements of the PAAM model 1.0 first, before we elaborate on the changes of key elements in this model, leading to the PAAM model 2.0. Specifically, the revision aims to incorporate dynamic psychological constructs that reflect the fluctuating nature of intention and other behavioral determinants over time. Additionally, it seeks to expand the role of anticipated affect as a key determinant in the formation of intention. By refining these elements, the adapted model aspires to improve its explanatory power, provide a more comprehensive framework for understanding the adoption and maintenance of PA, and offer actionable insights for the development of targeted, evidence-based interventions.

1. The PAAM model 1.0: overview

The PAAM model 1.0 is a heuristic framework designed to elucidate the mechanisms underlying the adoption and maintenance of PA behaviors (Strobach et al., 2020). Grounded in dual-process theories, this model integrates explicit and implicit processes to provide a comprehensive explanation of PA behaviors (Jekauc et al., 2024). Processes such as intention, trait self-control, and executive functions play a central role in the initiation of PA by supporting deliberate and goal-directed actions, although emerging evidence suggests that some aspects of goal pursuit may also operate outside of conscious awareness (Gollwitzer & Bargh, 2005; Gollwitzer et al., 2009). These explicit processes involve cognitive processes required to translate intentions into concrete behaviors, particularly during the early stages of behavior adoption when habits have yet to be formed.

In contrast, implicit processes – characterized by automatic, fast, and effortless processing components – become more important as behaviors become habitual over time. Habits, formed through repeated actions in stable contexts, are triggered by environmental cues and are supported by positive affective experiences. The PAAM model 1.0 posits that implicit processes, such as habit strength and affective responses, not only drive behavior maintenance but also interact dynamically with explicit processes. For instance, positive affective experiences during PA can accelerate habit formation, making PA rely less on explicit components (Jekauc, 2015); in contrast, negative affect may inhibit habit formation, maintaining the focus on these components. Furthermore, the model recognizes that the interplay between these two processes is contingent upon self-regulatory abilities, which determine whether explicit or implicit mechanisms dominate behavior in specific contexts.

The PAAM model 1.0 distinguishes itself from earlier frameworks by focusing on the dual-process interaction of explicit and implicit mechanisms and their roles in behavior adoption and maintenance. Unlike the Affective-Reflective Theory (Brand & Ekkekakis, 2018), which centers on momentary and anticipatory affective evaluations of exercise, the PAAM model emphasizes a broader dynamic interplay between intention, self-control, and habit formation as driving forces in PA. While the Affective-Reflective Theory provides an explanation of decision-making at specific moments of a behavioral choice, particularly under conditions of low self-regulatory resources, the PAAM model incorporates a more longitudinal perspective. It explains how explicit processes, such as intention, facilitate behavior adoption and how implicit processes, like habit and affect, become increasingly important for behavior maintenance over time. This dynamic interplay between explicit and implicit processes lays the groundwork for the next section, which explores how key constructs in the PAAM model 2.0, such as intention and self-control, are redefined as state variables to better reflect their fluctuating nature in regulating PA behaviors.

1.1. The PAAM model 2.0

The following sections elaborate on the main components and characteristics of the PAAM model 2.0. These sections do so by outlining the dynamic structure of the PAAM model 2.0 before introducing a more refined approach to assessing behavior. They then explore key components, including the roles of affect, trait and state self-control, and planning, while also discussing the reduced emphasis on EFs in the updated model. Finally, we highlight future research directions and implications of the model's expanded applicability. In this highlight, it becomes clear that, although originally developed to explain PA behaviors, the revised model provides a framework that can be applied more broadly to other repetitive health behaviors. This is so because core mechanisms such as habit formation, fluctuating self-control, and the role of anticipated affect are not exclusive to PA but are also fundamental in behaviors like consistent medication adherence,

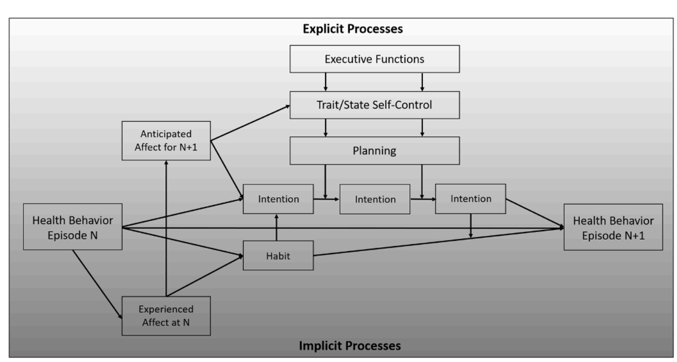

Fig. 1. The PAAM model 2.0.

maintaining a healthy diet, and establishing regular sleep routines. The PAAM model 2.0 is illustrated in Fig. 1.

2. The dynamic model structure

The PAAM model 2.0 emphasizes the dynamic nature of deliberative processes, particularly intention and self-control, as central in understanding the regulation of health behavior such as PA (Scholz, Nagy et al., 2008). Intention, traditionally conceptualized as a stable predictor of behavior, is redefined as a state variable that fluctuates in response to situational and contextual factors (Maher & Dunton, 2020). These variations reflect changes in motivation, competing priorities, and external demands, which are particularly pronounced during transitions between the adoption and maintenance phases of PA (Abraham & Sheeran, 2003; Conner et al., 2016). This dynamic perspective allows the model to more accurately capture the complexities of behavior regulation in real-world contexts.

While intention exhibits considerable variability (Conroy et al., 2013; Maher & Conroy, 2018), its relative stability remains critical for explaining behavior (Cooke & Sheeran, 2013; Sheeran & Abraham, 2003). Intention serves as a key link between deliberative processes and the execution of the intended behavior (Conner & Norman, 2022). During the adoption phase, the strength and consistency of intention are particularly important for initiating new behaviors (Maher et al., 2024). However, as individuals move into the maintenance phase, the influence of intention decreases relative to automatic processes such as habit, which gradually take on a more prominent role (Gardner et al., 2020).

In the revised PAAM model 2.0, self-control is not only treated as a trait-like variable but also as a state-like variable, reflecting its transient and context-dependent nature (Neal et al., 2017; Ridder & Fennis, 2025). Unlike the static trait-based conceptualizations of self-control, the revised model acknowledges that the ability to volitionally regulate certain behavioral tendencies fluctuates, especially if individuals had to regulate themselves during the course of the day (Englert & Rummel, 2016). These fluctuations can affect the ability to translate intentions into actions, particularly in demanding or stressful situations that require self-control (Frye & Shapiro, 2021).

Automatic processes, such as habit, are comparatively less dynamic but still subject to gradual change over time (Nilsen et al., 2012). Habit strength increases with repeated behavior in consistent contexts and is reinforced by positive affective experiences (Gardner & Rebar, 2019). This gradual shift underscores the importance of habit in sustaining PA, particularly as deliberative processes like intention and self-control fluctuate. By incorporating the dynamic nature of behavior change, the revised PAAM model 2.0 provides a comprehensive framework for understanding the interplay of deliberative and automatic mechanisms in both the adoption and maintenance phases of PA.

Building upon this dynamic framework, the revised PAAM model 2.0 proposes two central hypotheses to capture the bidirectional interplay between habits and intentions. First, we hypothesize that habit strength can influence intention formation by biasing the likelihood of forming intentions congruent with existing habitual behaviors. This bottom-up effect suggests that repeated behavior patterns can make certain intentions more accessible and more likely to be endorsed, even in the absence of conscious deliberation (Verplanken et al., 1998). This mechanism is not conceptualized as post-hoc rationalization, but rather as a process through which habitual behavior informs motivational alignment and intentional planning over time. Second, we hypothesize that strong intentions can override or suppress the expression of habitual tendencies, representing a top-down mechanism through which deliberate goal-directed processes can modulate or inhibit automatic responses (Gardner et al., 2015). The PAAM model 2.0 acknowledges that intention and habit exert direct effects on behavior, indirect effects (e.g., habits shaping intentions), and interaction effects where the content of intention moderates the influence of habit on behavior. Collectively, these mechanisms illustrate the dynamic, reciprocal relationships between implicit and explicit processes, emphasizing that health behavior adoption and maintenance depend on the continuous interaction among direct and indirect pathways (Rebar et al., 2016; Sheeran et al., 2013).

This incorporation of a more dynamic structure also allows making a distinction between the cognitive habit process (the learned cue-response association that generates an impulse) and habitual behavior (the observable action that may or may not follow from that impulse). By separating the two, recent work shows that habits are not necessarily “inflexible”; rather, they can operate at different levels within a behavioral hierarchy and permit flexible execution when goal-relevant options vary (Gardner, 2015; Gardner & Lally, 2023). When differentiating between higher-order (instigation) versus context-specific (execution) habits, only instigation habit reliably predicts whether an PA episode occurs at all; execution habit predicts how it unfolds once started (Gardner et al., 2016). Subsequent reviews and modelling work argue that this hierarchical architecture (“habitually deciding” vs. “habitually doing”) renders the classical claim of rigid stimulus-bound responding obsolete for many complex health actions, such as PA (Gardner & Lally, 2023).

3. Phases of PA adoption and maintenance

The PAAM model 2.0 delineates adoption and maintenance as distinct yet connected phases in the regulation of PA behavior, based on the interplay of deliberative and automatic processes. Behavior adoption begins after intention formation and its translation into action, with intention stability primarily influenced by individual self-regulatory competencies (e.g., trait self-control, planning skills). Individuals with stronger self-regulatory skills are more likely to maintain stable intentions over time, which facilitates the consistent enactment of PA behavior.

During initial activity episodes, individuals experience affective reactions, which are stored in memory alongside the behavior. Positive affective experiences are associated with approach tendencies toward future behavior (Brand & Cheval, 2019; Brand & Ekkekakis, 2018). Over time, frequent enactment of behavior – initially regulated by explicit processes – leads to a gradual shift toward more implicit control (Strobach et al., 2020). As habits strengthen through repetition in stable contexts, the behavior becomes increasingly automatic.

Maintenance is characterized by predominant implicit control, where automated behavioral schemas trigger behavior through cues or automatic affective responses, promoting stable and resilient engagement even in the face of obstacles (Pfeffer & Strobach, 2021). These automated behaviors are often resistant to disruption and persist over time. Although the exact temporal trajectory of this transition is unclear, a recent meta-analysis by Singh et al. (2024) reported median or mean times to substantial habit strength of 59–66 days (median) or 106–154 days (mean), with substantial individual variability (4–335 days). Simpler behaviors with clear cues and immediate rewards tend to automate more rapidly than more complex behaviors. This conceptualization of adoption and maintenance phases clarifies how the PAAM model 2.0 captures the determinants of sustained PA engagement.

4. Redefinition of PA behavior

The revised PAAM model 2.0 emphasizes the importance of defining PA with greater specificity, focusing on concrete, repeatable actions rather than abstract goals. This behavior is conceptualized as a sequence of distinct episodes that are observable, measurable, and contextually bound (Jekauc et al., 2025). This episodic perspective aligns with the understanding that PA yields the most substantial benefits when performed regularly and consistently over time (Rakowski, 1987).

Central to this redefinition is the role of repetition in establishing and maintaining PA. Regular engagement in specific actions allows individuals to develop routines that reinforce consistency and facilitate the transition from explicit to implicit processes. Sequential repetition, such as regular engagement on daily or weekly schedules, contributes to embedding behaviors into an individual's lifestyle by reinforcing action patterns over time (Finne et al., 2019). However, recent research highlights that effective habit formation also depends on additional factors beyond timing alone, including stable environmental cues, emotional states, and social contexts that consistently trigger behavior (Gardner & Rebar, 2019; Kaushal et al., 2025; Wood, 2024). Therefore, the revised PAAM model 2.0 acknowledges that while repetition is important, the quality and consistency of contextual cues are equally critical for successful habit formation.

An essential consideration in this framework is the exact correspondence between the determinants of behavior and the specific behavior being studied (Ajzen, 1991). All determinants, such as intention, self-control, and affect, must precisely relate to the behavior under examination. Any mismatch or misspecification between these determinants and the defined behavior introduces inaccuracies in the analysis and interpretation of results (Jekauc et al., 2025). For instance, measuring general intention toward PA but assessing a specific behavior, such as running, would result in conceptual misalignment and undermine the validity of the findings. This refined focus ensures that the PAAM model 2.0 provides robust insights by aligning theoretical constructs with precise PA targets.

This redefinition of PA behavior also addresses the multidimensional nature of the intention-behavior gap, as highlighted by recent research (Jekauc et al., 2025). By framing behavior as a series of episodes, the PAAM model 2.0 better accounts for variations across time, context, and type of action than the PAAM model 1.0. Such specificity enables more accurate assessments of how determinants influence PA, offering clearer foundations for intervention strategies that emphasize actionable, measurable behaviors.

5. The updated role of affect

Affect plays a pivotal role in the revised PAAM model 2.0, particularly through its influence on intention formation and behavior regulation (Rigoni et al., 2015). Anticipated affect refers to the expected emotional experience associated with future actions (Mellers & McGraw, 2001) and significantly contributes to motivation and the formation of behavioral intentions (Feil et al., 2025; Finne et al., 2022). For example, the expectation of enjoyment, pride, or guilt can influence the likelihood of engaging in PA by shaping its perceived emotional value (Feil et al., 2023). Conversely, negative anticipated affect, such as anticipated guilt or disappointment from non-participation, can serve as either a deterrent or a motivator depending on the context (Kwan, 2010).

The revised PAAM model 2.0 differentiates between experienced affect – affective states felt during or immediately after a behavior – and anticipated affect. Experienced affect provides feedback that informs future emotional expectations, creating a reciprocal relationship between what is felt during PA and what is expected to be felt in future sessions (Feil et al., 2022). For instance, if PA generates feelings of accomplishment and joy, these experiences positively influence anticipated affect for future activity, reinforcing intention formation. Conversely, negative experiences, such as frustration or physical discomfort, may diminish positive anticipation, potentially weakening intentions and increasing the risk of dropout from PA behavior (Kwan, 2010).

Moreover, the revised PAAM model 2.0 underscores the dynamic interplay between experienced and anticipated affect in the stabilization of intentions. Anticipated affect does not merely predict initial intention formation but also interacts with experienced affect to adapt and sustain intentions over time. Furthermore, a discrepancy between anticipated and experienced affect – known as affective forecasting error – can either motivate recalibration of expectations or discourage future engagement, depending on whether the error is perceived positively or negatively, respectively (Loehr & Baldwin, 2014; Ruby et al., 2011). Such errors are common when individuals underestimate the positive emotions they will experience during PA, as shown in prior studies (Aitken et al., 2021; Ruby et al., 2011).

By highlighting the interaction of anticipated affect with experienced affect (McGraw et al., 2005), the revised PAAM model 2.0 advances the understanding of how affective processes influence not only the formation of intentions but also their persistence. This nuanced framework underscores the importance of aligning anticipated affect with achievable, positively reinforcing experiences during PA to design effective interventions that support sustained PA.

In the original PAAM model 1.0, affect was primarily conceptualized as a moderator of the intention-behavior relationship, reflecting the idea that positive or negative affective states could strengthen or weaken the immediate translation of intentions into action (Strobach et al., 2020). However, emerging evidence suggests that affective processes operate more broadly and directly: anticipated affect plays a central role in intention formation by influencing the motivational value of planned behavior (Feil et al., 2022; Kwan & Bryan, 2010), while experienced affect during or after behavior episodes critically shapes future intentions (Finne et al., 2022; Richard et al., 1996) and the development of habits (Weyland et al., 2022). Studies show that anticipated affect prospectively predicts intention strength independently of other cognitive constructs (Feil et al., 2025, 2023; Finne et al., 2022) and that experienced affect enhances automaticity in exercise habits, with higher positive valence associated with increased automaticity (Feil et al., 2021; Weyland et al., 2020). Therefore, the PAAM model 2.0 positions experienced affect as a determinant of habit formation and anticipated affect as a determinant of intention strength, reflecting a more comprehensive and empirically grounded understanding of how affective processes drive both the initiation and maintenance of health behaviors.

6. Executive functions

In the PAAM model 1.0, EFs are an essential component in predicting PA behavior. EFs are a set of higher-order cognitive control mechanisms that regulate the dynamics of human behavior. In the prominent unity/diversity framework (Friedman & Miyake, 2017; Miyake & Friedman, 2012; Miyake et al., 2000), the complexity of different processes involving the EF construct was systemized primarily in three domains: inhibition, updating, and shifting. Inhibition is related to the deliberate overriding of dominant or prepotent responses, updating refers to monitoring and manipulating working memory contents, and shifting is associated with switching flexibly between different tasks or mental sets (i.e., cognitive flexibility).

It is assumed that EFs support the self-control of goal-directed behavior by organizing information and behavior to effortfully overcome short-term gratifications that conflict with long-term goals. Self-control entails 1) a standard or a goal that individuals endorse, mentally represent, and monitor, 2) sufficient motivation to invest effort into reducing discrepancies between standards and actual states, and 3) sufficient capacity to achieve the goal or the standard by reducing the discrepancy despite temptations and barriers that might arise. Particularly, individual differences in these processes may predict PA behavior and the translation of intentions into action. Consistent with this assumption, the updating (Pfeffer & Strobach, 2017), inhibition, and shifting (Pfeffer & Strobach, 2021) abilities are associated with the gap between intentions to be physically active and the actual PA. Furthermore, inhibition (Hall et al., 2012) and updating (Pfeffer et al., 2020) are associated with the relation between making PA plans and realizing this activity. The results of a meta-analysis of prospective studies showed that the total effect size for the relationship between EFs and PA was small, but this analysis quantitatively revealed that baseline EFs predicted later PA significantly (Gürdere et al., 2023). Additionally, studies showed that grey matter volume and activation in the lateral prefrontal cortex (lPFC) are linked with EF performances, and it has been shown that larger lPFC volume and activation in lPFC regions predicted higher adherence to PA (Best et al., 2017; Yuan & Raz, 2014). Therefore, we suppose that EFs are the biological basis for the self-control of PA behavior and are basic abilities that support the pursuit of long-term goals.

Nevertheless, measuring EFs in the context of behavior models is challenging since EF tests are time-consuming and they incorporate the task-impurity problem (Miyake & Friedman, 2012; Miyake et al., 2000), namely that any target EF must be embedded within a specific task so that the target EF has something to operate on (e.g., the Stroop task to measure inhibition). Any score derived from an EF task necessarily includes systematic variance attributable to non-EF processes associated with that specific task (e.g., perceptual processes, response processes, and general processing speed). Unfortunately, this non-EF variance is substantial, making it difficult to plainly measure the target EF variance in general and as a basis of self-control in the context of the PAAM model 2.0. A solution for this difficulty is to measure self-control directly.

7. Trait and state self-control

Previous research has reliably shown that the relatively stable ability to control behavioral impulses and to deal with goal conflicts (i.e., trait self-control) plays an important role in explaining certain (un-)healthy behaviors (i.e., trait self-control; e.g., Andrade & Hoyle, 2023). For instance, individuals who are not used to being physically active on a regular basis oftentimes perceive PA as a rather aversive experience. Consequently, individuals must force themselves to follow through with their PA intentions, or more precisely, they have to exert self-control, which is linked to increased sensations of effort (Kurzban, 2016). According to Napolitano et al. (2024), individuals with higher levels of trait self-control are more adept at controlling themselves because they use more adaptive self-control strategies (see also Ridder & Fennis, 2025). Gillebaart et al. (2022) explain the benefits of trait self-control by arguing that there is a strong relationship between trait self-control and habits, meaning that the behavior of individuals with higher levels of trait self-control is primarily driven by habits instead of conscious self-control exertion.

This primary drive due to habits may vary depending on the complexity of the behavior (Phillips & Mullan, 2023). Simpler behaviors with clear procedural steps (e.g., taking a vitamin) can become automated more quickly than more complex behaviors requiring multiple sequential actions and more planning (e.g., going to the gym; Saunders & More, 2025). Although recent cross-sectional studies (e.g., Phipps et al., 2025) report associations between trait self-control components and habitual behaviors of varying complexity, these findings are based on between-person correlations and cannot establish whether self-control and habit interact dynamically within individuals over short timeframes, highlighting the need for intensive longitudinal studies. We hypothesize that over repeated behavioral episodes, self-control and habit may reciprocally shape each other through long-term processes of behavior adoption and maintenance, but acknowledge that current evidence using intensive longitudinal designs to test these within-person dynamics is lacking. Thus, in the short-term, relationships between self-control and habit strength may not manifest clearly within individuals, highlighting an important avenue for future research. The revised PAAM model 2.0, apart from these relatively stable interindividual differences in self-control, assumes that there are also factors that affect the efficiency of self-control exertion in a given situation (i.e., state self-control). Earlier self-control models postulated that there is a depletable metaphorical self-control resource empowering all types of self-control (e.g., Baumeister et al., 2007). After having exerted self-control this resource supposedly depletes for a certain amount of time, and it is assumed that in such a state of *ego depletion*, subsequent self-control acts are more likely to fail (Englert, 2019). However, several large-scale replication projects failed to replicate the ego depletion phenomenon, raising questions regarding its validity (e.g., Englert & Bertrams, 2021; Vohs et al., 2021). Berkman and colleagues (2017) argue that lapses in self-control are not the consequence of depleted self-control resources but rather the result of a value-based choice. If individuals have to choose between different options, they are likely to select the option that promises the highest value. For instance, if a physically inactive individual must make the decision whether to a) go to the gym, b) meet with friends, or c) watch TV at 6 pm. on a given Sunday, they are most likely to choose the option with the highest subjective value. The revised PAAM model 2.0 assumes that physically inactive individuals perceive PA as rather aversive and effortful, leading them to avoid effortful gym sessions while rather seeking more pleasant situations. Based on these premises, self-control processes are assumed to be particularly important in the adoption of a novel and thus effortful behavior. As the respective behavior is carried out more regularly over time in relatively stable contexts, habits evolve (e.g., Gardner & Lally, 2018). Consequently, the necessity to exert self-control decreases as the behavior is primarily driven by habits instead of effortful self-control acts (Gillebaart et al., 2022).

Importantly, while several large-scale replication projects have challenged the ego depletion model and called into question the existence of a depletable self-control resource (Hagger et al., 2016; Vohs et al., 2021), the PAAM model 2.0 does not rely on the assumption that self-control diminishes because of resource exhaustion. Instead, our conceptualization of state self-control aligns with contemporary theories viewing self-control failures as motivational shifts in value-based decision-making (Berkman et al., 2017; Inzlicht et al., 2014). This perspective assumes that the likelihood of enacting an intended behavior can fluctuate over time depending on the subjective value of competing options, situational factors, and emotional states, even if no finite resource is depleted. We acknowledge ongoing debates around the stability and variability of self-control (Inzlicht & Friese, 2019) and believe that considering self-control as a dynamic, context-sensitive process remains crucial for understanding the behavior change (for a critical discussion, see also Goschke & Job, 2023; Inzlicht & Roberts, 2024)

7.1. *Planning*

Planning is conceptualized as a prospective self-regulatory strategy that facilitates the translation of intentions into sustained behavior. In the revised PAAM model 2.0, planning serves two complementary functions: first, it stabilizes intention strength across time and contexts, and second, it facilitates behavioral repetition through the formation of cue-response associations that promote automaticity (Scholz, Schüz et al., 2008; Sniehotta, Schwarzer et al., 2005). These roles work in tandem to support the maintenance of PA behavior.

Planning is not a stable trait but varies dynamically across situations, depending on factors such as available cognitive resources, motivation, and perceived demands (Bayuk, 2015; Madanipour, 2010). It is also associated with individual differences in self-control, with higher levels of trait self-control predicting greater use of planning strategies (Ridder & Fennis, 2025). In the context of health behavior, such as PA, planning corresponds to the formation of implementation intentions – mental representations that link anticipated situations with specific behavioral responses (e.g., "If situation X occurs, then I will perform behavior Y") (Gollwitzer, 1999).

This type of planning facilitates cue-response learning, which contributes to the development of automatic instigation habits (Gardner, 2022; Orbell & Verplanken, 2020). Repeated enactment of behaviors in response to consistent cues gradually reduces reliance on deliberative control. Over time, the behavioral response becomes more efficient and less effortful, especially under conditions of cognitive fatigue or diminished self-regulation (Pfeffer & Strobach, 2017).

However, within the PAAM model 2.0 framework, planning is conceptualized primarily as a mechanism that stabilizes intention strength across repeated behavioral episodes. Rather than functioning solely as a direct moderator of the intention-behavior link, planning reinforces the consistency and durability of intentions, which in turn supports behavior repetition. This repeated enactment allows for the gradual transition from reflective regulation to automatic execution. This dual function of planning, supporting both intention stability and habit development, is illustrated in Fig. 1, where planning is depicted as influencing intention dynamics rather than immediate behavior execution.

Empirical evidence supports this dual role: meta-analyses show that planning interventions yield small to medium improvements in PA behavior, particularly when implemented over time (Peng et al., 2022). Thus, PAAM model 2.0 frames planning not only as a behavioral trigger but also as a regulatory process that sustains motivation and intention commitment, contributing to long-term behavior change.

8. Implications for future research

The revised PAAM model 2.0 emphasizes that health behavior regulation unfolds across time, contexts, and psychological states. These dynamic features require methodological approaches that can capture within-person variability, temporal co-regulation among constructs, and context-sensitive patterns – all of which are central to the model's structure and predictions.

Intensive longitudinal data (ILD; Bolger & Laurenceau, 2013) and Ecological Momentary Assessment (EMA, Reichert et al., 2020) are particularly well-suited to test key features of PAAM model 2.0 (Maher et al., 2024). For instance, the model posits that intention, self-control, and affect fluctuate at state-level and interact dynamically with habit formation. ILD and EMA enable fine-grained assessment of these time-varying processes and their interactions across real-life contexts. This temporal granularity is necessary to identify, for example, how short-term affective responses influence the consolidation of habits or how temporary lapses in self-control affect the enactment of intentions.

Advanced statistical modeling techniques will be crucial for testing the model's dynamic predictions. Multilevel structural equation modeling can examine the hierarchical organization of regulatory processes across different time scales. Time series analyses can investigate the temporal sequencing of regulatory failures and successes. Person-centered analyses, such as latent profile analysis, can identify distinct patterns of regulatory dynamics across individuals and contexts.

While PAAM model 2.0 is grounded in psychological constructs that are often measured quantitatively, the interpretation and subjective meaning of these constructs may vary across individuals. The integration of qualitative methodologies with quantitative approaches is essential for developing a comprehensive understanding of behavior regulation processes (Steckler et al., 1992). In-depth interviews and focus groups can provide valuable insights into individuals' subjective experiences of intention-behavior discrepancies and the contextual factors that influence regulatory success or failure. These qualitative investigations are especially valuable when guided by established and systematic analytical procedures, such as thematic analysis (Braun & & Clarke, 2014) or grounded theory approaches (Charmaz, 2006), which support identification of emergent patterns and theoretical relationships not captured by existing quantitative measures. By integrating qualitative insights with quantitative assessments, researchers can enhance both the conceptual clarity and ecological validity of the PAAM model 2.0 framework.

A mixed-methods approach, integrating EMA with qualitative insights, aligns with the model's aim to explain both mechanistic pathways (e.g., temporal patterns of intention failure) and subjective experience (e.g., affective meaning). Combining EMA data with qualitative findings could yield a comprehensive picture of both the measurable dynamics and the lived experiences of behavior regulation (Altweck & Tomczyk, 2025). For instance, quantitative data from EMA can identify patterns and relationships, while qualitative data can elucidate the underlying mechanisms or contextual explanations for these patterns. Such an approach is particularly suited to addressing complex, multidimensional phenomena like the intention-behavior gap and the interplay between explicit and implicit processes.

9. Implications for future practice

The revised PAAM model 2.0 offers valuable insights for designing practical interventions to support the adoption and maintenance of health behaviors, particularly PA. It suggests that behavior regulation varies across individuals and contexts, not only due to trait-level differences but also because of state-level fluctuations in motivation, affect, and self-control. This implies that interventions may benefit from adapting to individual patterns over time, but it does not preclude the value of broader, scalable interventions.

Effective interventions must be tailored to account for individual differences in self-control and affective responses. Personalization can optimize the balance between explicit processes, such as goal-directed planning, and implicit processes, such as habit formation and affective responses (Lustria et al., 2009). Personalized programs are likely to increase the likelihood of sustained behavior change by aligning intervention strategies with participants' unique profiles (Fishbein & Dariotis, 2019).

Practitioners should implement flexible and adaptive goal-setting techniques that reflect the fluctuating nature of intention and self-control (Mann et al., 2013). Short-term, manageable goals provide a sense of achievement and can adapt as individuals' self-regulatory resources change. For instance, an initial goal of walking ten minutes daily can evolve into a more ambitious target as habit strength and self-efficacy grow. Dynamic goal setting ensures that interventions remain realistic and sustainable over time, accommodating the varying demands of individuals' daily lives.

Promoting habit formation is not only important for easing the burden of effortful self-regulation (Gardner et al., 2020) but also constitutes a core mechanism within the PAAM model 2.0 framework. Future interventions should leverage consistent repetition in stable contexts, employing strategies like cue reminders, environment restructuring, and positive reinforcement to embed health behaviors into routines (Gardner & Lally, 2018). For example, placing workout clothes in a visible location can act as a cue for exercise, while providing small rewards for consistent engagement reinforces positive habits (Weyland et al., 2020). By strengthening these automatic regulatory pathways, interventions can enhance long-term adherence while reducing the need for continuous deliberation or effortful inhibition.

Practitioners should incorporate techniques to strengthen positive anticipated affect associated with health behaviors (Conner et al., 2015). Visualization exercises, for instance, can help individuals imagine the immediate and long-term benefits of engaging in PA, such as feeling energized or experiencing a sense of accomplishment. Highlighting the emotional rewards of health behaviors can enhance motivation and strengthen intentions, bridging the gap between intention and action.

To ensure sustained behavior change, future interventions should incorporate maintenance-focused strategies, such as relapse prevention plans and contingency management (Bouton, 2014). These approaches prepare individuals to navigate setbacks and adapt their routines in response to changing circumstances. Gradual reinforcement of health-related habits and periodic adjustments to goals or strategies can support long-term engagement. Emphasizing adaptability and resilience ensures that interventions remain effective as individuals progress through different stages of behavior change.

10. Conclusion

The revised PAAM model 2.0 provides a dynamic and context-sensitive framework for understanding the adoption and maintenance of PA. The model gives a more complete explanation of how behavior is controlled by showing how explicit processes like intention and self-control change over time and how implicit processes like habit form over time. The expanded role of anticipated affect in shaping intention further enhances its predictive power, bridging the gap between motivation and sustained action. Additionally, the shift toward defining behavior with greater specificity improves the model's applicability in both research and intervention contexts. Future studies should employ intensive longitudinal methodologies, such as EMA and mixed-methods approaches, to capture the dynamic interplay of psychological constructs. In practice, interventions should be tailored to account for individual differences in self-regulation, habit formation, and affective responses, ensuring that strategies align with the evolving needs of individuals across different stages of behavior change. By integrating these advancements, the PAAM model 2.0 provides a robust foundation for developing effective, evidence-based interventions to promote long-term engagement in PA and other health behaviors.

CRediT authorship contribution statement

Darko Jekauc: Writing – review & editing, Writing – original draft, Conceptualization. **Ines Pfeffer:** Writing – review & editing, Writing – original draft, Conceptualization. **Tilo Strobach:** Writing – review & editing, Writing – original draft, Conceptualization. **Chris Englert:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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