The relationship between affect-related constructs and physical activity habit

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Starting physical activity is good.

Sticking with it is better.

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Summary

When I mention that my PhD deals with how one could succeed in forming the habit of being physically active on a regular basis, I usually see very interested faces and receive the request to let them know as soon as I have more information. Now I have more information. Here is the summary:

In psychology, habit is defined as a process in which a cue triggers an impulse to perform a behavior, with this impulse having become an automatic, learned response to the cue through prior learning experiences.

The problem: Given the importance of regular physical activity for health, it is clear that there is a need to promote healthy habits, especially in the face of prevailing inactivity. This is illustrated, for example, by a study within the context of university sports and exercise courses (KIT not included) that quantified the issue of dropout. The study found that by the fourth week, less than half of the students who had the opportunity to attend the course were still present.

The Solution? Keeping in mind the definition of habits, they are considered automatic, in the long-term independent of goals, and context-dependent. What can be the downfall of unhealthy habits such as unhealthy snacking can be the solution to a problem when it comes to healthy habits: The formation of habits can help ensure that habitually instigated behavior is performed more frequently. It bypasses the need to wrestle with one's inner resistance ("innerer Schweinehund"). Where a cue automatically triggers an impulse to perform a behavior, there is no need to weigh alternatives, as long as the habit, if not inhibited, automatically propels the individual into the action phase. In fact, relationships have been observed between the degree of automaticity of a decision regarding physical activity behavior and the maintenance of that behavior. Therefore, habits could be a key factor in promoting regular physical activity.

How can this be implemented concretely? To effectively promote habit formation, it is essential to explore determinants of habit formation. Dual-process models serve as a suitable theoretical framework since they encompass automatic phenomena such as affect-related constructs (e.g., automatic affective responses) and impulses while interrelating them. More specific models that explain habit formation hold promise for enhancing the effectiveness of interventions in the realm of physical activity promotion.

Theoretically, habits develop in four stages. First, the plan to perform the behavior must be forged, creating an intention. This intention then needs to be translated into action by utilizing self-regulatory resources. Through continued self-regulation, the behavior must be repeated to establish an association between the cue and the behavior. Based on this developmental process, determinants of habit formation can be categorized into cue-related, behavior-related, and individual factors, with the (affective) reward value of the behavior contributing to the formation of habits, especially in the early stages of behavior change.

It becomes apparent that two variables from the realm of affective and automatic phenomena could be interrelated: affect-related constructs and habit. That is, the automatic affective response to physical activity or the conscious emotion physical activity enjoyment may be associated with habit formation. Therefore, the overarching goal of this PhD was to examine this relationship.

Study 1: (How) Are affective responses and habit related in the context of physical activity?

In this study conducted in the university sports context, 226 participants of weekly sports and exercise courses were surveyed over a period of 13 weeks regarding their affective responses after each course and their levels of automaticity concerning the decision to attend these courses (instigation habit). A two-level modeling approach suggested a positive relationship between affective responses and instigation habit on the between-subject level. This implies that individuals who, on average, reported more positive affective responses were also more likely to automatically decide to attend the course, indicating a stronger instigation habit. With this relationship in mind, Study 2 was conducted, focusing on the challenge of designing scalable interventions for promoting physical activity.

Study 2: Does an affect-based intervention for exercise trainers have an impact on course participants' affective responses, and does this affect habit formation?

This study aimed to examine whether an intervention for exercise trainers specifically designed to promote positive affective responses could indeed facilitate the development of positive affective responses of their course participants. Additionally, it sought to investigate the extent to which this affective development was related to habit formation. Two interventions were designed for this study, with the affect-based intervention drawing upon the results of a study on factors that elicit positive affective responses in the context of physical activity, while the control

intervention did not emphasize affective responses in the same way. Five trainers from the university sports and exercise program each received either the affect-based or the control intervention and were tasked with implementing the learned content over the course of the semester.

The focus of the study was on 132 participants, who were not the trainers themselves but rather the participants in the sports and exercise courses, and their affective responses and habit formation. While the affect-based intervention did not prove to be superior to the control intervention in terms of fostering the development of positive affective responses in course participants, the relationship between affective responses and habit formation was once again evident. In a latent growth curve model, the linear trend of valence emerged as a significant predictor of the final habit strength. Further, this study provided numerous insights into the planning, implementation, and evaluation of affect-based interventions.

Study 3: Does personality moderate the relationship between physical activity enjoyment and habit?

Building on the relationship between affective responses and habit found at the between-subject level in Study 1, Study 3 was conducted. The assumption here was that this relationship may not be the same for all individuals and that, for theoretical and evidence-based reasons, it is worth considering personality as a moderator in the relationship between affect-related constructs such as physical activity enjoyment and habit.

From a theoretical perspective, the constructs of habit and personality share similarities, as consistent patterns of behavior constitute personality, which, in turn, can also be a result of habits. Furthermore, research shows that personality traits such as extraversion, neuroticism, and conscientiousness are associated with the level of physical activity and are also linked to the experience (or lack thereof) of physical activity enjoyment.

In Study 3, a cross-sectional study, 578 participants provided information on their physical activity enjoyment, their personality traits according to the Big Five and the more recent approach of emotional style, as well as their physical activity habit, using validated questionnaires. The analysis revealed that neuroticism (a Big Five personality trait) and resilience (an emotional style dimension) moderated the relationship between physical activity enjoyment and habit.

Specifically, this means that for individuals with higher scores in neuroticism or lower scores in resilience, the relationship is stronger. This suggests that it is particularly emotionally unstable individuals who benefit from affect-based interventions in terms of habit formation.

Study 4: How do we actually measure physical activity enjoyment?

In this study, there was a comprehensive theoretical exploration of the terms "affect" or "affect-related constructs" or "emotions" – which are often understood differently in the literature. Not only was the distinction between automatic affective responses and more complex emotions, including physical activity enjoyment, clarified, but it was also determined that individuals are capable of cognitively reflecting on their emotions, for example, to learn from them. Therefore, the Physical Activity Enjoyment Scale (PACES) was found to be suitable for both assessing the acute experienced emotion of enjoyment and, after rephrasing the item-stem, for capturing subsequent reflections on past emotions. The short version of PACES was tested for its psychometric properties, with a focus on invariance across languages to be prepared for future international collaborations.

Collectively, the results of the four PhD studies provide valuable insights into the interplay and measurement of affect-related constructs and habit, the design of affect-based interventions, and the consideration of personality in their evaluation – all in a real-world context far removed from laboratory settings, focusing on the complex health behavior of physical activity.

Not only are affect-related constructs and habit two promising variables for maintaining physical activity, but approaches for their manipulation are not yet adequately researched, and interventions are often not particularly effective. Future research can learn from the challenges encountered in conducting the four PhD studies described here. For instance, it can explore alternative approaches for promoting and measuring positive affective responses (e.g., ecological momentary assessment), implement longer study periods to investigate habits until their final formation, and consider personality as a variable in the research design.

Zusammenfassung

Wenn ich erzähle, dass ich mich in meiner Doktorarbeit damit auseinandersetze, wie es gelingen könnte, die Gewohnheit zu bilden, regelmäßig körperlich aktiv zu sein, blicke ich meistens in sehr interessierte Gesichter – und erhalte die Aufforderung, bitte sofort Bescheid zu geben, sobald ich mehr weiß. Jetzt weiß ich mehr. Hier ist die Zusammenfassung:

Die Gewohnheit wird in der Psychologie als ein Prozess definiert, bei dem ein Hinweisreiz (Cue) einen Impuls auslöst, ein Verhalten zu zeigen, wobei dieser Impuls durch Lernerfahrungen zu einer automatischen, erlernten Antwort auf den Hinweisreiz geworden ist.

Das Problem: Dass es notwendig ist, gesunde Gewohnheiten zu fördern, wird angesichts der Wichtigkeit regelmäßiger körperlicher Aktivität für die Gesundheit bei gleichzeitiger überwiegender Inaktivität deutlich. Sichtbar wird dies zum Beispiel in einer Studie im Hochschulsportkontext (KIT nicht eingeschlossen), die das Problem des Dropouts quantifizierte – so fand diese Studie beispielsweise, dass bereits nach der vierten Woche nicht einmal mehr die Hälfte der Studienteilnehmenden, die die Möglichkeit gehabt hätten, den Sportkurs zu besuchen, anwesend war.

Die Lösung? Eingedenk der Definition von Gewohnheiten gelten diese als automatisch, langfristig unabhängig von Zielen und abhängig vom Kontext. Was bei gesundheitshinderlichen Gewohnheiten wie ungesundem Knabbern zum Verhängnis werden kann, soll bei gesundheitsdienlichen Gewohnheiten zur Lösung eines Problems werden: Die Bildung von Gewohnheiten kann dazu beitragen, dass das gewohnheitsmäßig initiierte Verhalten häufiger ausgeübt wird. Die Auseinandersetzung mit dem „inneren Schweinehund“ kann so umgangen werden. Wo ein Hinweisreiz automatisch einen Impuls auslöst, ein Verhalten zu zeigen, bedarf es keines Abwägens von Alternativen, da die Gewohnheit, sofern sie nicht gehemmt wird, das Individuum automatisch in die Handlungsphase katapultiert. Tatsächlich zeigen sich Zusammenhänge zwischen dem Grad der Automatisierung einer Entscheidung für Aktivitätsverhalten und der Aufrechterhaltung dieses Verhaltens. Gewohnheiten könnten also ein Schlüsselfaktor bei der Aktivitätsförderung sein.

Wie kann das konkret aussehen? Um Gewohnheiten gezielt fördern zu können, ist es wichtig, ihre Entstehungsbedingungen zu erforschen. Als theoretischer Rahmen eignen sich hier zunächst

einmal Zwei-Prozess-Modelle, da sie automatische Phänomene wie Affekt (z.B. automatische affektive Reaktionen) und Impulse miteinbeziehen und diese miteinander in Beziehung setzen. Auch spezifischere Modelle, welche die Gewohnheitsbildung erklären, sind im Hinblick auf die notwenige Effektivitätssteigerung von Interventionen im Bereich der Aktivitätsförderung vielversprechend.

Theoretisch bilden sich Gewohnheiten in vier Stufen. Zunächst muss der Plan, das Verhalten ausüben zu wollen, geschmiedet und somit eine Intention gebildet werden. Diese muss sodann unter Anwendung selbstregulativer Ressourcen in die Tat umgesetzt werden. Unter weiterem Einsatz von Selbstregulation muss das Verhalten wiederholt werden, sodass sich eine Assoziation zwischen dem Hinweisreiz und dem Verhalten bilden kann. Entsprechend dieses Entstehungsprozesses lassen sich Determinanten der Gewohnheitsbildung in die Bereiche cue-, verhaltens-, und personenbezogene Einflussfaktoren einteilen und insbesondere der (affektive) Belohnungswert des Verhaltens kann maßgeblich dazu beitragen, dass gerade in frühen Stadien einer Verhaltensänderung Gewohnheiten gebildet werden.

Es wird ersichtlich, dass zwei Variablen aus der Welt der affektiven und automatischen Phänomene zusammenhängen könnten: Affekt und Gewohnheit. Affektbezogene Konstrukte wie zum Beispiel die automatische affektive Reaktion auf körperliche Aktivität oder die komplexere Emotion Freude an körperlicher Aktivität können mit der Bildung von Gewohnheiten einhergehen. Das übergeordnete Ziel dieser Dissertation war es daher, diesen Zusammenhang zu überprüfen.

Studie 1: (Wie) Hängen Affekt und Gewohnheit im Kontext körperlicher Aktivität zusammen?

In dieser Studie im Kontext des Hochschulsportes wurden 226 Teilnehmende wöchentlicher Kurse über 13 Wochen nach ihren affektiven Reaktionen nach der Kurseinheit sowie nach ihren Automatizitätswerten bezüglich der Entscheidung, zu diesem Kurs zu gehen, befragt. Ein zweistufiger Modellierungsansatz legte einen positiven Zusammenhang zwischen affektiven Reaktionen und der Gewohnheit auf der Ebene zwischen den Probandinnen und Probanden nahe. Das bedeutet, dass Menschen, die im Schnitt eine positivere affektive Reaktion berichteten, auch eher automatisch zu der Entscheidung gelangten, den Sportkurs zu besuchen, also eine stärkere Gewohnheit hatten. Mit diesem Zusammenhang im Hinterkopf wurde Studie 2 durchgeführt, die

sich der Herausforderung der Konzipierung skalierbarer Interventionen zur Aktivitätsförderung annahm.

Studie 2: Hat eine affektbasierte Intervention für Trainerinnen und Trainer eine Auswirkung auf den Affekt der Kursteilnehmenden und dieser auf die Gewohnheit?

Diese Studie hatte es zum einen zur Absicht, zu prüfen, ob eine speziell für die Förderung positiven Affekts entwickelte Trainerintervention tatsächlich den Verlauf positiver affektiver Reaktionen der Kursteilnehmenden begünstigen kann. Zum anderen sollte untersucht werden, inwiefern diese Affektentwicklung dann auch mit der Bildung von Gewohnheiten zusammenhängt. Im Rahmen der Studie wurden zwei Interventionen konzipiert, wobei die affektbasierte Intervention sich der Resultate einer Studie zu Faktoren, welche positive affektive Reaktionen im Kontext körperlicher Aktivität mit sich bringen, bediente, während die Kontroll-Intervention keinen solchen affektiven Fokus aufwies. Je fünf Trainerinnen und Trainer aus dem Hochschulsport erhielten entweder die affektbasierte oder die Kontroll-Intervention und waren aufgefordert, die gelernten Inhalte im Verlauf des Semesters mit Leben zu füllen. Die 132 Studienteilnehmenden, von denen im Anschluss über 10 Wochen hinweg Daten erhoben wurden, waren nicht die Trainer selbst, sondern deren Kursteilnehmende, deren affektive Reaktionen und Gewohnheitsbildung der Fokus waren. Während sich die affektbasierte Intervention der Kontroll-Intervention als nicht überlegen hinsichtlich der Entwicklung positiver affektiver Reaktionen bei den Kursteilnehmenden herausstellte, so zeigte sich dennoch erneut der Zusammenhang zwischen Affekt und Gewohnheit: In einem latenten Wachstumskurvenmodell erwies sich der lineare Trend der Valenz (also die Wertigkeit einer affektiven Reaktion) als ein signifikanter Prädiktor der finalen Gewohnheitsstärke. Zusätzlich konnten zahlreiche Lernerfahrungen bezüglich der Planung, Umsetzung und Evaluation einer affektbasierten Intervention im Rahmen dieser Studie gesammelt werden.

Studie 3: Moderiert die Persönlichkeit den Zusammenhang zwischen Freude an Bewegung und Gewohnheit?

Erneut unter Rückgriff auf den in Studie 1 gefundenen Zusammenhang auf der Ebene zwischen den Probandinnen und Probanden zwischen Affekt und Gewohnheit wurde Studie 3 durchgeführt. Die Annahme war es hier, dass dieser Zusammenhang nicht für alle Individuen derselbe ist und

dass es sich aus theoretischen wie evidenzbasierten Gründen lohnt, die Persönlichkeit als Moderator der Beziehung zwischen affektiven Konstrukten wie der Freude an körperlicher Aktivität und Gewohnheit miteinzubeziehen. Aus theoretischer Sicht ähneln sich die Konstrukte Gewohnheit und Persönlichkeit insofern, als unter anderem konsistente Verhaltensmuster die Persönlichkeit ausmachen, die ja wiederum auch eine Folge von Gewohnheiten sein können. Zudem zeigt Forschung auf, dass Persönlichkeitseigenschaften wie Extraversion, Neurotizismus und Gewissenhaftigkeit mit dem Ausmaß körperlicher Aktivität zusammenhängen und auch mit dem (Nicht-) Empfinden von Freude an körperlicher Aktivität assoziiert sind. An Studie 3, einer Querschnittstudie, partizipierten 578 Teilnehmende, die mittels validierter Kurzfragebögen Angaben zu ihrer Freude an körperlicher Aktivität, ihren Persönlichkeitseigenschaften gemäß der Big Five und gemäß dem moderneren Ansatz des emotionalen Stils, sowie ihrer Gewohnheit tätigten. Die Auswertung ergab, dass Neurotizismus (eine Big Five-Persönlichkeitseigenschaft) und Resilienz (eine Dimension des emotionalen Stils) Moderatoren der Beziehung zwischen Freude an körperlicher Aktivität und der Gewohnheit sind. Genauer bedeutet dies, dass für Individuen, die höhere Werte in Neurotizismus bzw. niedrigere Werte in Resilienz aufweisen, der Zusammenhang stärker ausfällt. Hieraus ließe sich ableiten, dass es besonders emotional instabile Personen sind, die von affektbasierten Interventionen hinsichtlich ihrer Gewohnheitsbildung profitieren.

Studie 4: Und wie messen wir Freude an Bewegung eigentlich?

In dieser Studie ging es noch einmal um eine gründliche theoretische Auseinandersetzung mit den in der Literatur häufig so unterschiedlich verstandenen Begriffen „Affekt“ – oder „affektbezogene Konstrukte“ – oder „Emotion“ – oder, oder, oder. Nicht nur wurde der Unterschied zwischen automatischen affektiven Reaktionen und komplexeren Emotionen, zu denen die Freude an Bewegung zählt, herausgearbeitet, sondern auch wurde festgestellt, dass Individuen in der Lage sind, ihre Emotionen kognitiv zu reflektieren, um beispielsweise durch sie zu lernen. Insofern eignet sich die Physical Activity Enjoyment Scale (PACES) zum einen zur Erfassung der akut empfundenen Emotion Freude und nach Umformulierung des Itemstammes zum anderen zur Erfassung einer Reflexion bezüglich vergangener Emotionen. Als vielversprechendes Messinstrument wurde somit die Kurzversion von PACES einer Testung ihrer psychometrischen Eigenschaften unterzogen. Insbesondere wurde hierbei auch die Messinvarianz hinsichtlich der

Sprache berücksichtigt, um zukünftig auch für internationale Zusammenarbeiten gewappnet zu sein.

Zusammengenommen ergeben sich aus den Ergebnissen der vier Dissertations-Studien wichtige Erkenntnisse zum Zusammenspiel und der Messung von Affekt und Gewohnheit, zur Konzipierung von affektbasierten Interventionen und zur Berücksichtigung der Persönlichkeit bei der Evaluation eben dieser – und das alles in einem realen Kontext fernab von Laborkatzen in Bezug auf ein komplexes Gesundheitsverhalten, die körperliche Aktivität. Nicht nur handelt es sich bei Affekt und Gewohnheit um zwei vielversprechende Variablen für die Aufrechterhaltung körperlicher Aktivität, auch sind Ansätze zu deren Manipulation noch nicht ausreichend erforscht und Interventionen daher oftmals noch nicht besonders effektiv. Zukünftige Forschung kann auch aus den Problemen, die sich bei der Durchführung der vier hier beschriebenen Studien ergeben haben, lernen und beispielsweise andere Ansätze zur Förderung und Messung von positivem Affekt anwenden (Stichwort: ecological momentary assessment), längere Untersuchungszeiträume realisieren, die es ermöglichen, Gewohnheiten bis zu ihrer finalen Bildung zu untersuchen und die Persönlichkeit als Variable berücksichtigen.

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PhD Thesis research

Parts of this thesis have been published as articles in peer-reviewed journals or have been submitted for publication. This concerns the following publications or submissions:

Chapter II: Study 1

Weyland, S., Finne, E., Krell-Roesch, J., & Jekauc, D. (2020). (How) Does affect influence the formation of habits in exercise?. *Frontiers in Psychology, 11*, 578108. https://doi.org/10.3389/fpsyg.2020.578108

Chapter III: Study 2

Weyland, S., Fritsch, J., Feil, K., & Jekauc, D. (2022). Investigating the relation between positive affective responses and exercise instigation habits in an affect-based intervention for exercise trainers: A longitudinal field study. *Frontiers in Psychology, 13*, 994177. https://doi.org/10.3389/fpsyg.2022.994177

Chapter IV: Study 3

Weyland, S., Fritsch, J., Kaushal, N., Feil, K., Jekauc, D. (submitted). Neuroticism and resilience moderate the relationship between physical activity enjoyment and habit. *International Journal of Sport and Exercise Psychology.*

Chapter V: Study 4

Weyland, S., Kaushal, N., Fritsch, J., & Jekauc, D. (submitted). Validation and invariance testing of the English Short Physical Activity Enjoyment Scale. *BMC Psychology.*

Chapters II to V can therefore be read independently.

The relationship between affect-related constructs and physical activity habit

Chapter I – General introduction

What better way to elucidate the relief that habits provide than by referring to Dumont's essay on habit: "On a moins de peine à replier un papier dans le sens où il a été déjà plié antérieurement" (Dumont, 1876, p. 324; translation by the author "It is easier to fold a sheet of paper in the direction in which it has already been folded previously"). In 1890, William James also emphasized the importance of habits and wrote: "The more of the details of our daily life we can hand over to the effortless custody of automatism, the more our higher powers of mind will be set free for their own proper work" (James, 1890a, p. 54). It is no surprise that even years after these literary acknowledgments, the concept of habit continues to be a subject of discussion in numerous publications. Habit is reflected in popular science books such as "Atomic Habits" (Clear, 2018), in modern popular culture, for example the song "Breaking the Habit" by Linkin Park and finally also found its consideration in health and sport and exercise psychology.

Accordingly, the term "habit" has become part of everyday language: On New Year's Eve we resolve to fight bad habits and call ourselves creatures of habit if we fail to do so – and the majority of us likely are not even aware that it was once again William James who had previously described living creatures as "bundles of habits" (James, 1890a, p. 3). It is a catchy and understandable phenomenon that everyone knows and yet first needs a scientific definition to clarify what habit is – so as not to run the risk of realizing, when you step back and look at your own scientific work from a distance, that you are one of those psychologists mentioned by Maddux (1997) who do not even question what the habitually employed term "habit" actually means. While in colloquial language, as Gardner and Rebar (2019) point out, we tend to understand habit as a frequently practiced behavior, in psychology habit means the process whereby an impulse automatically triggered by a cue might translate into behavior (Gardner, 2015). Habit cannot be the behavior itself and a determinant of the behavior: "To say that behavior that is an automatic response to situational cues is caused by habit is to say that a habit is caused by habit" (Maddux, 1997, p. 335). In order to remove the contradictory nature of this

"pseudoexplanation" (Maddux, 1997, p. 335), this General Introduction begins with a definition of habit established in recent sport and exercise psychology.

The relevance of developing healthy habits is then demonstrated by contrasting the benefits of regular physical activity (e.g., Reiner et al., 2013) with the evidence for dropout in physical activity courses (Finne et al., 2019). Using the general structure of motivation (Michie & West, 2013; West & Brown, 2013), it is then explained *how* and supported with empirical evidence *that* habit can facilitate behavioral instigation and execution by bypassing complex cognitive operations. Given the resulting significance of habit to physical activity maintenance (as found in our work, Feil et al., 2021), the general focus of this PhD was on variables related to its formation. In one of his papers entitled "People have feelings! Exercise psychology in paradigmatic transition", Ekkekakis (2017) argues that the scientific discipline of exercise psychology does not add value to society if it produces interventions that do not lead to sustained increases in physical activity (McEwan et al., 2022). He goes on to discuss that the "rational educational model" (see also Weare, 2002), which suggests that people only need to be properly educated about the benefits of physical activity in order to change their behavior, is inadequate, assuming that there are two processes that can guide human behavior – because, as said, people also have feelings. More precisely, the main focus of this PhD was therefore the relationship between affect-related constructs (e.g., acute affective response or physical activity enjoyment) and physical activity instigation habit. As such, in this General Introduction, the dual-process approach is then concretized by means of two theoretical models to better understand the affective conditions under which habits form, namely the Physical Activity Adoption and Maintenance model (Strobach et al., 2020) and the Affective–Reflective Theory of physical inactivity and exercise (Brand & Ekkekakis, 2018).

> Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur; […] The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond.
>
> (Thorndike, 1911, p. 244)

Although affect-related constructs have only gradually found their way into exercise psychology, their relevance to habit formation is actually a classic in psychology: The law of effect (Thorndike, 1911). Cynics might note that, despite artificial intelligence, surprisingly little has been added to our knowledge since Thorndike's work on animal intelligence. The General Introduction will therefore not only deal with theoretical assumptions, but also list some empirical evidence for the relationship between affect-related constructs and real-world physical activity habits and propose very concrete approaches to interventions that promote positive affective responses. Putting the theoretical knowledge, some of which relates to laboratory cats, to the practical test and evaluating an affect-based intervention in order to both improve affective responses and consequently habit formation was the second focus of this PhD. This is not least in response to calls from authors such as Ekkekakis and Zenko (2016) to increase the health-promoting impact of the discipline by designing scalable and effective interventions (we had no idea that our intervention would have been ineffective...). Thus, this is where the value of sport and exercise psychology becomes particularly clear, not as just another discipline regurgitating old wisdom, but as a discipline with a unique subject of physical activity to which both new and established approaches from the world of psychology need to be applied.

Further, it is well known that habit formation curves vary considerably between individuals (Lally et al., 2010), and that affective responses during physical activity (especially at the ventilatory threshold) can also vary between individuals (Ekkekakis et al., 2008) – so it seems relevant to analyze more closely the individuals whose habits are thought to be influenced by affective responses. Who are they? In the last part of the General Introduction to consider the third focus of this PhD, we get closer to the individual by considering the construct of personality as a potential moderator in the affect-habit relationship, since personality was shown to be related to both physical activity (Rhodes & Smith, 2006) and physical activity enjoyment (Engels et al., 2022) – the measurement of which was the fourth focus of this PhD.

Condensed wisdom: William James on habits

As one of the founders of scientific psychology, it is not surprising that William James attempted to approach habits in terms of brain states and natural laws. In his work on habits, he presents them as physical phenomena (James, 1890a). James sees the assumption that organic beings consist of composite matter, especially nerve tissue, as causative of habits. He describes

the plasticity of organic beings as providing the necessary variability for habits. This means that the structure of composite matter is changeable, and while the structure of nerve tissue is well-protected within the skull against certain influences such as temperature differences, he postulates that it is susceptible to influences through the blood and sensory nerve roots. More specifically, this means that the paths in the brain are modifiable. According to James, these paths can be newly formed, or existing ones can be strengthened. He asserts that the creation of new neural paths in the brain, whether occurring by chance or not, represents an inherent human tendency to exceed the limitations set by established paths. After the restructuring of paths, a new set of habits emerges in a temporarily stable state of equilibrium in the structure. In the habit process, paths in the brain interconnect, with the stimulation of one serving as a stimulus for the next, much like a chain reaction that only ends with the impression of finality. Given this self-perpetuating activation of paths, James (1890a) postulates that the practical application of habits is to reduce fatigue and to minimize the effort required to achieve a result, especially the conscious attention with which we achieve it – even to the point of involuntariness with which we then show quite inappropriate reactions (e.g., getting the key out of our pocket when the doorstep triggers us to do so, even if it is that of someone we know rather than our own house). Furthermore, he suggests that sometimes habits are not even in the focus of our attention, so we may not be able to articulate, for example, in which direction our door opens. However, our hand consistently follows the habitual movement routine without error. These habits may be difficult to reproduce, even if we try to replay them mentally. We must physically represent and perform them in order to truly observe what we habitually do.

A habitual action, according to James (1890a), is triggered by an initial impulse, which could be the thought of the first step in the sequence of actions or the anticipation of the outcome. Finally, it could be the mere perception of a stimulus. What happens after habitual instigation?

> In action grown habitual, what instigates each new muscular contraction to take place in its appointed order is not a thought or a perception, but the *sensation occasioned by the muscular contraction just finished*. A strictly voluntary act has to be guided by idea, perception, and volition, throughout its whole course. In an habitual action, mere sensation is a sufficient guide, and the upper regions of brain and mind are set comparatively free.
>
> (James, 1890a, pp. 35f)

It is not surprising, then, that James (1890a) advises habituating as many useful actions as possible, with the goal of preventing each minor daily task from becoming the result of willful deliberation, thereby saving time spent on decisions or regrets. At the same time, he emphasizes the importance of not giving up the ability to exert effort.

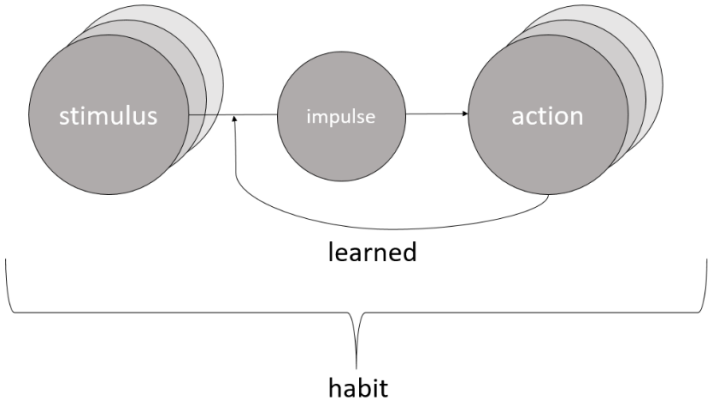
Personal note: In conclusion, James' (1890a) work on habits is inspiring, and it is impressive how many of his collected thoughts align with contemporary understandings of habits. However, James projects racist and classist motives into habits when he writes that habits prevent the mixing of diverse social classes or cultures. It is explicitly stated here that such ideas are condemned in this PhD. The following will explore Benjamin Gardner's contemporary definition of habits in health psychology, partly building upon the examination of James's earlier insights.

Defining physical activity instigation habit

Gardner (2015) emphasizes that a definition of an abstract, man-made concept cannot be judged by its objective correctness, but should be judged by its usefulness. Indeed, his own definition of habit turns out to be useful in predicting behavior and, in particular, overcomes logical inconsistencies in previous definitions. According to his definition, habit is: "*a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations*" (Gardner, 2015, p. 280) – see also the visualization in Figure 1.1 (self-created graphic). What does it mean and why is it useful?

Figure 1.1

Definition of habit



Note. Visualizing Gardner's (2015) definition of habit through a personal representation.

Process. By defining habit as a *process* capable of initiating behavior, habit acquires significance as a variable that can facilitate behavior. This definition also helps break the circular argument that arises when habit is defined solely as a form of behavior and, in turn, becomes its own precursor (Gardner, 2015; Maddux, 1997). More precisely, habit is not to be understood as a mere frequency of behavior, since this would also lead to a logically problematic conclusion, according to which habit strength would continue to increase with further increases in the frequency of behavior (Verplanken, 2006).

Moreover, Gardner (2015) states that the term "process" includes several elements, so it does not define habit as one of the properties of habit such as automaticity of responses, for example, as in the definition referred to by Verplanken and Wood (2006) – while it should be acknowledged that Verplanken (2006) calls habit a mental construct consisting of several facets, one of which is automaticity. As Gardner (2015) notes it is important to include the cue-dependence and learned stimulus-response associations along with automaticity in the definition of habit, because habit-related automaticity may differ from other types of automaticity. Gardner et al. (2012) list behavior following implementation intentions (Gollwitzer & Sheeran, 2006) or priming (e.g., Dijksterhuis & van Knippenberg, 1998) as examples of types of automaticity that differ from habit, which per definition involves a history of repetition in terms of learning. Mazar and Wood (2018) add automatic goal pursuit as an example of automaticity that differs from habits because the definition of the latter involves a specific cue-behavior association, whereas the activation of a goal can elicit nonspecific goal-related behaviors (see also Kruglanski et al., 2002). In this sense, Wood and Neal (2009) do not use the terms habit and automaticity synonymously, arguing that the latter should be further specified as "type of automaticity characterized by a rigid contextual cuing of behavior that does not depend on people's goals and intentions" (Wood & Neal, 2009, p. 580). Further, Orbell and Verplanken (2020) also understand habit as a construct whose characterization includes a theory of its development: Regarding its characteristic stimulus-response association, they identify behavioral repetition in stable stimulus contexts as the cause, and cue contingency, goal independence, and features of automaticity as hallmarks of the behavior elicited by this association.

Stimulus. In the course of the process defined by Gardner (2015), a cue or *stimulus* automatically generates an impulse. From a theoretical point of view, a cue can be any active

ingredient in the context that recurs immediately before an action (Gardner et al., 2021). Pimm et al. (2016) investigated how various cues, such as time, people, activity, routine, location, and mood, which they identified as being present whenever subjects initiated physical activity, were associated with habit-related automaticity and physical activity behavior. For example, while a consistent time was a predictor of physical activity behavior, the consistency of the routine within which one begins to be physically active was a predictor of automaticity. One characteristic of habit-related cues might therefore be, as already explained by Lally and Gardner (2013), their salience, which is not necessarily given in the case of the time of day, since it requires monitoring (looking at the clock), whereas sequences within a routine can serve each other as a cue (see also Graybiel, 1998) and, as for example the sequence "after breakfast", obviously take place recognizably (see also Gardner et al., 2021). In addition to being in the same sequence of a routine, other predictors of physical activity automaticity were being with the same people, and being in the same mood when initiating the behavior (Pimm et al., 2016).

But what is the evidence for whether cues can really directly trigger a response? Neal et al. (2012) gave 53 participants a lexical decision task in which they had to classify letters on a screen as words or nonwords. Unbeknownst to the participants, they were primed with a prime word before the target stimulus was presented. For example, they were primed with the context word "forest" when they had indicated that this was the context in which they usually ran and in other trials with the subject-specific goal word, e.g., "relax", if they had reported this as their goal beforehand. They were then shown the behavior word "running/jogging" in the critical context-behavior and goal-behavior trials. One of the results was that habitual runners identified the word "running/jogging" faster when they had been primed with the context word, but not when they had been primed with the goal word. In addition to this evidence for direct cueing, Wood and Neal (2009) also list evidence from the field of neuroscience. They summarize that less goal-oriented brain areas, but rather stimulus control areas, are involved when habits have been formed.

Automaticity. According to the definition by Gardner (2015), the way the stimulus generates an impulse is *automatic*. But as Mazar and Wood (2018) mention, defining habit in terms of automaticity falls short if it fails to elaborate on what automaticity is. Moors and De Houwer (2006) discuss the following features of automaticity: goal-related features (i.e., unintentional, goal independent, uncontrolled, autonomous), stimulus-driven, unconscious,

efficient, and fast. Considering that the multifaceted automaticity is only one of the elements of the defined habit process, the construct habit becomes very complex at this point, if not before. This brings us back to the starting point of the definition of habit, which was intended to be of practical use: With regard to practical application, it may be sufficient to capture only automaticity as the "core" (Sniehotta & Presseau, 2012, p. 139) or "active ingredient" (Gardner et al., 2012, p. 6) of habit. This is because in stable contexts it is ultimately a matter of automaticity to predict future behavior from past behavior (see also Gardner, 2012; Ouellette & Wood, 1998). Further, depending on the focus of the study (e.g., differentiating various types of automaticity based on precise definitions vs. application-oriented research on the conditions of habit or automaticity formation) it might be sufficient to examine whether a certain degree of automaticity is present, instrumentalized by certain rather than by all of the constructs' facets (see also Mazar & Wood, 2018; Moors & De Houwer, 2006). What are the facets that constitute habit-related automaticity? According to the authors of the Self-Report Habit Index, the automaticity characteristics that make up everyday habits are uncontrollability, lack of awareness, and efficiency (Verplanken & Orbell, 2003). This is reflected in concrete item formulations as follows: "Behavior X is something..." "I do automatically", "I do without having to consciously remember", "I do without thinking", and "I start doing before I realize I'm doing it" (Self-Report Behavioural Automaticity Index; Gardner et al., 2012, p. 3).

Impulse. What the stimulus automatically generates is an *impulse* according to the definition by Gardner (2015). Considering the structure of motivation (Michie & West, 2013; West & Brown, 2013; the structure of motivation, which is only broadly referred to here for definitional purposes, will be presented in more detail later) it becomes clear that habits are not simple reflex responses, meaning that the response (i.e., modification, initiation or stopping of an action) does not have to follow immediately after encountering the stimulus. Rather, there is another motivational element, an impulse, mediating between the stimulus and the response. Impulses are organized representations or schemas of action, and because they compete with counter-impulses from moment to moment and within each and every moment, only those stimuli that "have" the strongest motivational force elicit a response (Michie & West, 2013; West & Brown, 2013). Why should a stimulus have motivational power to make us act? Well, because of instinct or habit (see also West, 2006).

Action. According to the definition by Gardner (2015), the impulse within the process is an impulse towards *action*, but what is actually meant by action here? This action can first of all be described as "habitual behavior", because it is controlled by habit (Gardner, 2015). What may be different, however, is what exactly is controlled by habit: Is it only the initiation of the behavior or also the subsequent performance of the entire behavioral sequence? For example, it would not be very advantageous if a person who habitually decides to ride a bicycle instead of using other means of transportation (habitually initiated behavior) then automatically navigates through traffic without using any cognitive resources for the course of the road (habitually performed behavior) (see also Gardner, 2015). The rough distinction between the two action phases selection and performance of action (for a more precise differentiation of action-phases see for example Heckhausen & Gollwitzer, 1987) leads Gardner et al. (2016) to distinguish also between two types of habitual behavior: habitual instigation and habitual execution. Thus, it may well be that a person automatically activates an action schema and automatically selects the first sub-behavior (e.g. putting on a helmet), but then consciously performs the rest of the cycling sequence and is not automatically cued by the sub-behaviors of it (see also Gardner, 2015; Gardner et al., 2016).

On the relevance of habit: The problem of the regularity of physical activity

The (habitual) behavior that establishes the relevance of studying the conditions of habit formation, specifically in this PhD, is physical activity behavior. Although the focus of this PhD was on affective determinants of habit formation, it is essential to first establish why physical activity should indeed become a habitual behavior. It seems that for too many people, physical activity is not yet habitually instigated. Attendance data from ten weekly university sports and exercise courses at two German universities (KIT not included) show that one week after the first observation, the attendance rate was 58 %; after four weeks, not even half of those who had attended the first week were still there; and another eight weeks later, it did not exceed 20 % (Finne et al., 2019). Further, although interventions might lead to an increase in physical activity during the intervention period, these improvements are typically not maintained once the intervention ends (McEwan et al., 2022). Given the long-term health benefits of physical activity (Reiner et al., 2013), the challenges people encounter in sustaining regular physical activity are especially crucial. Relatedly, the World Health Organization (2018, p. 8) has published its vision of "more active people for a healthier world" and its target, a 15 % relative reduction in physical

inactivity by 2030. In a paper highlighting the need to promote physical activity among young people, Woll et al. (2021) warn that it is already five past twelve.

Habit as a problem solver? Theory of and evidence for habit-behavior relationships

Consider the following scenario:

If a scientist whose research focuses on habits does not act on her intention to work an extra two hours because she follows her physical activity habit instead, she can claim to have worked anyway because she explored why she acted habitually rather than on intention.

In a meta-analysis by McEachan et al. (2011), it was found that compared to other health behaviors, physical activity in particular is one of the behaviors that can be predicted by intentions, defined here as the motivational component within the Theory of Planned Behavior ("the intention constitutes a plan of action in pursuit of the behavioral goal"; Ajzen, 1985, p. 24). But human mental life is complex, and so is the world, and so is this field of research.

In an experimental study by Cheval et al. (2015), the experimental group received health-related messages promoting physical activity, while the control group received messages on healthy eating. The type of message had no direct effect on physical activity, which was assessed using accelerometers for one week following the intervention. However, intentions (to be sufficiently physically active in the next week) measured after the intervention did predict physical activity – but this effect was only observed in individuals with a moderate or low impulsive approach tendency towards sedentary behavior, as measured by a manikin task conducted before the intervention. For individuals with high impulsive approach tendencies towards sedentary behavior, intentions showed no connection to physical activity. That is, someone with an intention to be physically active may not necessarily act on it if they simultaneously feel a strong impulse to remain seated. This suggests that relying solely on intentions can be susceptible to impulses. The impulse should, therefore, align with the same direction as the intention, namely towards physical activity. So, the solution may lie in the development of physical activity instigation habits, which can then counteract impulsive approach tendencies towards sedentary behavior.

Further, when analyzing day-to-day within-person variation, it turned out that intentions were subject to daily fluctuations and that these were related to fluctuations in physical activity

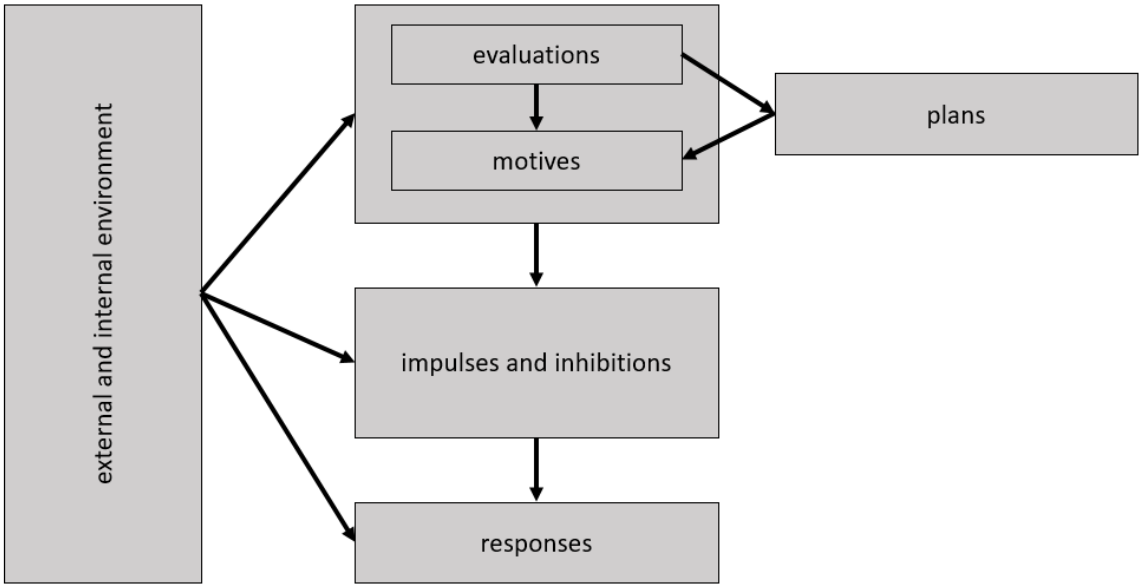
(Conroy et al., 2013). In turn, the relationship between habit and behavior can be explained by such fluctuations in intention. In a study by Rebar et al. (2014), 128 university students first indicated their physical activity habit strength and then daily reported their intentions for physical activity, while wearing accelerometers for two weeks. The findings revealed that when individuals had intentions for physical activity that were weaker than their usual level, their habit strength positively influenced their actual physical activity. However, when individuals had intentions that were typical or stronger than their usual level, their habit strength did not show any such effect. Accordingly, Rebar et al. (2020, p. 989) summarize that habits could be valuable because they "can sustain and shield exercise from the potential effects of losses in motivation, attention, or awareness". Further, they mention that establishing exercise habits might offer the advantage of requiring less cognitive effort compared to engaging in non-habitual behavior. For example, Wood et al. (2002) found resource-saving and self-regulatory benefits of habits by showing that habitual behavior was associated with thinking about something else than the behavior and less stress. The consistent findings of several reviews on the relationship between habit and physical activity, each updated at five-year intervals (Feil et al., 2021; Gardner et al., 2011; Rebar et al., 2016), can be incorporated into these considerations of the benefits of habit.

To theoretically understand these findings, it is worth taking a step back: What is behavior, and how does it come about? As defined by Hobbs et al. (2011), behavior encompasses every physical event occurring in the body, regulated by the brain, in response to internal or external stimuli and it may fluctuate in terms of its level of specificity. Notably, Baumeister et al. (2007) distinguish these events (which they refer to as "action") from emotions and cognitions. In the process of developing an "overarching model of behavior", one principle of US criminal law was taken into account by Michie et al. (2011). When it comes to understanding what can cause behavior change, it seemed helpful to consider which factors indicate that an individual is responsible for a behavior. Alongside theory-driven approaches, this gave rise to the COM-B system. In this "framework for understanding behavior" capability, opportunity, and motivation interact to generate behavior. Assuming an individual possesses both the opportunity and capability to engage in a behavior, the facets of the motivation component, whether automatic or reflective, can be linked to behavior.

The structure of human motivation within the Theory of Plans, Responses, Impulses/inhibition, Motives and Evaluations (PRIME Theory; Michie & West, 2013; West & Brown, 2013) may provide a useful framework for understanding the motivation component and likewise the benefits of habit from a theoretical perspective (see Figure 1.2).

Figure 1.2

Structure of human motivation



Note. Own simplified representation based on "The structure of the motivational system" as depicted in West (2006). Current responses are influenced by impulses, partially driven by present motives shaped by plans and evaluations about worthwhile actions. Evaluations and plans impact actions when they generate motives (desires). The system is continually shaped by internal and external environments. Plans and evaluations can be easily overridden by stimulus-driven motives, and these, in turn, can be readily overridden by stimulus-driven impulses.

According to this structure, there is no direct link between our beliefs about what behavior is likely to be good for us (i.e., evaluations) and behavior, nor between our intentions (i.e., plans) and behavior (Michie & West, 2013). Rather, it is theorized that these reflective, higher levels of motivation must act on the automatic, lower levels of the motivational structure from moment to

moment in order to have any chance of influencing behavior. That is, they must create a desire (i.e., motive) that triggers an impulse – because ultimately it is only internal or external environmental stimuli and impulses that are proposed to trigger a behavioral response. Accordingly, it takes some steps to get from plan to behavior, while the impulse, as the proposed lowest level of the motivational structure, has a direct link to behavior. Engaging in habitual behavior defined by cues and impulses may thus require less self-control resources or mental energy, although this should be understood more as a metaphor (Michie & West, 2013).

Dual-process theories and affect-related determinants of habit formation

Now that habit has been defined and its relevance explained, it is important to focus in the direction of its formation. In this PhD, the focus was on affect-related determinants. To further explore the relationship between affect-related constructs and habit in the context of this PhD, this section first defines affect-related constructs using a dual-process approach to emotion and then explains two dual-process theories as the basic theoretical framework. Empirical studies in the field of exercise psychology demonstrated the limits of human rationality by showing that crucial motivational factors can be influenced by changing contextual cues even when no new information is introduced (Zenko et al., 2016). For example, Zenko et al. (2016) demonstrated the effect of the heuristic of anchoring (Tversky & Kahneman, 1974) on desirability of exercise, affective attitude, and exercise intention. Authors such as Ekkekakis (2017) therefore argue for the consideration of affect in the context of dual-process models. After explaining the two dual-process theories, a habit-specific model and empirical evidence is presented for a more precise understanding of affect-related determinants of habit.

Defining affect-related constructs using a dual-process approach

In this PhD, as in a narrative review by Stevens et al. (2020), the umbrella term "affect-related constructs" was used to encompass both the acute affective or emotional experience of varying complexity (e.g., acute automatic affective response to physical activity or acute physical activity enjoyment) and subsequent "emotion-stimulated cognitive processing" (e.g., cognitive reflections regarding the emotion physical activity enjoyment) (Baumeister et al., 2007). It must be admitted that the term "constructs" may sound like a human-made categorization and less like an automatic sensation that does not necessarily need to be conscious and categorized with an emotion word (Russell & Barrett, 1999). Nevertheless, this term was chosen because it is most

likely to avoid misunderstandings: Some authors use the umbrella term “affective phenomena” instead, including affect, mood, and emotion (Ekkekakis, 2012), but this may remind others of “core affect” (Russell & Barrett, 1999), and thus confuse them as to whether the term should also encompass emotion and mood. Moreover, it is not only the acutely experienced affective phenomenon that should be addressed in this PhD, but also the cognitive processing based on it. Thus, the term “affect-related” seemed particular useful to also refer to the latter.

Acute affective or emotional experiences can be defined within the framework of the dual-process approach: Strack and Deutsch (2004) consider core affect to be a result of the impulsive system, which they characterize as involving automaticity, speed, and effortlessness – This aligns with the definition of automatic affective responses by Baumeister et al. (2007), who understand them as being based on perception and association. According to them, they represent rapid gut feelings that can be differentiated by their valence, either positive or negative. Russell (2003), in an circumplex approach belonging to psychological constructivism (see also Gross & Barrett, 2011), defines core affect as a neurophysiological state that can be consciously experienced as a basic, instinctual feeling that combines hedonic (valence dimension from displeasure to pleasure) and arousal (from sleepy to activated) components. Thus, the acute affective response to physical activity, that is, how one feels in response to physical activity (Stevens et al., 2020) can also be decomposed into these basic dimensions, i.e., how well someone feels right now (Hardy & Rejeski, 1989) and how aroused someone feels (Svebak & Murgatroyd, 1985).

According to the dual-process approach, reflective processes can transform this simple feeling into more complex feelings (Strack & Deutsch, 2004), also referred to as full-fledged emotions (Baumeister et al., 2007). Baumeister et al. (2007) posit that for a conscious emotion to occur, it requires more complex steps than just mere perception and association. For example, a stimulus should also be cognitively appraised, and the bodily state should be recognized by the brain as an emotion. This complexity is also reflected in component process models, which suggest that emotions consist of multiple components, namely cognitive, neurophysiological, motivational, motor expression, and subjective feeling components (Scherer, 2010). It is also worth mentioning that emotions are directed towards an object, while affective responses do not necessarily have to be object-oriented (Russell & Barrett, 1999). For example, immediately after physical activity, a person may experience pleasure without it being directed towards someone or

something. In contrast, the person consciously experiencing the emotion of physical activity enjoyment could not only feel pleasure but also attribute it to an object, namely physical activity. Thus, in our previous work, we refer to physical activity enjoyment as an emotion directed toward physical activity that includes pleasure at its core (Chen, Weyland et al., 2021; Fritsch et al., 2022).

Further, individuals can reflect on their past affective responses or emotions in terms of an affective judgment (Stevens et al., 2020; Williams & Evans, 2014). Baumeister et al. (2007) refer to this as "emotion-stimulated cognitive processing" including learning or reflection and contrast it with the affective or emotional experience per se. For instance, following the experience of physical activity enjoyment, individuals might contemplate whether they find physical activity pleasurable in general.

Now that affect-related constructs have been integrated into a dual-process framework, let us explore how they might be connected to habit using two specific dual-process theories.

Physical Activity Adoption and Maintenance Model

Based on empirical evidence of automatic associations that may be involved in the regulation of exercise behavior (Bluemke et al., 2010), and noting the lack of superiority of interventions based on Social Cognitive Theory and Transtheoretical Model over interventions not based on theory (e.g., Prestwich et al., 2014), the authors of the Physical Activity Adoption and Maintenance Model (PAAM model; Strobach et al., 2020) emphasize the additional role of implicit processes. Thus, the model assumes that both implicit and explicit processes are relevant to the adoption and maintenance of physical activity and is therefore a dual-process model. As such, it takes up, for example, the propositions of the Reflective-Impulsive Model (Strack & Deutsch, 2004) that implicit processes consume few cognitive resources and that explicit processes are more likely to activate a behavioral schema and thus take control of behavior when resources are sufficiently available. It also assumes that different variables are relevant for adoption and maintenance (see also Jekauc et al., 2018), which means that explicit processes are more relevant for adoption and implicit processes become more important for maintenance. As the model aims to fill the gap of specifying implicit and explicit processes, aspects of reflective and automatic processing are proposed – but in the following, the focus will be on the latter, as this corresponds to the focus of this PhD.

What are called implicit processes in the PAAM model overlap with what Strack and Deutsch (2004) call impulsive system, and in this respect these processes are characterized by automaticity, speed, effortlessness, associative links and behavior control trough spread of activation. Since automaticity is a characteristic of habits, as described in the definition of habits (Gardner, 2015), it is apparent to include habit in the implicit processes. In addition, Strobach et al. (2020) refer to affective responses as part of the implicit process.

Based on the law of effect (Thorndike, 1911), the PAAM model postulates that affective responses influence habit formation.

> We learn many bad habits, such as morphinism, because there is incomplete adaptation of all the interests of the body-state to the temporary interest of its ruling class, the neurones. So also the unsatisfying goods are not goods to the neurones at the time. We neglect many benefits because the neurones choose their immediate advantage. The neurones must be tricked into permitting the animal to take exercise when freezing or quinine when in a fever, or to free the stomach from certain poisons.
>
> (Thorndike, 1911, p. 246)

Thorndike (1911) already emphasized the role of immediate advantage for habit formation. Later literature on the psychology of habits, and more specifically on habitual health behaviors, also mentions that the sensory experience of pleasure can have a stronger rewarding effect than the anticipation of benefits (e.g., health benefits that will occur in the long term; Mullan & Novoradovskaya, 2018), which, as Gardner et al. (2021) point out, occur with a delay and not immediately. In a nutshell, physical activity should be accompanied by positive affective responses, because if “learning of an animal is an instinct of its neurones” (Thorndike, 1911, p. 248), but the neurons are not tempted to form associations by the long-term benefits of physical activity, then they would presumably find it easier (i.e., would not need to be “tricked”) to learn habits, if physical activity would have immediate benefits – i.e., if it was pleasurable.

However, Strobach et al. (2020) point out that, apart from animal studies, there is little empirical evidence for this relationship, especially in real-world physical activity settings. Another dual-process theory that zooms in a bit further can be used to further justify the relationship between affect-related constructs and habit.

Affective-Reflective Theory of physical inactivity and exercise

The Affective-Reflective Theory of physical inactivity and exercise (ART; Brand & Ekkekakis, 2018) is also a dual-process model. Here, the theoretical underpinnings can be found in force-field analysis (Lewin, 1951), i.e., the assumption that driving and restraining forces must be analyzed in the very moment of behavior change. Further, it is rooted in hedonistic thinking according to which pleasure can be motivating (see also Rozin, 1999). In fact, Rozin (1999) defines pleasure as a state experienced as positive that we want to approach, maintain, if not enhance – thus including the motivational component in the definition. Combining force-field analysis and hedonistic approaches, Brand and Ekkekakis (2018) conclude that positive affect-related constructs can represent driving forces. Since the theory also relies on automatic affective associations (see also Antoniewicz & Brand, 2016) as well as dual-process thinking (see also Strack & Deutsch, 2004), Brand and Ekkekakis (2018) assume that momentary automatic affect-related phenomena can lead to action impulses directly – as Zajonc (1980) puts it in the title of his paper on feeling and thinking "preferences need no inferences"; and that they, in turn, can also inform a reflective system that leads to action plans. In Kahneman's work (e.g., Kahneman et al., 1993), the temporal frame of affect-related constructs is also taken up, and Rozin (1999) concludes that experienced pleasure (hedonism of the present) controls momentary behavior, while anticipated (hedonism of the future) and remembered pleasure (hedonism of the past) do so, but are simultaneously involved in evaluations of future behavior.

How does this theory, which does not in itself attempt to explain habits, underpin the relationship between affect-related constructs and habit? According to ART (Brand & Ekkekakis, 2018), if an exercise-related stimulus results in positive automatic affect-related processes that lead to an action impulse, the latter would only need to be overridden using self-regulatory resources if there was a conflict between the two systems, i.e., an opposite reflective evaluation would lead to an opposite action plan. Thus, assuming an individual who is aware of the health benefits of physical activity and has the intention to be active, positive affect-related processes would keep behavioral control implicit, i.e., behavior would automatically proceed from automatic associations via automatic affective valuations to action impulse. Thus, in this scenario, positive affect-related processes could render cognitive processes superfluous and keep behavior in automatic fairways.

A classic by social psychologist Festinger (1978; first published in 1957), the theory of cognitive dissonance, can also be applied here. Consistent with findings on the decreasing subjective attractiveness of rejected alternatives (Brehm, 1956), the theory postulates that cognitive dissonance is uncomfortable for the individual to experience and therefore, it is a motivating factor. Consequently, individuals are motivated to establish consonance, for example through the modification of a cognitive element resulting in a change in behavior or attitude. However, if there is no dissonance because the implicit and explicit systems are in harmony, there is no need for further cognitive evaluation (see also Brand & Ekkekakis, 2018). Similarly, Kaushal and Rhodes (2015) theorize that unpleasant environments are a distracting factor that involves conscious sensory awareness, and unpleasant experiences (with subsequent negative affective judgements) could lead to conscious evaluation prior to re-execution of exercise behavior.

In sum, both the PAAM model and the ART postulate that automatic processes are involved in behavior maintenance in addition to reflective ones. Further, while the PAAM model explicitly postulates a relationship between the implicit processes of affective responses and habit formation while referring to Thorndike (1911), it can also be indirectly deduced from the ART that affective processes could be involved in the automation of behavior in the long term. However, both models focus more on explaining behavior rather than habit formation. The assumption that behavior repetition in turn contributes to habit formation, and, thus, that the models' assumed relationship between affect-related constructs and behavior provides further theoretical underpinning of the relationship between affect-related constructs and habit, becomes more understandable when a concrete model is used that attempts to explain the formation of habits. In this course, then, the details will be further elaborated, and automatic processes will be further specified, rather than merely distinguished from reflective ones (see also Wood & Neal, 2009).

Framework for Habit Formation

As mentioned earlier in this PhD, habit formation has been well studied in animal studies and has led, among other laws, to the formulation of the "law of effect", according to which creatures will repeat a behavior if it was previously satisfying (Thorndike, 1911). As valuable as these findings are, human beings struggling with competing impulses, some of which "want" to go to the gym and some of which "want" to stay on the couch, are not cats in boxes that can get

food through simple motor actions. Gardner and Lally (2018) also make this point, emphasizing the importance of studying habits in real-world, human scenarios.

From the definition of habit (Gardner, 2015), it can be inferred that behavioral repetition in the presence of a cue is required to learn cue-behavior associations and thus form habits. The framework for understanding habit formation and its determinants by Gardner and Lally (2018) postulates a habit formation process consisting of four stages and that determinants can influence any of the stages. In stage 1, deciding to act is related to intention formation, and in stage 2, self-regulating leads to action initiation. Stage 3 is divided into simultaneous stages 3a and 3b, with repeating behavior (stage 3a) and developing cue-behavior associations (stage 3b) together leading to habit formation. Gardner and Lally (2018) broadly divide the determinants that may influence habit formation at different stages into variables that characterize the cue, the behavior, or the person, and refer to reward value as a behavior-related determinant.

What is a reward? In the operant tradition, Skinner (1965, p. 72) tends to talk about "reinforcers", which he describes as follows: "the only defining characteristic of a reinforcing stimulus is that it reinforces." He cites food, water, or sexual contact as examples of positive reinforcers. Deci et al. (1999, p. 627) refer to these as "extrinsic rewards" and distinguish them from "inherent reward", which is seen in the behavior itself. Very broadly, Thorndike (1911, p. 245) understands "satisfaction" as a condition that the animal does not make any effort to avoid, often engaging in activities to achieve and maintain it. Affect-related constructs, then, when they are reinforcing and the individual does nothing about them, can be understood as satisfying reinforcers. In this respect, they could be assigned to the more borrowed word "reward", which, according to Skinner (1965), also includes negative reinforcers (stimuli whose removal has a reinforcing effect). Given these open-ended definitions, it is not surprising that intrinsic rewards have been operationalized in different ways in research, with pleasure and intrinsic motivation emerging as effective reward indicators in one study (Judah et al., 2018).

Thus, understood in terms of intrinsic reward as a determinant of habit formation, affect-related constructs can influence the four stages described in the framework for understanding habit formation (Gardner & Lally, 2018). To make it more concrete, below is a description of how the acute affective response to physical activity can specifically affect each stage.

Stages 1 and 2. As Gardner and Lally (2018) also mention, the initial stages of the framework are not habit specific. For example, stages 1 and 2 correspond to the preactional phases of the Rubicon Model of Action Phases (e.g., Heckhausen & Gollwitzer, 1987). Therefore, these two stages were not the focus of this PhD. This is also because affective responses per se reach their limits in explaining intention formation and translation of intention into action within dual-process models (e.g., Brand & Ekkekakis, 2018; Strobach et al., 2020) when the behavior has never been performed in the past, i.e., no "encoded affect" has been formed from previous affective responses that could implicitly or explicitly influence the behavior. Similarly, Strobach et al. (2020) propose that self-regulation is relevant for behavior adoption, while implicit processes are increasingly important for behavior maintenance.

Stage 3a. At stage 3a, the general question of this PhD, namely whether and how affect-related constructs are related to habit, is more specifically formulated as whether the affective response is related to repetition of behavior. As a theoretical framework, the "law of effect" can be used again, from which it can be deduced that satisfaction-generating, i.e., affectively positively associated, behaviors tend to be repeated (Thorndike, 1911). However, the presented framework for understanding habit formation and its determinants intended to go beyond animal studies and transfer habit formation to human life (Gardner & Lally, 2018). In general, the relationship between the affective response during physical activity and physical activity behavior maintenance was shown in many studies (e.g., Rhodes & Kates, 2015; Williams et al., 2016). At least one question arises in relation to human behavior: Does the affective response play a role in relation to higher cognitions and is linked to behavior maintenance in this way? Since intention has been found to be an important determinant of physical activity behavior (McEachan et al., 2011), and since almost no one reports being physically active without having the intention to do so (Rhodes & de Bruijn, 2013), one way in which the affective response could be related to behavior maintenance is via sustained intention. Intentions to re-attend an exercise course are usually very high among present attenders and initial enactment of intentions seems less critical than later maintenance of the behavior when weeks have passed (Finne et al., 2019). In one of our studies, we found that positive affective responses after an exercise course predicted intentions to re-attend the course, and were thus indirectly related to course re-attendance via intentions (Finne et al., 2022). What was not shown was that affective responses moderated the relationship between intentions to re-attend and subsequent re-attendance. In two other of our studies, we examined

anticipated affect-related constructs (Feil et al., 2023; Feil et al., 2022), suggesting that affective responses serve as a basis for the emergence of anticipated affect-related constructs (Baumeister et al., 2007) that may then contribute to the activation of an intention at a given moment (Michie & West, 2013).

Thus, the hypothesis derived here would be that the affective response is related to the re-execution of a behavior and this in turn is related to habit formation (mediation hypothesis).

However, one study showed that it is not only repetition that influences real-world health behavior habit strength, but that there might also be variance between individuals or behaviors that cannot be explained by the number of repetitions alone (Lally et al., 2010).

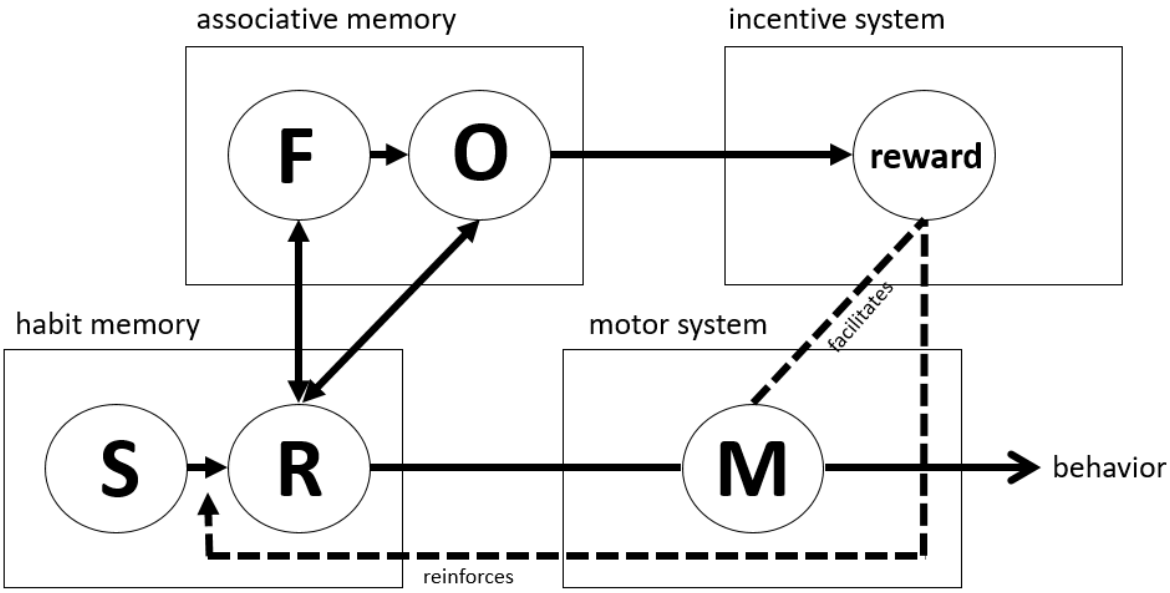
Stage 3b. At stage 3b, the general question of this PhD, namely whether and how affect-related constructs are related to habit, is more specifically formulated as whether the affective response is related to the development of cue-behavior associations. If so, this would mean that the extent to which behavior execution in specific contexts contributes to the development of habit is moderated by the affective response – in other words: the affective response quickens cue-behavior learning. Again, the law of effect (Thorndike, 1911) can be used here, which states that satisfying behaviors are more likely to be associated with the context that elicits them, i.e., a stimulus-response association is more likely to be learned. In contrast to the previous stage (3a), in which affect-related constructs (e.g., affective response or anticipated affect) would promote behavioral repetition through sustained motivation, and thus habit would grow incrementally with each subsequent behavior execution, the assumption that the affective response might also moderate the relationship between behavior execution and habit assumes that a single behavior execution can lead to a greater increase in habit if it has been (affectively) rewarded. Thus, the hypothesis derived here would be that the relationship between behavior execution and habit is strengthened through positive affective responses (moderation hypothesis).

A model combining both the mediation and moderation hypothesis is the associative-cybernetic model (de Wit & Dickinson, 2009). Figure 1.3 shows a simplified representation. The model is based on animal learning (e.g., Thorndike, 1911) and human goal-directed or ideomotor action (e.g., James, 1890b) and explains both goal-directed (intentional) and habitual behavior. It

was tested by Wiedemann et al. (2014) to examine the influence of intrinsic rewards on habit strength of fruit and vegetable consumption.

Figure 1.3

The associative-cybernetic model (simplified)



Note. Own simplified representation based on the "Schematic representation of the basic architecture of the associative-cybernetic model" as depicted in de Wit and Dickinson (2009, p. 470). S = sensory unit that reacts to environmental stimuli, R = response unit, M = unit in the motor system that corresponds to motor program, F = sensory feedback unit, O = outcome unit

Findings by Thorndike (1911) again play an important role in this model because it assumes that behavior initially emerges from habit memory, the stimulus and response units of which can be more strongly linked when reinforced by a reward in the incentive system. According to the model, it is the motor system that ultimately generates the output of the habit memory in the form of actual behavior. The motor system also receives a facilitating signal from the incentive system so that the performance of the behavior is facilitated. Overall, this "feed-forward pathway" explains the moderation hypothesis, because even the first rewarded behavior

an individual performs contributes to the strengthening of the stimulus-response relationship and thus habit.

If only these three systems were described, i.e., habit memory, motor system, and incentive system, all behavior would rather be stimulus-driven than goal-directed. Thus, the model also integrates associative memory, which contains the sensory feedback unit arising from response performance (thinking about the response) and the outcome unit (representation of the result of the response). Thus, the thought of the response is also activated in associative memory when the response is activated by the stimulus. Now it depends on what kind of outcome this feedback unit is associated with in the associative memory. For example, the outcome associated with running could be reaching the finish line at the race. If this were the case, the individual would have the belief, the instrumental knowledge, that running and the outcome reaching the line will certainly occur together. The experience of the acute affective response to the outcome, when it really occurs, leads to "incentive learning" (Dickinson & Balleine, 1994), that is, learning of a value of the outcome. Reaching the finish line feels good? So the outcome unit included in the associative memory will be connected to the reward unit. Back to the beginning, the stimulus: The stimulus now represents not only the response, but is also associatively linked to the reward. In terms of goal-directed behavior, the stimulus is now interpreted as one that should be followed by the response because of its outcome (as long as this is valuable).

Purpose 1: Is the affective response related to habit formation?

The main focus of this PhD, namely the exploration of the relationship between affect-related constructs and habit in relation to physical activity behavior, runs through four empirical studies that we conducted with different emphases.

Chapter II presents an empirical study that examined the relationship between affective responses and habit formation in university exercise course participants (Study 1; Weyland et al., 2020). Data were collected from 226 individuals over 13 weeks, so the longitudinal design allowed for within-person level analysis. Weekly exercise course attendance was used as an objective indicator of behavior, while affective responses and habit were collected with weekly questionnaires.

The focus of this study was to better understand the role of affective responses in the formation of habits. Is there a direct relationship? The Affective–Reflective Theory of physical inactivity and exercise (Brand & Ekkekakis, 2018) postulates a relationship between affective processes and an impulse to act. From this it could be inferred that positive affective processes keep behavior at an automatic level. Is the relationship rather explained by behavior, which is what the framework for understanding habit formation and its determinants (Gardner & Lally, 2018) and the associative-cybernetic model (de Wit & Dickinson, 2009) suggest in terms of mediation (reward influences goal-directed behavior, which in turn influences habit) or moderation (reward strengthens the relationship between behavior and habit)? Thus, we examined whether behavior frequency increases habit, whether positive affective responses increase habit, and whether positive affective responses moderate the relationship between behavior frequency and habit.

Purpose 2: Can we manipulate affect-related constructs? Intervention strategies

In their chapter "Escape From Cognitivism: Exercise as Hedonic Experience", Ekkekakis and Zenko (2016) contend that exercise psychology's influence on society is limited due to the relatively modest impact of interventions aimed at fostering physical activity, which tend to yield small effect sizes. They explain this by saying that we are "perfecting the art of peeking at the universe through a keyhole" (p. 393) – the keyhole being the cognitivist paradigm and its assumption of rationality. Therefore, they point the way to the "postcognitivist era" and urge that as more attention is paid to affect-related constructs, there should be an immediate, cost-effective, efficient way to change them for the better on a large scale so that as many people as possible can have positive affective experiences with physical activity.

However, what methods exist for altering affective experiences (i.e., affect per se such as the affective response) through interventions? Addressing this query, Chen, Finne et al. (2021) conducted a meta-analysis which revealed that techniques such as facilitating social comparison can be impactful interventions. This finding is coherent with the understanding that relatedness aligns with basic psychological needs tied to intrinsic motivation (Deci & Ryan, 2008). Moreover, social comparison has the potential to enhance one's perception of competence, another basic need according to self-determination theory (Deci & Ryan, 2008). Similarly, a qualitative investigation by Wienke and Jekauc (2016) found parallels between factors fostering intrinsic

motivation and those enhancing affective experiences. Their study identified four key factors associated with the emergence of positive affect-related constructs, such as enjoyment, in recreational sport and exercise. First, an emotional facilitator was perceived competence. This factor encompasses individual and collective achievements, progress, competitive elements, and challenges. Second, the perception of social interaction played a crucial role. This includes various aspects of interaction with peers, such as communication, group participation, and the formation of close relationships or friendships. Third, the experience of novelty emerged as another influential factor. In particular, recreational sport and exercise was perceived as different from non-sport activities such as work, family, or other leisure activities. Perceived physical exertion constituted the final factor, involving the level of exhaustion, and the notion of recreational sport and exercise compensating for sedentary lifestyles.

Based on these findings, Wienke and Jekauc (2016) propose the development of interventions aimed at enhancing the affective experience during physical activity by targeting these four identified factors. This could involve strategies like refining the training program's structure or shaping the behavior of exercise trainers. The latter approach holds significant promise, particularly due to the exercise trainers' pivotal role in shaping the affective experience of their course participants (e.g., Strauch et al., 2019). It becomes evident that certain behavior-related competences, such as adaptability competence, which have emerged as crucial in the study by Strauch et al. (2019), can be effectively translated into interventions. For example, by providing exercise trainers with practical illustrations of how to tailor training programs to the specific physical abilities of individual participants, the situational aspects can become the focus of an intervention for exercise trainers – as such, the approach of educating exercise trainers on situational factors can be seen as a combination of the situational approach by Wienke and Jekauc (2016) and the competency-based approach by Strauch et al. (2019), as situations are to be changed through interventions for exercise trainers.

Returning to the question of how affect-related constructs and habit are related, one concern for the study described in Chapter III was whether the development of affective responses elicited by an affect-based intervention for exercise trainers was related to habit formation in their course participants (Study 2; Weyland et al., 2022). Thus, consistent with the assumption that affect-related constructs and habit are related, this study was designed to examine not only the

effectiveness of an affect-based intervention in terms of its ability to improve affective responses, but also the relationship of these affective responses to habit. In this regard, ten exercise trainers of weekly sports and exercise courses at Karlsruhe Institute of Technology participated in interventions, with five receiving an affect-based intervention and five receiving a control intervention that did not explicitly focus on affective experiences. Over a ten-week period, 132 participants in the pre-trained exercise trainers' courses were surveyed with questionnaires on affect-related constructs (i.e., affective response and affective attitude) and habit in order to examine both the effectiveness of the affect-based intervention and the relationship between the development of affective responses and exercise instigation habit strength.

Purpose 3: The same effects for everyone? The role of personality

Following these two studies which dealt with the existence of a relationship between affective responses and habit, the third study was designed to investigate whether this relationship differs according to personality traits (Study 3; Weyland, Fritsch et al., submitted). For example, whether it is stronger or weaker according to the expression of the Big Five personality trait neuroticism or the emotional style dimension resilience.

What is personality? Personality means uniqueness in the structure of personality traits that refer to enduring patterns of thinking, feeling, and behaving (McCrae & Costa Jr, 1997). McCrae and Costa (1985) presented a version of the five-factor model, which they consider to be a suitable classification system for personality traits. This model combines various linguistic and questionnaire-driven methods and comprises the following "Big Five" personality traits: neuroticism, extraversion, openness, agreeableness, and conscientiousness. According to McCrae and Costa (1987), neuroticism is thought to cover more than just feeling negativity – it also includes the troubled thoughts and behaviors that come with emotional distress. When this personality trait is strongly expressed, individuals can be described as worrying, nervous, emotionally unstable, or vulnerable. The active ingredient of extraversion is the pleasure derived from the presence of others, i.e., sociability. Further, it includes the tendency to be affectionate, energetic, and talkative. Openness can be the basis for the development of intelligence, and intelligence can also be the basis for an individual's openness to values or ideas, for example. In any case, openness includes the tendency to be original, creative, perceptive, and reflective. On the dimension of agreeableness, the continuum extends to the antagonistic pole, where individuals

corresponding to this extreme tend to be permanently opposed to others. In contrast, individuals scoring high in agreeableness tend to be soft hearted, forgiving, and generous. Conscientiousness may be related to how well individuals can carry out their intentions, and it includes the tendency to be careful, well organized, reliable, and hardworking (McCrae & Costa, 1987). In addition to differentiating these five factors, McCrae and Costa (1987) also acknowledge that there are alternative approaches to studying individual differences, such as physiological ones. Whatever the results of these approaches, however, the five-factor model can always be used as a frame of reference because it is universally used to describe personality in words.

Emotional style theory is one such alternative approach, based on affective neuroscience, to describe the consistent pattern of responses to life experiences (Davidson, 1993; Davidson & Begley, 2012; Jekauc et al., 2021). According to the theory, a person's emotional style is determined by an individual combination of six dimensions: Outlook, resilience, social intuition, self-awareness, contextual sensitivity, and attention. These dimensions combine to create a healthy emotional life (Kesebir et al., 2019). Davidson and Begley (2012) postulate that outlook refers to the ability to maintain positive emotions, and relatedly, resilience includes the ability to bounce back quickly from negative emotions after a negative event. The skill to correctly interpret nonverbal social cues is called social intuition. High self-awareness scores indicate that an individual is able to interpret endogenous emotional signals. Adapting emotion regulation to the social context is called contextual sensitivity. Finally, attention refers to the ability to focus attention (Davidson & Begley, 2012).

While Chapter IV will discuss in more detail why each trait might act as a moderator, this section will provide a more basic account of how personality emerges as an interesting variable in the context of the relationship between physical activity enjoyment and habit. From a theoretical perspective, there are certain similarities in the definitions of habit and personality. Regarding habit, once a cue-behavior association has been formed, an impulse towards behavior is automatically triggered upon perception of that cue (Gardner, 2015). With regular exposure to the cue, the habitually instigated behavior becomes a persistent pattern of behaving – which is precisely one of the patterns that constitute personality (McCrae & Costa Jr, 1997). In fact, although the most common instrument for capturing habits has since been restricted to capturing automaticity (SRBAI, Gardner et al., 2012), the originally proposed version, the Self-Report Habit

Index (SRHI, Verplanken & Orbell, 2003), also includes items related to one's identity (e.g., "that's typically me"). The SRHI authors propose that habits are related to how individuals organize their daily lives, and thus, the expression of one's identity is an aspect of habits.

In one of our studies that focused on the emotional style, the total score for healthy emotionality, as well as the two dimensions of outlook and resilience, which were also highly correlated, were most strongly negatively related to neuroticism (Jekauc et al., 2021). We interpreted this as an indication that resilience and outlook are the core constructs of the total healthy emotionality score. Given this finding and their relationship, by definition, to the duration of emotions, these two dimensions were the focus of the study described in Chapter IV, along with the three Big Five traits of neuroticism, extraversion, and conscientiousness. Regarding the latter three traits, significant correlations with physical activity were found in a meta-analysis (Rhodes & Smith, 2006).

In the study described in Chapter IV (Study 3; Weyland, Fritsch et al., submitted), we were interested in the extent to which the five traits listed above moderate the relationship between physical activity enjoyment and habit. An online survey was taken by 587 participants, encompassing assessments of physical activity enjoyment, physical activity habit, Big Five personality traits (neuroticism, extraversion, and conscientiousness), along with emotional style dimensions (outlook and resilience). The gathered data was subjected to moderation analyses.

Purpose 4: How to measure physical activity enjoyment?

In all our self-report measurements, we assume that inherently implicit constructs like habits or affective responses can actually be consciously captured and reported – certainly, this is not without bias (as also discussed by Allom et al., 2016). Therefore, it becomes even more important to choose the appropriate measurement instruments based on the construct and research question and to examine them in terms of their psychometric properties (see also Zenko & Ladwig, 2021). Regarding the choice of an appropriate measure of affect-related constructs it is useful to distinguish between automatic affective responses and full-blown conscious emotions according to Baumeister et al. (2007). While the Feeling Scale is suitable for measuring automatic affective responses to physical activity or to anything else ("How do you feel right now?"; Hardy & Rejeski, 1989), the Physical Activity Enjoyment Scale (PACES) can measure both the experience of the full-blown conscious emotion physical activity enjoyment ("Please rate how

you feel at the moment about the physical activity you have been doing"; Kendzierski & DeCarlo, 1991) and reflection on past emotions ("When I am physically active it feels good"; Jekauc et al., 2020). This scale was recently shortened by Chen, Weyland et al. (PACES-S; 2021) according to Scherer's (2010) component process model to the subjective feeling component and has only been validated with German-speaking samples (see also Fritsch et al., 2022). A more in-depth reflection on physical activity enjoyment and its measurement properties within an English-speaking sample was the purpose of the validation study within the framework of this PhD (see chapter V; Study 4; Weyland, Kaushal et al., submitted).

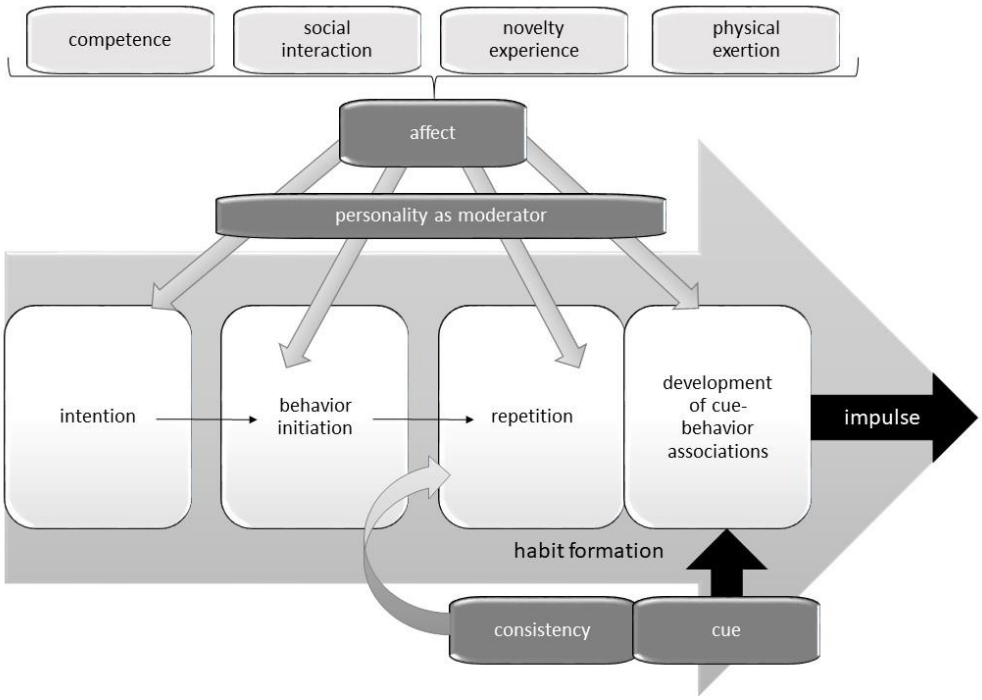
The investigation of measurement invariance was a particular focus here. In general, for the interpretation of mean differences between groups, it is necessary to assume measurement invariance, because otherwise the psychometric equivalence of the measured construct in the two groups would be questioned (Putnick & Bornstein, 2016). For example, if an item is less important for the perception of physical activity enjoyment in one group, then PACES-S means in this group could be lower, but not because this group feels less physical activity enjoyment, but because they scored low on an item that is not important for physical activity enjoyment anyway. In order to plan future large-scale studies with English-speaking colleagues, it was therefore essential to test measurement invariance across languages.

Very short summary and graphical illustration

All studies undertaken within the scope of this PhD research were formulated to investigate the association between affect-related constructs and habit (or its formation) within the realm of physical activity. Study 1 (Weyland et al., 2020) established the foundational understanding by scrutinizing theoretically derived connections and identifying a direct relationship between affective responses and habit. This established groundwork was subsequently subjected to more comprehensive exploration through Studies 2 (Weyland et al., 2022) and 3 (Weyland, Fritsch et al., submitted). Study 2 encompassed the manipulation of affective experiences as part of an intervention for exercise trainers aimed at establishing a closer understanding of the causality within the relationship. The third study delved into potential moderators of the enjoyment-habit relationship using a cross-sectional design, employing a measurement tool that underwent psychometric assessment in Study 4 (Weyland, Kaushal et al., submitted).

Figure 1.4

PhD in a nutshell



Note. The process depicted by the vertical grey arrow corresponds to the framework for understanding habit formation and its determinants proposed by Gardner and Lally (2018, p. 211).

The fundamental theories used to justify the studies are synthesized in Figure 1.4 (self-created graphic). Starting from the top, it can be observed that the factors found by Wienke and Jekauc (2016), which bear similarity to the Self-Determination Theory (Deci & Ryan, 2008), were regarded as determinants of affective responses. The process depicted by the vertical arrow corresponds to habit formation proposed by Gardner and Lally (2018) and provides stages where affect-related constructs can reinforce habit formation. For instance, it is shown that affect-related constructs can enhance the formation of a cue-behavior association, which could be moderated by personality. Ultimately, it is also illustrated that starting from the left, it is the intention that initiates the beginning of habit formation and that the eventual triggering of an impulse by a cue is akin to a shortcut, bypassing a cognitive process.

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Chapter II – The relationship between affective responses and instigation habit

Study 1: (How) Does affect influence the formation of habits in exercise?

Slightly modified version of the published manuscript:

Weyland, S., Finne, E., Krell-Roesch, J., & Jekauc, D. (2020). (How) Does affect influence the formation of habits in exercise?. *Frontiers in Psychology, 11*, 578108. https://doi.org/10.3389/fpsyg.2020.578108

Abstract

Objectives. Habitually instigated exercise is thought to increase health behavior maintenance. Previous research has explored several aspects of habit formation. However, there is a lack of longitudinal research investigating affective determinants, especially post-exercise affective states. Therefore, the present study aimed to investigate (a) if behavior frequency will enhance automaticity, (b) if positive affect will enhance automaticity, and (c) if positive affect will moderate the relationship between behavior frequency and automaticity.

Methods. 226 participants (64 % females, mean age 24 years) who attended weekly sports and gym classes at two universities were followed for 13 weeks. Class attendance was documented on a weekly basis (behavior frequency) during the semester. Before, during and immediately after each class, participants filled in the Feeling Scale (affective valence). Furthermore, at the beginning of each class, they answered a question about their automaticity in arriving at the decision to attend the class (instigation habit). We used a two-level modeling approach to predict subsequent automaticity by the different constructs at the previous attendance.

Results. The cumulative frequency of prior class attendance did not significantly enhance the automaticity of the decision to re-attend the class. There were significant effects of valence on automaticity on the between-subject level, i.e., a one-point higher mean valence score was associated with a 0.62 point increase in automaticity ($p = 0.001$). No moderation effects of affect on the association between behavior frequency and automaticity were observed.

Conclusion. Behavior repetition, albeit not significant, and positive affective states at the end of an exercise class may be beneficial in building exercise instigation habits. Practitioners and researchers alike may thus want to emphasize the importance of behavior repetition and affective response for health behavior maintenance.

Introduction

"The first letter of the psychological alphabet is A for Attitude." – This statement by Jung, quoted by Hamilton (1929, p. 126), puts the cognitivist paradigm, which later dominated psychological research, in a nutshell. However, since authors like Ekkekakis and Zenko (2016) propose the "escape from cognitivism," one might consider that A stands for Affect.

In the context of physical activity (PA), affect plays a key role and increasingly gains attention among researchers and practitioners alike. On the one hand, affect serves as a motivator of behavior (Finucane et al., 2003) and is involved in the process of PA behavior maintenance (Rhodes & Kates, 2015), and on the other hand, PA can influence affect in both negative (Ekkekakis et al., 2008) and positive (Ekkekakis et al., 2000; Hogan et al., 2013) ways. This study focuses on the role of affective states in the formation of habitual instigation of exercise. Affective states subsume the whole range of states based on core affect (Scherer, 1984; Ekkekakis, 2003), which is defined as "the most elementary consciously accessible affective feelings (and their neurophysiological counterparts) that need not be directed at anything" (Russell & Barrett, 1999, p. 806). Thus, these rapidly and automatically occurring feeling states (Slovic et al., 2007), with the two dimensions valence (pleasure/displeasure) and arousal (low/high) (Russell, 1980), differ from emotions (Ekkekakis, 2003). The broader and general term "affect" refers to any other valenced responses in the global domain of affective feelings (Ortony et al., 1987).

In addition to a potential positive impact on affect, several other benefits of PA with regard to psychological variables have been reported. For example, there is evidence that regular PA reduces levels of stress and anxiety as well as incidence rates of depression, and improves overall psychological well-being (Goodwin, 2003; Ströhle, 2009; Rebar et al., 2015; Rhodes et al., 2017). Furthermore, current research demonstrates that regular PA is associated with the prevention of over 25 chronic medical conditions (Warburton et al., 2007; Garber et al., 2011). Nevertheless, about 31 % of adults worldwide are physically inactive (Hallal et al., 2012) and only an alarming 22.6 % of adults in Germany meet the WHO recommendations for aerobic and muscle strengthening PA (Finger et al., 2017), even though many individuals may have the intention to be physically active. For example, a recent study showed that 90 % of participants intended to engage in moderate PA for at least 150 min per week (de Bruijn et al., 2009). This failure to translate intentions into behavior is a phenomenon referred to as intention-behavior-gap, which

reflects “the black-box nature of the underlying psychological process that leads from intention to action” (Sniehotta et al., 2005, pp. 143-144). In their meta-analysis, Rhodes and de Bruijn (2013) quantified the intention-behavior-gap by showing that only 42 % of “intenders” acted on their PA intentions. Also, interventions that focus on enhancing intentions thereby promoting behavior change have limited success (Webb & Sheeran, 2006; Rhodes & Dickau, 2012). Thus, there is not only an urgent need to make more people cognitively aware of the health benefits of sustained PA, but to also help them to successfully carry out an intended behavior, such as engaging in PA.

Focusing on intention as the proximal determinant of behavior, as postulated in traditional social-cognitive models like the Theory of Planned Behavior (TPB; Ajzen, 1985), may not be sufficient in explaining actual behavioral instigation and regular execution. Rather, automatic processes need to be additionally considered (de Bruijn & Rhodes, 2011). The two pathways are summarized in dual process theories such as the Affective-Reflective Theory (ART) of physical inactivity and exercise. The ART was developed by Brand and Ekkekakis (2018) to explain the initiation of exercise-related actions or the persistence of physical inactivity. According to the theory, a fast type-1 process leads to an action impulse via automatic associations and automatic affective valuations (Antoniewicz & Brand, 2016), and a slower type-2 process can result in action plans via reflective evaluation provided that self-control resources are available (Baumeister & Heatherton, 1996). Explaining their PAAM model that identifies predictors of PA adoption and maintenance, Strobach et al. (2020) argue that the control of behavior gradually shifts from being explicitly to being implicitly controlled when it is repeated under stable contexts due to habit formation. One study found that past exercise behavior had a significant positive effect on the intention to continue exercising during the next six months, thus stabilizing it, while at the same time past behavior did not exhibit a significant indirect effect via intention on future behavior, but had a strong direct effect (Rodrigues et al., 2021). In sum, one of the implicit constructs that should be considered with regard to the intention-behavior-gap is habit (de Bruijn & Rhodes, 2011).

Gardner and Lally (2018, p. 207) define habit as “a process whereby encountering a cue triggers an impulse to perform an action that has, through learning, become a learned response to the cue.” In order to develop a method of measuring habit, Verplanken and Orbell (2003)

summarize the basis features of habit as follows: previous repetition of the behavior; and features of automaticity, namely difficulty of overruling strong habits, lack of awareness, efficiency; and their reflection of someone's identity. Thus, automaticity is a main characteristic of habit (Aarts & Dijksterhuis, 2000; Hagger, 2019). Assuming that habit automaticity is cue-dependent (Orbell & Verplanken, 2010; Wood & Rünger, 2016), once behavior has become habitual it is supposed to be insensitive to lack of motivation (Rebar et al., 2019; Gardner et al., 2020). In their recent meta-analysis, Gardner et al. (2011) found a medium-to-large correlation between habit and behavior, suggesting that habit explains for about 20 % of variance in those health-related behaviors. Combining these two effects of habit on behavior, namely bridging dips in motivation and a correlation between habit strength and behavior frequency (Gardner et al., 2012; Rebar et al., 2016), it is possible that establishing habits might facilitate behavior maintenance. The underlying assumption is that the habit process may trigger selecting an action out of several behavioral alternatives. This habitual selection of an action for performance is defined as habitual instigation (in contrast to habitual execution, which means habitually performing the already chosen behavior; Gardner et al., 2020). In a randomized controlled trial examining the effect of a workshop on establishing a preparatory exercise habit, the experimental group indeed showed a significant increase in physical activity, use of cues and practice consistency compared to the control group (Kaushal et al., 2017).

Theoretically, habits are easily developed, as repetition of behaviors in stable contexts might be sufficient to strengthen links between salient cues and subsequent actions in associative memory, which may in turn result in highly accessible context-behavior associations that speed up enactment (Verplanken, 2006; Danner et al., 2008; Gardner & Lally, 2018; Hagger, 2019). However, reality is more complex. In their attempt to model habit formation in the real world, Lally et al. (2010) asked volunteers to repeat a self-chosen health behavior in the presence of a cue of their choice and to report automaticity on a daily basis. An asymptotic curve reflected the process of habit formation, assuming that automaticity increases rapidly with every repetition in the first days while additional gains then decelerate over time. Finally, habit formation reaches a point where growth in automaticity is no longer possible despite maintaining repetitions. This model was valid for 62 of the 82 participants, which indicates that repetition of behavior was sufficient to form automaticity in these 62 individuals. However, there was variation in the absolute level of achieved automaticity and the number of days needed to reach this individual

maximum. Thus, rates of automaticity formation are highly variable albeit an equal number of repetitions, leading the authors to conclude that the final habit strength is not exclusively determined by repetition. While it is possible that anticipated affect or intrinsic rewards played a role in the participant's choice of the health behavior, the study reveals no information about affect itself. In the present study, the research question was whether affective states is another variable that influences habit formation.

Conceptually, determinants of habit formation can be categorized into variables influencing the intention to act, the likelihood of acting on intentions, the motivation to maintain a behavior after successfully initiating it, or the development of cue-action associations (Gardner & Lally, 2018). As for affect, this intrinsic rewarding outcome is supposed to play a role on multiple levels: First, it may lead to more frequently performed behavior and sustained motivation which in turn may prompt maintenance and habit development. This assumption is based on a psychological hedonism of the past which is associated with learning theories (Insko & Schopler, 1972). An example is the "law of effect," which was developed by Thorndike (1911). His animal-learning studies led him to conclude that a behavioral response to a cue will be more likely to be shown after encountering the stimulus again in the future, if the behavior was followed by satisfaction. Hedonism of the past, in general, states that individuals engage in behavior that maximized reward and minimized displeasure in the past (Insko & Schopler, 1972). In fact, individuals having a more positive affective response during acute moderate-intensity exercise were more active in the future (Schneider et al., 2009). Second, affect may increase or expedite context-behavior associations. This assumption is based on a premise resulting from a combination of hedonism of the past and a stimulus-response approach: When the affective response to a cue-response situation is pleasurable, a learned association between stimulus and response will be formed (Insko & Schopler, 1972). In the law of effect, a positive correlation between satisfaction and the resulting strengthening of the bond is assumed (Thorndike, 1911). In line with this, the Associative Cybernetic Model proposes that once an outcome is rewarding, the signal to habit memory, which strengthens the stimulus-response relationship, will be supported (de Wit & Dickinson, 2009). Consequently, this process reinforces the contribution of each rewarded behavior performance to habit formation (Wiedemann et al., 2014) and can therefore explain different curves of habit formation despite comparable behavioral frequency. Thus, affect – especially during exercise – is supposed to influence habit development not only due to

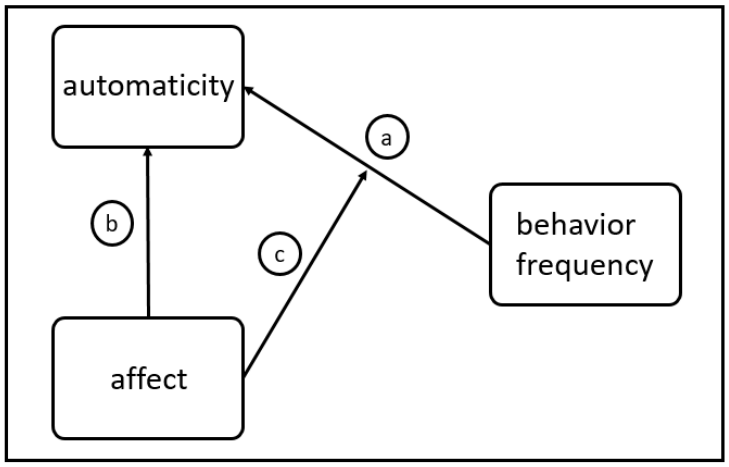
repetition of the behavior but also via the reinforcement of the relationship between behavioral repetition and habit strength.

Investigating determinants of habit strength, one cross-sectional study found an interaction between motivational regulation and past behavior (Gardner & Lally, 2013). The authors hypothesized that past behavior may be a stronger predictor of habit strength among intrinsically motivated participants, suggesting that enjoyment derived from autonomously motivated PA may strengthen the relationship between past behavior and habit development even more. In line with this, another study investigated intrinsic rewards such as enjoyment and found that intrinsic rewards predict exercise frequency via habit strengths for maintainers (and via behavioral intentions for initiators; Phillips et al., 2016). Furthermore, Kaushal and Rhodes (2015) investigated the influence of affective judgments about exercise on habit formation in a longitudinal study among new gym members, and reported that affective judgments at baseline were the main predictor of habit development. The authors concluded that a reward like positive affect increased the likelihood of an individual performing the behavior again without conscious deliberation. However, the study had several limitations, i.e., the first follow-up assessment of habit scores was done after six weeks; and, in particular, affective judgments refer to beliefs or expectations about affect and are therefore not affective responses per se (Ekkekakis et al., 2018). Overall, only few long-term studies that examined affective determinants of habit formation are available, especially in the context of physical exercise.

Therefore, the purpose of the present longitudinal study was to examine the role of affective states and behavior repetition in the formation of real-world exercise instigation habits among adults. Since it is recommended in the literature to not only analyze affective changes in group means, but also at an individual level, we explored affective states on both between-person and within-person level (Ekkekakis, 2008). We hypothesized that (a) behavior frequency will enhance automaticity, (b) positive affect will enhance automaticity, and (c) positive affect will moderate the relationship between behavior frequency and automaticity (see Figure 2.1).

Figure 2.1

Hypotheses



Materials and methods

Participants

Participants were university students or employees who participated in 10 sports and gym classes at no or low cost during the winter term 2015/16. These courses are unconditionally offered each term to all students or employees of the universities. As the limited available spots were assigned by applying the "first come first served" principle, interested persons had to register for specific courses ahead of time. Each specific class started at the beginning of the lecture period and there was a great variability in date, coach and participants from semester to semester. Given this fluctuation, the participants may have attended a similar course, but they cannot have attended the identical course on the same date, with the same instructor, the same co-participants nor at the same sports facilities as before. Therefore, context-specific cues that may have been associated with the exercise behavior before change. We consequently assume that participants started the class with no habit to attend this specific class and are appropriate for studying the development of a new habit. We included classes with a medium size (about 15-30 participants) and an adequate practice time (about 60-90 min). Thus, our study sample can be regarded as a convenience sample, although participants were not self-selected as throughout the courses nearly all consented to participate in our study.

This approach led to a total sample of 145 female und 81 male (N = 226) university students and employees, who provided sufficient complete data and were included in the presented analyses. Course instructors of the 10 classes were informed prior to the study about the design and aims, and all instructors gave their consent to participate in this research. Study participation for participants of the sports classes was voluntary and interested individuals were asked to provide written informed consent, which was done by nearly all of potential participants. However, we have no information on the number of individuals who refused to participate, as the complete list of participants attending the sports classes was not available to our research team due to data protection policies. The study was approved by the Data Security Commissioner and the Ethics Committee of one of the universities.

Design and setting

In order to study the influence of affective states and behavior frequency on automaticity formation on a between- and within-person level, this study had a longitudinal design with weekly measurement time points. It was conducted at two German universities during the winter semester 2015/2016 (October 2015 to February 2016). Course duration varied slightly depending on the length of the semester at each university (ranged from 13 to 15 sessions; for comparability, only the first 13 weeks were included in the analyses), and no classes took place during the two weeks Christmas holiday break. The number of weeks needed to form a habit is highly variable (for an overview see Hagger, 2019), but since evidence suggests that attendance in the first five weeks is crucial for habit formation (Armitage, 2005), we consider the time span of one term to be sufficient. The study settings were sports and gym classes during which participants carried out various types of aerobic exercise, including dance-related exercise (Zumba, Bokwa), martial arts (Kickboxing, Taekwondo, Capoeira), Freeletics (a specific set of endurance and strength exercises), and basketball training.

Procedure

Individuals who agreed to participate in the study signed a consent form during their first attendance of the course. Participants then completed a baseline questionnaire to report past exercise behaviors and habit strength (please refer to section “Baseline Questionnaire”). Student assistants attended all selected courses on a weekly basis. At the beginning of a course, they

documented participation and handed out a short questionnaire measuring affective states and automaticity to all attending study participants. After approximately half of the class time (after about 45 min), and immediately after the training, the same short questionnaire was again provided to participants. After each class, the student assistants regathered all questionnaires. In order to collect the data pseudonymously, each participant had an individual code, consisting of letters and numbers derived from family names, year and place of birth. This enabled the lead investigator to match the questionnaires to each participant.

Measures

Participants filled in a baseline-questionnaire during their first week of attendance and, every week they attended the class, a short weekly questionnaire at three time points: at the beginning of the training, approximately after half of the class time, and immediately afterward. In the following, only measures relevant for the present analyses are described.

Baseline questionnaire

Sociodemographic information. Sex (male, female), age (in years), and student status (student yes/no) were collected.

Past exercise behavior. To adjust for past behavior, participants were asked whether they had already been exercising on a regular basis (yes/no) before registering for the class. If they responded with "yes," they were asked to provide information on how long they had been exercising on a regular basis (in months or years). Exercise was defined as any leisure time activities that included physical exercise regardless of whether these activities were performed alone, in a team, or a sports club, and examples were given (e.g., team sports either within or outside of a club, walking, swimming, horse riding, etc.). Mainly sedentary sports like chess, computer games or fishing were explicitly excluded from the definition.

Habit strength. To measure general exercise instigation habit strength, the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) was completed by study participants. However, three items on frequency of behavior from the original 12-item measure were excluded, as they have been subject to discussion in literature (Gardner, 2015) and since leaving them out did not change the main results of the original scale development studies (Verplanken & Orbell, 2003). For the remaining nine SRHI-items, the wording of each item stem was "To go exercising is

something…" and ended, for example, in one item at "…is something I do without thinking." Therefore, the scale rather taps the decision to go exercising than the execution of a specific exercise behavior (for a distinction between instigation and execution habit see the response to Hagger by Gardner et al., 2020). The scale showed a very good internal consistency of $\alpha = 0.917$ and was approximately normally distributed. The scale did not address the same decision/behavior as the short weekly questionnaire. As habit strength for instigation habit was measured before the weekly course started, measuring the habit to attend exactly this course would not have made sense.

Weekly short questionnaire

Attendance. The weekly attendance of each participant was recorded by a student assistant who attended every session (1 = present, 0 = absent, or missing when class did not take place). As a measure for frequency of behavior, we built a variable that indicated number of prior class attendance for every week. That is, for someone who attended the class for the second time, the variable "frequency of attendance" had a value of 1. We also coded the length of the interval until an individual attended the class again, with the unit of measurement being the opportunities to participate (since there were instances where a class did not take place for 1 week). For someone who came back regularly the next time, the length of time was coded 1, for someone who missed one opportunity before they came back, the length was coded as 2, and so on.

Affective state. Current affective states were measured by two items based on Russell's affect circumplex model (Russell, 1980). According to the model, two dimensions of affect need to be distinguished, namely affective valence and energetic arousal. Affective valence was measured through the Feeling Scale (Hardy & Rejeski, 1989). The question "How do you feel at this moment?" was answered on a scale of 1 (very bad) to 10 (very good). In the original version, response options range from -5 to 5, but we modified it to range from 1 to 10 to better align with other scales used in this research. Energetic arousal was measured by the Felt Arousal Scale (Svebak & Murgatroyd, 1985). The item read "How aroused do you feel at this moment?" and was answered on a 10-point scale of 1 (extremely tired) to 10 (extremely energized). According to Backhouse et al. (2007), the two scales have been widely applied and showed both satisfactory convergent and discriminant validity. Additionally, as further predictor of positive affect the

increase in affective valence from the start to the end of the class (valence end minus valence start) was used. Positive values reflect an increase in valence during the class.

Automaticity. On a weekly basis, automaticity was measured at the beginning of the class. Participants were asked to rate how strongly they agreed with the following statement on a scale of 1 (not at all) to 10 (absolutely): "I arrived at the decision to attend the class today completely automatically (without thinking)." This single automaticity item is based on a similar measure employed by White et al. (2017) and derived from the automaticity subscale of the Self-Report Habit Index (SRHI) (Verplanken & Orbell, 2003; Gardner et al., 2012). This single item has shown adequate content and predictive validity (Verplanken & Orbell, 2003; Gardner et al., 2012), and was therefore chosen in order to keep the weekly questionnaire short for reasons of feasibility. The phrasing of the item is consistent with the concept of instigation (in contrast to execution) habits (Gardner, 2015). The decision to exercise is an important element of exercising behavior (Verplanken & Melkevik, 2008).

Statistical analysis

Data are described as means (*M*) and standard deviations (*SD*) for continuous variables and number (*N*) and percentages *(%)* for categorical variables.

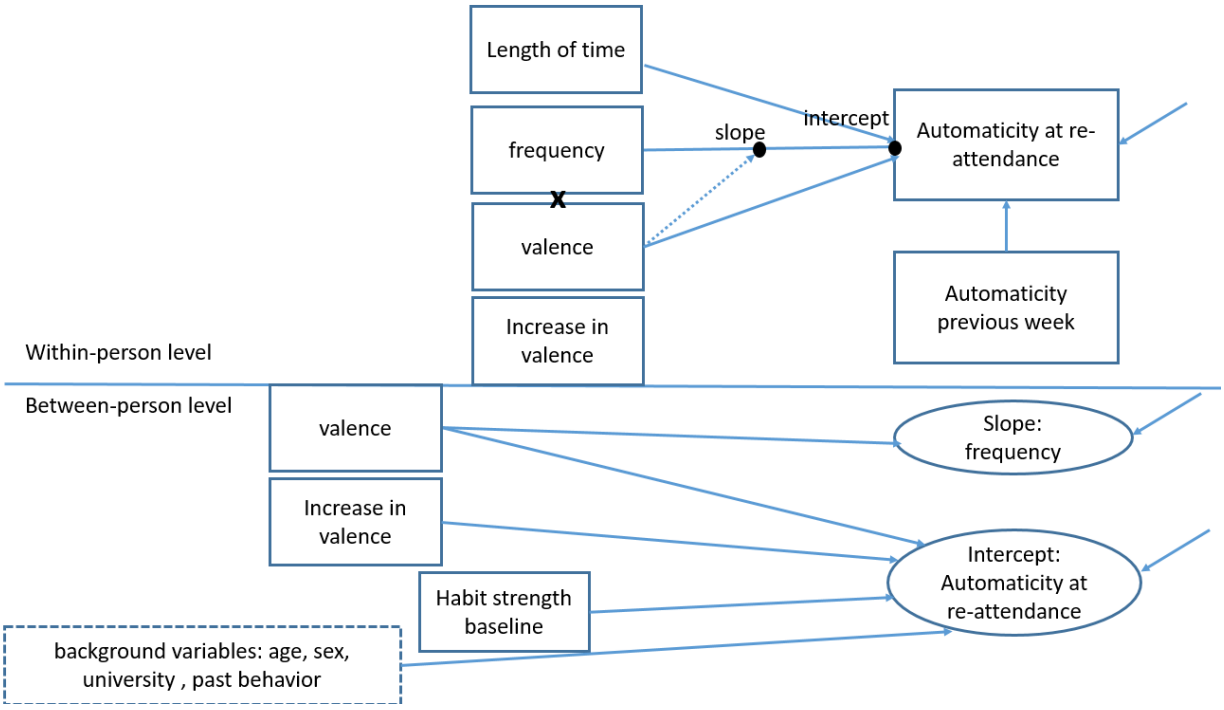
Automaticity at a given participation week was predicted by affective state at the preceding participation in the exercise class. As the weekly data was nested within individuals, we used a two-level modeling approach, employing Mplus version 8 (Muthén & Muthén, 1998-2015).

At the within-person level, automaticity was predicted by preceding affective valence, changes in affective valence during the preceding class, the cumulative frequency of subsequent participation, the length of the period from last attendance at the exercise class as well as the interaction between affect and frequency. Since automaticity was measured at each participation, the preceding automaticity was also included as predictor to adjust for autocorrelation over time.

As a predictor at the between-person level besides affect, baseline habit strength was used to adjust for differences in habit base level. Different sociodemographic measures were tested as predictors and included when meaningful. See Figure 2.2 for the final model with interactions.

Figure 2.2

Final model with interactions



Research shows that positive changes during exercise are relevant for future exercise behavior (Schneider et al., 2009; Rhodes & Kates, 2015), however, contextual limitations lead us to conclude that we were not able to detect those dynamic changes (please refer to section "Discussion"). Due to high correlations of the three items which were completed at different times during the class, we could not include all of them in our model (see Tables 2.1-2.3 for correlations). Rather, we used the measurement at the end of the class as well as the change in affect from beginning to the end as manifest variables in the prediction. Arousal and valence are seen as two orthogonal dimensions in the circumplex model. However, we found that both were highly correlated ($r = 0.714$) and could not be used in the same model because of multicollinearity. We therefore decided to examine both affect dimensions in separate models. However, in line with Barrett (Barrett, 2006), we suppose that valence is the most basic building block of emotional life and, therefore, expect it to have a greater influence on habit formation via motivational processes than energetic arousal, which may rather indicate the intensity of valence. Thus, the results presented here only refer to valence.

Table 2.1

Correlations: within-person level

	SA	PA	AV3	CF	DR	DV
SA	1					
PA	0.292	1				
AV3	0.032	0.073	1			
CF	0.101	0.140	-0.037	1		
DR	-0.074	-0.112	-0.029	-0.080	1	
DV	-0.019	-0.096	0.626	0.033	0.041	1

Note. SA, subsequent automaticity; PA, preceding automaticity; AV3, affective valence (end of class); CF, cumulative frequency of participation; DR, duration until re-attending; DV, difference valence (increase in valence during participation in exercise class). The sample statistics for within and between refer to the maximum-likelihood estimated within and between covariance matrices, respectively.

Table 2.2

Correlations: between-person level

	HB	AGE	SEX	PB	UNI	SA	AV3	DV
HB	1							
AGE	0.158	1						
SEX	-0.151	-0.188	1					
PB	0.435	0.304	-0.149	1				
UNI	0.100	0.220	-0.110	0.253	1			
SA	0.335	-0.101	0.049	-0.030	-0.483	1		
AV3	0.172	-0.094	-0.032	-0.064	-0.329	0.427	1	
DV	-0.029	-0.088	0.112	-0.077	-0.267	0.053	0.400	1

Note. HB, habit strength baseline (SRHI); PB, past behavior (regular exercising in months); UNI, University (1 vs. 2); SA, subsequent automaticity; AV3, affective valence (end of class); DV, difference valence (increase in valence during participation in exercise class). The sample statistics for within and between refer to the maximum-likelihood estimated within and between covariance matrices, respectively.

Table 2.3

Correlations: descriptive statistics of overall sample

	HB	AGE	PB	SA	PA	AV1	AV2	AV3	AR1	AR2	AR3	CF	DR	DV
HB	1													
AGE	0.151	1												
PB	0.447	0.315	1											
SA	0.203	-0.053	-0.017	1										
PA	0.167	-0.043	-0.042	0.550	1									
AV1	0.081	0.020	0.030	0.210	0.251	1								
AV2	0.139	0.029	0.005	0.185	0.227	0.510	1							
AV3	0.054	-0.033	-0.019	0.185	0.196	0.370	0.625	1						
AR1	0.103	0.046	0.043	0.239	0.266	0.712	0.399	0.270	1					
AR2	0.131	0.016	-0.003	0.185	0.212	0.454	0.727	0.559	0.447	1				
AR3	0.061	0.002	-0.022	0.163	0.218	0.269	0.509	0.715	0.251	0.630	1			
CF	0.069	0.096	0.027	0.073	0.141	-0.100	-0.093	-0.080	0.034	-0.101	-0.017	1		
DR	-0.055	-0.046	-0.030	-0.090	-0.113	-0.068	-0.017	-0.035	-0.054	-0.029	-0.020	-0.080	1	
DV	-0.026	-0.047	-0.044	-0.029	-0.056	-0.582	0.085	0.540	-0.409	0.078	0.382	0.020	0.031	1

Note. HB, habit strength baseline (SRHI); PB, past behavior (regular exercising in months); SA, subsequent automaticity; PA, preceding automaticity; AV1-3, affective valence (three measurement time points); AR1-3, arousal (three measurement time points);); CF, cumulative frequency of participation; DR, duration until re-attending; DV, difference valence (increase in valence during participation in exercise class).

Valence was used as a predictor at the within- as well as the between-person level. To this end the variable is decomposed into two latent components: At the between-person level a between covariance matrix is used where the variation between persons is captured by subtracting the overall mean from the latent person mean (grand mean centering). At the within-person level, a pooled within covariance matrix is used where the indicators are implicitly group mean centered. That is, the between component of a person is subtracted from the value at a given occasion.

We excluded those observations where no information on automaticity at the beginning of the class and no information on valence at the end of the preceding class were available. Other missing values were estimated implicitly using the full information maximum likelihood approach implemented in MPlus. Furthermore, we only included data from participants if one participation week was followed by re-attending the class, so that automaticity at the following participation could be predicted.

Results

Descriptive statistics

After the exclusion of missing observations, the final sample consisted of 1082 observations from 226 individuals. 64.2 % of the sample were females, 87.9 % were students (percentage of valid answers, 44 were missing), 46 % were from university 1, 54 % from university 2, and the mean age was 24.46 (*SD* = 5.25) years.

On average, each individual participated 6.8 times (range, 2-13). The intra-class correlation for automaticity was 0.360, that is about 36 % of variation was between persons. See Table 2.4 for descriptive statistics.

Table 2.4

Descriptive statistics

Variable	*N*	*Mean (SD)*	*Min - Max*	*Median*
Measured between-persons (time invariant)				
Habit strength baseline	209	4.092 (1.401)	1.00-7.00	4.11
Past exercising (in months)	203	87.394 (94.914)	0-384	36
Measured within-person (time-varying, *N* is overall number of observations)				
Automaticity (at subsequent participation)	1082	6.893 (2.941)	1.00-10.00	8.00
Automaticity (at preceding participation)	1076	6.573 (3.127)	1.00-10.00	8.00
Frequency of behavior (accumulated number of attended classes)	1082	2.987 (2.640)	1.00-12.00	2.00
Duration until re-attending (opportunities, generally equals weeks)	1082	1.471 (1.048)	1.00-12.00	2.00
Increase in valence from beginning to end of class	1045	0.917 (1.850)	-6.00-9.00	1.00
Valence (at end of class session)	1082	7.679 (1.629)	1.00-10.00	8.00
Arousal (at end of class)	1055	7.317 (1.862)	1.00-10.00	8.00

Note. Overall, 1082 observations from 226 persons were included. Number of observations for individual variables differs due to missing values.

Prediction of automaticity

The candidate models for the prediction of automaticity at subsequent participation were tested in a stepwise manner. We first analyzed if age, sex, past behavior, and university predicted

automaticity and, therefore, should be included as confounders. The only variable with a significant effect was university: the automaticity value from the university 2 subsample was estimated 1.520 points lower on average than at university 1 ($p < 0.0001$). All other potential confounders were not significant and thus not included in the final models. The variable university, however, distorted the model. We tested interaction effects with the other predictors of relevance. None of these interactions were approaching significance. We therefore decided to also exclude university as a predictor in favor of a more precise estimation. A model with age, sex, past behavior, and university had larger BIC (31632.3) and AIC (31402.9) values than the model without these background variables. Hence, we proceeded with the more parsimonious models without the tested background variables.

As described before, we restricted our models on valence as affective state variable, since including arousal caused multicollinearity and large standard errors. The separate model for arousal (not shown) achieved essentially the same results as the separate model for valence which is presented here.

The results of SEM models are shown in Table 2.5. We first tested the model with main effects only and then entered the interactions between number of sessions attended before (frequency) with valence on both the within- and the between-person level.

As can be seen in the right columns of Table 2.5, the interactions between cumulative frequency of participation with valence were not significant, neither at the within-person nor the between-person level. Both models did not differ in terms of a chi-square difference test [χ^2 (4) = 0.69, n.s.], but AIC and BIC values preferred the model with only the main effects. Although the estimated coefficients of both models were very similar, we focus on the results of the main effect model.

On the within-person level, automaticity was only predicted by preceding automaticity. None of the other predictors were significant. On the between-person level, we found automaticity to be predicted by baseline habit strength, preceding valence, and the change in valence during the preceding class.

Table 2.5

Results of the prediction model for valence

	Model with main effects			Model with interactions		
	Coeff.	***SE***	***p*-value**	**Coeff.**	***SE***	***p*-value**
Within-person level fixed effects (weekly fluctuations)						
Automaticity previous attendance	0.229	0.053	<0.001	0.210	0.069	0.002
Duration until re-attendance	-0.084	0.080	0.294	-0.085	0.081	0.292
Frequency of attendance before	0.038	0.028	0.169	-0.039	0.177	0.825
Valence end of class	0.028	0.083	0.733	-0.003	0.108	0.978
Increase in valence during class	0.018	0.063	0.778	0.022	0.065	0.740
Valence × frequency	/	/	/	0.011	0.023	0.629
Between-person level fixed effects						
Habit strength baseline	0.298	0.090	0.001	0.303	0.091	0.001
Valence end of class	0.623	0.195	0.001	0.639	0.229	0.005
Increase in valence during class	-0.367	0.181	0.042	-0.376	0.189	0.047
Cross-level interaction: Valence x frequency (slope)	/	/	/	-0.009	0.039	0.819
Random effects (variances)						
Residual variance automaticity within	4.438	0.408	<0.001	4.316	0.414	<0.001
Residual variance automaticity between	1.747	0.454	<0.001	2.019	0.773	0.009
Slope frequency	/	/	/	0.014	0.034	0.671

Model fit information		
LL	-13499.424	-13499.027
AIC	27058.849	27066.053
BIC	27208.446	27235.597

Note. Results from Mplus 8 using full information maximum likelihood estimation for cases with missing values. N = 1082 observations from 226 persons, results of maximum likelihood estimation with robust standard errors. *SE*, standard error; LL, Log-likelihood; AIC, Akaike's information criterion; BIC, Bayes information criterion.

Prediction of automaticity by behavior frequency

Cumulative frequency of prior class attendance as a measure of behavior repetition was not associated with an enhanced automaticity of the decision to re-attend the class (as indicator of habit strength).

There was a significant correlation between frequency and preceding automaticity (regression coefficient for frequency = 0.157, $p < 0.001$). In a model without preceding automaticity, frequency was significantly associated with subsequent automaticity (coefficient = 0.077, $p = 0.026$) although the effect was also small (overall model results not shown).

Prediction of automaticity by affective states (valence)

There was no association between valence and enhanced subsequent automaticity at the within-person level. This indicates that there was no change in automaticity for an individual after weeks where valence was especially high compared to other weeks. The same was true for an increase in valence during the preceding class, which also showed a non-significant effect on subsequent automaticity. However, significant associations were found at the between-person level. Individuals with a higher average valence (higher mean values over the weeks when participating in class) had higher automaticity values than those with lower mean valence, with a one-point higher mean valence score associated with a 0.62 point increase in automaticity (both measured on the same scale, $p = 0.001$). This effect was present after accounting for baseline habit

strength as well as preceding automaticity. In terms of changes in valence during the class, our result pointed to persons with a higher average increase in valence during class, showing smaller automaticity values when re-attending (per one-point-increase expected automaticity went down by 0.37, $p < 0.05$).

Prediction of automaticity through the interaction of frequency and valence

There was no moderating effect of affect on the relationship between behavioral repetition and automaticity, as indicated by non-significant effects in the model with interactions on either level (Table 2.5). Neither was the association between behavioral frequency with automaticity strengthened after weeks when valence was higher, nor was this expectation approved between persons, that is, persons with higher average valence over the term did not show larger associations between behavioral frequency and subsequent automaticity.

Discussion

The purpose of this study was to examine the role of affective states and behavior frequency in the formation of real-world exercise instigation habits among adults. Overall, it could be shown that positive affect was significantly associated with subsequent automaticity, whereas behavior frequency did not significantly predict subsequent automaticity, and that affect did not significantly moderate the relationship between behavior frequency and automaticity.

With regard to our first hypothesis that behavior repetition will enhance automaticity, we did not observe a significant effect of frequency on automaticity. Two aspects need to be critically mentioned here. First, behavior frequency was rather low as participants attended the class on average only seven times (range 2-13). How long it takes to establish a habit is discussed in the literature (Walter, 2018; Hagger, 2019). In line with this discussion it is possible that in our study, behavior repetition did not occur often enough to enhance automaticity. Second, despite the non-significant prediction of automaticity, there was a significant correlation between frequency and preceding automaticity (about twice as large as with predicted automaticity at the within level), which might point to preceding automaticity masking the effect of frequency. In a model without preceding automaticity, frequency was significantly associated with subsequent automaticity although the effect was also small. Furthermore, in the model presented here, there was a minimal increase in the expected direction, i.e., for each exercise class visited, the resulting automaticity

increased slightly. Additionally, we found the duration until re-attendance to be slightly negatively associated with automaticity. These tendencies are in line with other findings that support the role of behavior frequency for the formation of habits. One study that explored habit formation in a real-world setting found that repeating a behavior in a stable context increases automaticity (Lally et al., 2010). An asymptotic model best reflected the process of habit formation for 62 out of 82 individuals, and those study participants for whom this model provided a poor fit had shown lower behavior frequency during the time of the study. The finding that repeating a behavior leads to greater automaticity scores is also in line with the habit theory that suggests that habits are developed through the strengthening of a cue-behavior relationship (Verplanken, 2006; Gardner & Lally, 2018). Therefore, this cue-behavior association needs to be encountered at all which requires the enactment of a behavior when confronted with the cue and, in order to gain a degree of automaticity, needs to be repeated.

The second hypothesis stated that positive affect will enhance automaticity. Significant relationships were found for affective valence on the between-person level, but not on the within-person level. The non-significant effect on the within-level indicates that after weeks in which the valence score of a person at the end of class or the increase of affective valence during class was higher than usual for this person, there was no increase in the resulting automaticity. However, we found two significant effects on the between-person level and thereby added new insights on the role of affective states on automaticity development to the literature. First, for affective valence at the end of the class, the effect on the between-person level suggests that people who on average reported higher values in valence at the end of the class also had higher automaticity scores. One explanation for this is that individuals repeated the behavior more often because of the positive affect they associated with it and therefore built stronger habits. Theoretically, this assumption is supported by psychological hedonism of the past which states that formerly rewarded behavior is repeated more often in the future (Insko & Schopler, 1972). In their review, Ekkekakis and Dafermos (2012) concluded that affective responses to exercise, although measured in various ways due to methodological diversity, in fact predict subsequent exercise behavior. One study measured affective valence during and immediately following a brief treadmill walk at two time points (six months apart) and found that affect reported during the walk was cross-sectionally and longitudinally associated with physical activity (Williams et al., 2012). Another study found that the relationship between intrinsic exercise rewards (such as enjoyment)

and exercise behavior can be explained differently depending on the stage of adoption (Phillips et al., 2016). For initiators, this relationship was mediated by intentions, whereas it was mediated by habit strength for longer term exercisers (maintainers). Given that the participants in this study were unexperienced in terms of the specific instigation behavior, it is possible that positive affect strengthened their intentions to attend the course again.

Due to the non-significant effect of frequency on automaticity, however, we cannot confirm that affect influences habit strength via behavior frequency. Therefore, other explanations are also possible, one of them being the possibility of a direct influence of affect on habit formation independent of behavior repetition and another one being methodological artifacts. We measured the two implicit constructs automaticity and affect on a weekly basis, one after the other, in one questionnaire. Depending on the answer a participant gave to the question of automaticity, they may have drawn conclusions about their affect, similar to what Gardner and Lally (2013, p. 494) call "a post hoc self-perception process." So possibly, habitual exercisers inferred positive affect from their habitual behavior whereas non-habitual exercisers reported no or less positive affect.

Second, for the increase in affective valence during class, the effect on the between-level suggests that people who had a higher increase in valence had lower automaticity scores. Two lines of reasoning lead us to conclude that this result should not be over-interpreted. First, it was impossible to measure affective states multiple times during the exercise class as this would have meant a serious disruption of the flow of participants. We conclude that we were not able to detect dynamic changes in affect during exercise – although being aware that it would be desirable for future research (for recommendations regarding the timing of affect assessment see Ekkekakis et al., 2020). The affect assessment at the end of the class and the difference variable (after minus before) might therefore not reveal the true and differentiated affective response. However, one study also showed the tendency of affective responses after a hard-intensity task to be positively associated with future participation (Schneider et al., 2009). It should be investigated whether dynamic changes in the affective response during exercise influence habit formation. Second, further methodological concerns should be mentioned. That is, the affective state at the beginning of the class can be based on various reasons, while the state at the end of the class may more exclusively refer to the sports class itself. Subtracting these values from each other can therefore

be problematic, and potential solutions discussed in the literature include a direct comparison operationalization (Peter et al., 1993), e.g., an item that directly asks for affective change.

The third hypothesis stated that positive affect may moderate the relationship between behavior frequency and automaticity. No significant moderation effects could be found, neither on the between-level nor on the within-level, and neither for affective valence at the end of the class nor for the increase of affective valence during class. These findings suggest that the relationship between frequency and automaticity does not differ depending on the degree of valence. In light of the above mentioned non-significant effect of affect on automaticity on the within-level and this non-significant moderation effect, our findings contradict parts of the assumptions of the Associative-Cybernetic Model (de Wit & Dickinson, 2009). The model suggests that there are two ways a reward can have an impact on habits. First, a reward should strengthen habits mediated by behavior repetition. Second, a reward should moderate the relationship between behavior repetition and habit. This could not be shown in our study. We speculate that this is because our study measured affective states per se, a mental but not cognitive or reflective phenomenon (Russell, 2003), while other studies that reported a moderation effect operationalized intrinsic rewards as cognitive constructs. For example, one study that confirmed the Associative-Cybernetic Model for fruit and vegetable consumption assessed intrinsic rewards by directly asking the participants whether the consumption was rewarding (Wiedemann et al., 2014). Gardner and Lally (2013) found that prior action was a stronger predictor of habit strength among participants who were of the self-determined motivational regulation type and showed autonomous motivation such as intrinsic interest. In line with our hypothesis on the moderation effect, they speculate that the enjoyment of intrinsically motivated PA may reinforce the past behavior-habit strength relationship. However, they did not measure enjoyment or any implicit constructs.

Strength, limitations, and future directions

One strength of this study is the weekly measurement of exercise class attendance over a period of three months in a relatively large sample. In order to understand habit formation, cross-sectional studies or observations for only a few weeks or at insufficient time points seem to be less appropriate. Further, the longitudinal design allowed us to explore the effects on a between- and within-subject level. Future studies should investigate the relationship between affective

states, habit formation, and exercise maintenance by continuous measurement over an even longer period of time than in the present study. This would allow for examining the effects of affective states and habits on long-term adherence. Moreover, exercise class attendance was measured quasi-objectively by weekly observation of attendance so that we can rule out systematic bias of subjective measures of PA (Jekauc et al., 2014). The fact that we measured affective states rather than affective attitudes, affective judgments or anticipated affective responses which are not affective states per se (Ekkekakis et al., 2018) is also one of the several merits of this study. If one assumes that affect is not a cognitive or reflective sensation (Russell, 2003), it is not necessary to measure it as a cognitive construct: By asking participants to reflect about their affective attitudes or judgments, however, the answer is the result of cognitive operations (Ekkekakis et al., 2018). Applying the Feeling Scale (Hardy & Rejeski, 1989) and Felt Arousal Scale (Svebak & Murgatroyd, 1985), we are coming closer to measuring affective states per se and thereby extend the literature on the role of affect.

This study was an observational one which cannot prove causality, although future events were predicted from preceding ones. A potential shortcoming of the present study is the rather high percentage of missing values. Since we only collected data from those individuals who attended the class, there is no information about the reasons for the absence of the missing participants. Therefore, we do not know whether the missing is random, due to a lack of habit formation or other reasons. One promising approach to gather information about reasons for a dropout are real-time analyses and feedback from wearables (Ebner-Priemer et al., 2019). However, it is possible that the lack of motivation to attend the exercise course is associated with the lack of motivation to participate in the study.

Furthermore, the two weeks Christmas holidays in the middle of the semester led to a break, which is another limitation. As habits form due to repeated performance in stable contexts (Aarts & Dijksterhuis, 2000; Wood & Neal, 2007), the break might have represented an interruption in habit formation. Again, no data is available of the participants during the break. However, we found no indication of a drop in automaticity after this break.

Another, rather controversial limitation lies in the methodology for measuring habits. In this study, baseline habit and weekly automaticity scores were measured by self-report. Whether it interrupts or hinders the formation of habits when weekly questions are asked about the

automaticity of a process that is actually supposed to be no longer reflective, can be questioned critically. Also, some scientists have reported that subjective insights into unconscious processes may be lacking precision (Hagger et al., 2015) and some found comprehension and recall problems in participants' responses to self-report habit measures (Gardner & Tang, 2014). Others, however, argue that individuals are able to reflect on automatically occurring behaviors and can interfere habit from its salient consequences, the habitual behavior that they show, although they were not thinking about it (Verplanken & Orbell, 2003; Sniehotta & Presseau, 2012). Alternative measures of automaticity need to be developed in future research with a special focus on their feasibility in long-term studies.

Another limitation concerning the methods are the single-item scales used in this study to measure automaticity, affective valence, and arousal. Given that valence and arousal turned out to be strongly correlated, it must be critically noted that the scales were not appropriate for differentiating between the two dimensions that are actually considered orthogonal in the circumplex model (Russell, 1980). One explanation for this could be that we failed to explain the not very intuitive concept of arousal to the participants and, in particular, to describe its difference to valence (Ekkekakis & Petruzzello, 2002). Ekkekakis and Petruzzello (2002) note that exercise is able to change perceived activation and that these changes can lead to either positive or negative valence making it necessary to distinguish between the two dimensions of affect. However, since we were not interested in a differentiated pattern of affect as a dependent variable, but in this study focused on affect as a determinant of habit formation, the lack of specification appears to be negligible. Weighing the pros and cons of single-item measures, Ekkekakis and Petruzzello (2002) further mention that they pose a risk of random measurement error. However, important to our study was the assumption that given their compactness they do not induce reactivity to weekly testing.

Regarding the measure for past exercise behavior used in this study, it can be critically mentioned that the definition of exercise given in the questionnaire was rather wide compared to the definition by Caspersen et al. (1985), which contains, different from our definition, the planned, structured, and repetitive nature of exercise.

Implications

According to Gardner and Lally's (2018) model of habit formation, individuals first need to form an intention when deciding to act; second, they need to initiate the action which requires mobilization of self-regulatory resources; third, they need to repeat the behavior for the strengthening of cue–response associations. In the present study, we focused on behavior repetition and affect as determinants of habit formation.

Thus, the future research and practical implications that can be derived from this study and the literature that emphasizes the role of behavior repetition can be divided into two areas: Exercise promotion interventions and practitioners should design and implement interventions that result in (a) behavior repetition, and (b) a positive affective response to exercise. We suppose that the latter leads to behavior repetition.

However, other important aspects of behavior maintenance include skills required to translate intentions into action, such as inclusion of self-monitoring in combination with other self-regulatory techniques, e.g., specific goal setting (Michie et al., 2009). In order to attain a goal, implementation intentions have been proven to have had a positive effect (Gollwitzer & Sheeran, 2006). Future studies should explore how to best design an exercise program that elicits regular positive affective responses in the participating individuals, as this is still one of the major challenges in this field. One possibility is to focus on the role of teachers or coaches for the development of positive affect of exercise class participants. The manipulation or education of teachers' feedback (Leisterer & Jekauc, 2019), their leadership style (Raedeke et al., 2007), and their social-emotional skills (Strauch et al., 2018) are promising approaches. One study found four facilitators of positive emotional experiences of sport and exercise participants: perceived competence, perceived social interaction, novelty experience, and perceived physical exertion (Wienke & Jekauc, 2016). Furthermore, in one study, enjoyment after a theory-based "novel" physical education lesson that included evidence-based modifications, such as music, was higher than after a "traditional" physical education lesson, despite no significant differences in amount and intensity of PA components (Vazou et al., 2019). Future studies should investigate the relationship between affective states, behavior frequency, and habit formation by other measurements than self-reports and over a longer period of time, to explore the role of habits in long-term behavior maintenance. Since there is no such thing as a global physical activity habit

(Gardner et al., 2020), this study focused on automaticity as an indicator of instigation habits. However, deeper understanding on the different habitual behavior sequences and their interplay with intention or other cognitive and automatic constructs is needed to progress further to a theory of habit that is still missing in the field.

Conclusion

In conclusion, the present work discusses the importance of affective valence and behavior repetition in the formation of instigation habits in exercise contexts. Thus, interventions designed to encourage long-term behavior maintenance via habit formation processes, which are required for achieving sustainable health benefits, should try to elicit positive affective responses.

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Chapter III – Intervention effectiveness

Study 2: Investigating the relation between positive affective responses and exercise instigation habits in an affect-based intervention for exercise trainers: A longitudinal field study

Slightly modified version of the published manuscript:

Weyland, S., Fritsch, J., Feil, K., & Jekauc, D. (2022). Investigating the relation between positive affective responses and exercise instigation habits in an affect-based intervention for exercise trainers: A longitudinal field study. *Frontiers in Psychology, 13*, 994177. https://doi.org/10.3389/fpsyg.2022.994177

Abstract

The present study contains an affect-based intervention intended to support exercise trainers in positively influencing their course participants' affective responses to their exercise courses. We argue that positive affective responses are associated with habit formation, thereby being a promising approach for avoiding high drop-out rates in exercise courses. First, the present study aimed to investigate whether the intervention for exercise trainers could increase (a) affective attitudes, and (b) exercise instigation habit strength, and influence the development of (c) weekly measured affective responses and (d) automaticity among adult participants of exercise courses. Second, it examined the relationship between the development of affective responses and exercise instigation habit strength. Ten exercise trainers of weekly sports and exercise courses at a German university received either an affect-based intervention or a control intervention. 132 of their course participants answered the Self-Report Habit Index (SRHI; the automaticity sub-scale SRBAI was also analyzed) for exercise instigation habit strength and items to measure affective attitude in the initial and final assessment. Moreover, they were assessed for a duration of 10 weeks during which, each time after attending the course, they reported their affective response to exercise as well as their automaticity in arriving at the decision to exercise. In the repeated measures ANOVA, there was a significant main effect of time for exercise instigation habit strength. Overall, habit strength was higher in the final than in the initial assessment. However, there were no significant differences between the two conditions in all study variables. In the latent growth curve model, the trajectory of the latent growth curve of valence was a significant predictor of the final exercise instigation habit strength. While the applied affect-based

intervention was not successful in enhancing positive affective responses to exercise, the results indicate that positive affective responses may contribute to strengthening exercise instigation habits. Future studies should examine the effectiveness of interventions in long-term study designs.

Introduction

Physical activity (PA) is good for you: more precisely, preventive health benefits, e.g., a 20-30 % risk reduction for about 25 chronical diseases, derive from regular PA (Powell et al., 2011; Rhodes et al., 2017). Most adults are aware of exercise recommendations, with 68 % of one study's American respondents correctly identifying specific PA guidelines (Morrow et al., 2004). Accordingly, in a recent study following German voluntary university sports and exercise courses for 13 weeks, the means of the weekly intention to re-attend the course next time were constantly at around 9, on a scale from 1 to 10, where 10 corresponded to the strongest intention (Finne et al., 2019). However, it turned out that after the courses' fourth week, not even half of the initial participants were present. Thus, the research interest on what constructs might bridge this intention-behavior gap in the long run and increase exercise course re-attendance rates arises (for a meta-analysis quantifying the intention-behavior gap in a PA context, see Rhodes & de Bruijn, 2013). The model of physical activity adoption and maintenance (PAAM model, Strobach et al., 2020), which is a dual-process model, assumes that particularly for behavior maintenance it is important to also take affective and automatic processes into account.

The affective response to PA is an affective state, which refers to how an individual feels in response to acute PA (Stevens et al., 2020). The hedonic principle assumes that people seek pleasure and avoid displeasure (e.g., Williams, 2008), which is supported by numerous empirical findings that a positive affective response during PA is positively related to future PA (Rhodes & Kates, 2015; Williams et al., 2016). According to the Affective-Reflective Theory of physical inactivity and exercise (ART, Brand & Ekkekakis, 2018), which is a dual-process model, affective responses can influence exercise behavior in two ways. First, through an automatic affective valuation, the impact can be direct, leading to an action impulse (type-1 process). Second, affective responses can have an indirect impact in that they influence deliberative reasoning, resulting in action plans (type-2 process). In their recent narrative review, Stevens et al. (2020) refer to the cognitive processing of experienced affective responses as "affect processing" (see

also Williams & Evans, 2014). Accordingly, unlike affective responses, affect processing does not represent acute affect per se and can be invoked and measured outside the very situation of the target behavior. An example for affect processing is the affective attitude. Concerning the relationship between affective responses per se and affective attitudes, Stevens et al. (2020) argue that an affective attitude is theoretically formed after remembering the actual affective response first and then anticipating a future affective response. Accordingly, the affective attitude is per definition based on both probability and individual importance of affective outcomes. A meta-analysis has shown that affective judgements, to which, according to Stevens et al. (2020), the affective attitude belongs, are positively related to PA (overall $r = 0.42$) in adult samples (Rhodes et al., 2009). Therefore, in this study, the focus lies on implicit affective responses and explicit affective attitudes, which are influenced by affective responses.

There are several approaches on how to manipulate affect-based constructs through interventions (for an overview see Conner et al., 2020; Chen et al., 2021). With regards to the potential content of interventions targeting affective responses, the qualitative study of Wienke and Jekauc (2016) identified four facilitators of positive affective responses in exercise, namely perceived competence, perceived social interaction, novelty experience, and perceived physical exertion. These four facilitators were also found to be related to positive affective responses in other studies. Leisterer and Jekauc (2019) showed in two separate studies that positive competence-based performance feedback and the experience of partner exercises were positively related to positive affective responses. Further, perceived variety was found to be positively related to indices of exercise-related well-being (i.e., positive affect; Sylvester et al., 2016). Also, several studies exist that link self-selected exercise intensity to positive affective responses (for a review see Ekkekakis et al., 2011). A resource-saving approach that seems feasible in a university sports context could be to educate exercise trainers on how to elicit positive affective responses in course participants based on the identified facilitators. One intervention conducted by Jekauc (2015) educated exercise trainers on promoting positive affective responses in their course participants based on, amongst other things, autonomy (e.g., self-selected intensity and exercises), competence (e.g., giving positive feedback), and relatedness (e.g., choosing group exercises over single exercises). While enjoyment as an indicator of positive affective responses decreased in the control group during the first four weeks, it increased in the intervention group. The results in two studies by Strauch and colleagues (Strauch et al., 2018, 2019) suggest that an exercise trainer's

personal appearance and interactions with course participants have a major impact on course participants' affective responses. They found that the ability to manage one's own emotional expression is part of the coach competences that together lead to the generation of positive affective responses in participants of sport and exercise programs. This might be explained by the phenomenon of emotional contagion (Hatfield et al., 2014). These results reinforce the idea of a trainer-focused intervention, and also suggest a concrete way to manipulate affective responses, namely through the exercise trainer's emotional expressions themselves and not just through their behavior.

The other implicit construct on which this study focuses is habit. Habit is defined by Gardner and Lally (2018, p. 207) as "a process whereby encountering a cue triggers an impulse to perform an action that has, through learning, become a learned response to the cue." Orbell and Verplanken (2020) outline three basic components of habit, namely the repetition of a behavior as response to a consistent cue, the development of mental cue-behavior associations, and the resulting cue-dependent automaticity. Automaticity means performing a behavior, for example, without thinking and without having to consciously remember it (Gardner et al., 2012). The more global construct of habit measured by the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) includes frequency and relevance to one's self-identity in addition to automaticity. Automaticity can be understood as a key characteristic of habitual behavior and refers to the moment of the specific behavior. The frequency of a behavior is rather to be seen as a determinant of habit and self-identity might be a consequence (see also the reflection on the SRHI by Sniehotta & Presseau, 2012), which gives the construct habit measured by the SRHI a different degree of specification.

If a cue triggers the initiation of a behavior out of other alternative behavioral possibilities, it is called instigation habit, whereas triggering sub-behaviors within a given behavioral sequence is called execution habit (Gardner et al., 2020b). One study concluded that building instigation rather than execution habits is related to changes in future exercise frequency (Phillips & Gardner, 2016). Positive correlations between habit strength and PA were also revealed in a current systematic review, which included longitudinal studies (Feil et al., 2021). Given the assumption that a behavior is automatically triggered by a cue, habit might contribute to exercise maintenance

in that it bridges fluctuations in motivation and helps maintain the behavior even when rewards are removed (Neal et al., 2011; Rebar et al., 2019).

Since cue-behavior associations characterize habits, habit formation theoretically requires cue-consistent repetitions of a behavior (Gardner et al., 2020a). According to Gardner and Lally (2018), variables influencing the habit formation process can at first support individuals in building the intention to perform the behavior. Also, they can help initiating and maintaining the behavior under constant conditions. Moreover, they can act as moderators of the repetition-habit relation and thereby influence the developing mental cue-behavior association. The latter is all the more important since research shows that habit strength forms at different rates, despite an equal number of repetitions (Lally et al., 2010).

Linking habit to affect, a behavior might be repeated more often if accompanied by positive affect. This can be theoretically justified by the "law of effect," according to which responses to a situation that entail satisfaction are more likely to occur again in that same situation (Thorndike, 1911). Also, it can be argued that the relation between the mere repetition of a behavior and habit strength can be moderated by rewards (de Wit & Dickinson, 2009; Lally & Gardner, 2013). Accordingly, there is research suggesting that the cue-behavior association characteristic of habits might be strengthened through repetition, and each repetition might contribute more to habit formation when perceived as a reward (Wiedemann et al., 2014; Schnauber-Stockmann & Naab, 2019). Wiedemann et al. (2014) view affective constructs, namely satisfaction or pleasure, as examples for intrinsic rewards. A behavior that was accompanied by the experience of a positive affective response may be triggered impulsively in the next moment of decision making because the automatic affective valuation is positively valenced and no restraining forces counteract it, as can be argued with the ART (Brand & Ekkekakis, 2018). This type-1 process is fast and automatic, actually reflecting the idea of instigation habits, where a behavior is instigated before the individual realizes it, i.e., before type-2 processes have followed. Radel et al. (2017) found that self-determined motivations (e.g., intrinsic motivation) were stronger related to behavioral automaticity than non-self-determined motivations (e.g., extrinsic motivation) and that self-determination moderated the relationship between repetition of a behavior and behavioral automaticity. The authors explain their findings with the affective states associated with the different motivations, suggesting that positive

affective states might be related to intrinsic motivation. They argue that positive affective states lead the individual to rely on automatic processes which would not be equally the case had negative affective states been associated. Further, although theoretically unexpected, motivational or rewarding variables were found to directly predict habit formation of health behaviors independently of repetition: Gardner and Lally (2013) found this direct effect for self-determined motivation, Judah et al. (2013) found it for favorable attitudes, and Weyland et al. (2020) for affective responses. Regarding affective attitude, one cross-sectional study showed a significant positive correlation with exercise habit strength (de Bruijn & Rhodes, 2011). Referring to data from new gym members, Kaushal et al. (2018) found that affective judgement, together with behavioral regulation and preparatory habit (i.e., automatically preparing for exercise), collectively explained mediation between condition (an educative workshop that underlined the importance of self-regulative action planning, consistent use of cues, and rewards vs. control) and change in self-reported PA. Another variable from the affect processing domain is enjoyment, according to Stevens et al. (2020), and enjoyment was also shown in one study to positively predict exercise habit (Teixeira et al., 2022).

Considering the relationship between affective responses, habit, and thus behavior, affect-based interventions might not only lead to more positive affective responses to exercise and consequently to more positive affective attitudes, but also reinforce habit formation. Therefore, the primary objective of the present longitudinal study was to examine the effectiveness of a trainer-focused affect-based intervention to promote affective attitudes and habit strength as well as to influence the development of affective responses and automaticity among adult exercise course participants. The secondary objective was to examine whether the development of affective responses is related to the development of habit strength. In accordance with the primary objective, we hypothesized that a trainer-focused intervention, focusing on the induction of positive affective responses in exercise course participants (affect condition) compared to a trainer-focused intervention with a purely physiological content (control condition), would result (1a) in more positive affective attitudes towards exercise, and (1b) in higher exercise instigation habit strength. Further, we hypothesized that the intervention would influence the development of (1c) positive affective responses to exercise, and of (1d) automaticity among course participants. Moreover, regarding the secondary objective of the study, we hypothesized that the development

of positive affective responses to exercise is positively related (2) to the development of habit strength in the overall adult sample.

Materials and methods

Participants

Over the course of 10 weeks, data were collected from weekly sports and exercise courses offered by the department of university sports to all students and employees of one German university during the winter semester. The 10 selected sports and exercise courses covered basketball, yoga, badminton, table tennis, field hockey, and volleyball. Participants in the study from whom the questionnaire data were collected were participants of these courses who volunteered to participate in the study and provided written informed consent. Eligible participants of the exercise trainers' courses had to be at least 18 years old, feel physically healthy, and understand German. From those present in the first week of the study, 135 students and employees agreed to participate in the study (100 male, 33 female, 2 missing; mean age 22.30 years; 129 students, 4 employees, 2 missing). Sixty-six were in the affect condition, and 69 in the control condition. The study was approved by the university's data security commissioner and ethics committee.

Procedures

The exercise trainers were recruited via email after having consulted their head of university sports of their German university. This email informed them that the purpose of the study was to test the effectiveness of trainer-focused interventions in reducing drop-out rates in university sports and exercise courses and that participation would be voluntary. Participation in the intervention, for which individual appointments were made with the exercise trainers, did not obligate them to also participate in the study. Eligible exercise trainers had to lead courses that (a) were accessible to students and staff, i.e., without special restrictions (e.g., high costs, such as for golf, could influence participation), (b) were not related to official competitions (as competitions were seen as a type of participation obligation), (c) were led by the same exercise trainer every week, and (d) were theoretically eligible for the implementation of the intervention content (e. g., diving courses were excluded). Given the quasi-experimental design of the study, another

prerequisite for participation in the study was that two different exercise trainers instructed the respective courses where two similar courses of the same kind of exercise were offered.

Of the 72 exercise trainers contacted, we received a response from 14 who stated that they were interested in the workshop. For matched randomization, a coin toss, whilst considering "kind of exercise" and "course level" (from beginners to advanced), was used to assign the exercise trainers' courses to affect or control condition. For example, the two different advanced courses and the two different table tennis courses were matched, respectively. In total, 10 exercise trainers met the inclusion criteria and were randomly assigned to either affect (N = 5) or control condition (N = 5). Exercise trainers of these courses were informed and gave their consent, but were not asked to complete any questionnaires. During the first weeks of the winter semester 2019, a one-hour workshop for the affect condition was conducted by the lead investigator, at the same time, a workshop for the control condition was conducted by two sport science students. Exercise trainers were told which condition they were in, but they were blind to the other condition. Since organizational matters are settled in the first sessions of the university exercise courses, and many interested individuals just drop by to have a look, data collection began in the fourth week of the semester. In the first week of data collection, individuals who agreed to participate completed the first questionnaire (initial assessment) and the first of the weekly short questionnaires. During the study, all courses were attended by the study team on a weekly basis to collect data of all attending study participants. In the tenth week of data collection, the final questionnaire (final assessment) was additionally handed out after the course to all available study participants and, in case a person did not attend the course in the tenth week, also one week later.

Affect condition

The affect-based intervention for exercise trainers in the affect condition is based on the findings from Wienke and Jekauc (2016), namely on the four facilitators of positive affective responses in exercise perceived competence, perceived social interaction, novelty experience, and perceived physical exertion. It comprised a one-hour workshop, a summarizing laminated diagram (Supplementary Figure 3.A), an information booklet (Appendix 3.A) and a printed version of a manual for one get-to-know game. In the workshop, the four facilitators were explained, and techniques on how to implement the facilitators were discussed with the exercise trainers. They were not just taught, but it was also listened to their needs in order to take advantage of the benefits

of tailored interventions suggested by the literature, such as a greater personal connection to the intervention material (see for example Kreuter et al., 1999; Kroeze et al., 2006). For example, when educating the exercise trainers on the facilitator social interaction, possible techniques were discussed and a game instruction was handed out as an example of a social support technique. In addition to the four facilitators, we also emphasized that the coaches should try to become aware of their own affective states and emotional expressions. This is based on the finding that the ability to manage one's own emotional expressions leads to the generation of positive affective responses in participants of sport and exercise programs (Strauch et al., 2018, 2019).

Control condition

The intervention for exercise trainers in the control condition was designed to provide a benefit for the participating exercise trainers as well while at the same time not containing any relevant aspects of the affect-based intervention. It comprised a one-hour workshop and an information booklet. The workshop contained topics from current research in training science, such as aspects of warm up and cool down, motor skills as well as variations in coordination training.

Measures

For an overview of measures and assessment times see Supplementary Figure 3.B.

Initial assessment (week 1)

Habit strength (exercise instigation)/Automaticity. We measured exercise instigation habit strength in week 1 with a slightly adapted item stem of the German version of the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003), which was validated in its original version by Thurn et al. (2014). The wording of the item stem was, literally translated, "Going to an exercise course is something…," which was inspired by the English item stem by Phillips and Gardner (2016), who reported face-validity in that the stem rather taps the decision than the execution. Since the exercise courses in this study were just about to start, we did not expect the participants to have already formed an instigation habit and, therefore, asked about exercise courses in general. The item stem was to be answered with 12 responses on a 5-point Likert scale ("strongly disagree" to "strongly agree"). Habit strength was calculated as the mean of the 12 items, whereby a high mean indicated high habit strength. Cronbach's alpha was $\alpha = 0.89$.

Additionally, we calculated the Self-Report Behavioural Automaticity Index (SRBAI). The SRBAI is a four-item automaticity sub-scale of the SRHI (Verplanken & Orbell, 2003), which had previously been validated (Gardner et al., 2012). A high mean of these four items indicated high automaticity. Here, Cronbach's alpha was $\alpha = 0.86$.

Affective attitude. We assessed the affective attitude towards exercising similar to de Bruijn et al. (2014). The item stem was, "Exercising for me is…," and was answered on three 7-point bipolar adjectival scales, ranging from "very unpleasant" to "very pleasant," from "very unenjoyable" to "very enjoyable," and "very stressful" to "very relaxing." A high mean of the three items indicated a more positive affective attitude towards exercising. Cronbach's alpha was $\alpha = 0.78$.

Weekly short assessment (weeks 1–10)

Automaticity. In order to keep the weekly questionnaire short for feasibility, we assessed automaticity as a characteristic of habit strength with one item comprising two item wordings from the Self-Report Behavioural Automaticity Index (SRBAI; Gardner et al., 2012). This one item was: "I went to this exercise course today automatically, without thinking."

Affective valence. To measure affective responses to exercise, we applied a slightly adopted version of the widely used and, according to Backhouse et al. (2007), satisfactorily validated single-item bipolar Feeling Scale (Hardy & Rejeski, 1989) to answer the question, "How do you feel right now?"

While, according to the original versions, SRHI-items should be answered on at least a 5-point Likert scale and the Feeling Scale is an 11-point bipolar scale, that ranges from-5 ("very bad") to 5 ("very good"), similar to Weyland et al. (2020), we modified the response format to bipolar 10-point scales for both weekly measures (ranging from "strongly disagree" to "strongly agree" for the automaticity item and from "extremely bad" to "extremely good" for the Feeling Scale) in order to better align with previous research.

Final assessment (final week)

Habit strength/Automaticity and affective attitude. We assessed habit strength/automaticity and affective attitude just like in the initial assessment (week 1). Cronbach's

alpha was $\alpha = 0.88$ for exercise instigation habit strength, $\alpha = 0.85$ for the automaticity sub-scale, and $\alpha = 0.74$ for affective attitude.

Statistical analysis

According to a meta-analysis by Chen et al. (2020), the expected effect size of a PA intervention targeting affective variables on affective variables is $r = 0.26$. A priori power analysis using G Power 3.1.9.7 indicated that for two repeated measures in a repeated measures ANOVA (within-and between-measures interaction), $N = 72$ participants was sufficient to detect an effect size of 0.20, using a rather conservative estimate, with $p < 0.05$ and power adjusted to 0.80. As a preliminary analysis, we screened the data for missing values and checked their patterns with Little's MCAR test (χ^2; Little, 1988) to decide on how to deal with missing data (Jekauc et al., 2012). Data were missing completely at random (see Appendix 3.B for the results of the analyses of missing values). Thus, we decided that it was appropriate to use the expectation-maximization algorithm for data imputation to avoid list wise deletion in the case of analyses of variance (Dempster et al., 1977) and to use full-information maximum-likelihood estimation in the case of latent growth curve modeling (Arbuckle, 1996; Jekauc et al., 2012). Two-tailed independent sample t-tests and chi-square tests were conducted to check differences between the two conditions (affect versus control) regarding all variables assessed in the initial assessment at week 1 (gender, age, student status, habit strength, and affective attitude).

For the analysis of the primary objective, examining the effects of the affect-based intervention on affective attitudes (Hypothesis 1a) and exercise instigation habit (Hypothesis 1b), two 2 (condition: affect versus control) x 2 (time: initial versus final assessment) repeated measures ANOVAs were conducted, using IBM SPSS 25 (Armonk, NY). Partial eta square was calculated to examine effect sizes. The threshold for significance was 0.05 for all analyses. Analyses of habit strength were conducted primarily with SRHI scores (automaticity, frequency, self-identity). Likewise, the analyses were calculated with the SRBAI values (automaticity only) to see if they differed.

For the analysis of the primary objective, to analyze the effects of the affect-based intervention on the development of the weekly measured variables affective responses to exercise (Hypothesis 1c) and automaticity (Hypothesis 1d), we applied latent growth curve modeling with

IBM SPSS Amos 26 (Arbuckle, 2019), using a structural equation modeling framework. Moreover, for the analysis of the secondary objective, examining the relationship between the development of weekly measured affective responses and the development of habit strength (Hypothesis 2), we also applied latent growth curve modeling. To determine the overall goodness of fit of the models, chi-square statistics (χ^2) are reported with *p*-values larger than 0.05, indicating that the model is fitting (Barrett, 2007). However, to avoid problems due to the small sample size, we additionally applied the comparative fit index (CFI) to evaluate the proposed model based on its relative improvement to the initial model – with values less than 0.90 indicating that the proposed model could still be improved considerably, values between 0.90 and 0.95 indicating acceptable fit, and values greater than 0.95 indicating good fit (Bentler & Bonett, 1980; Hu & Bentler, 1999; Hooper et al., 2008). Further, the root mean square error of approximation (RMSEA) was applied. According to Browne and Cudeck (1993), an RMSEA value of 0.05 or less is considered good and a value between 0.05 and 0.08 is considered acceptable. Moreover, the lower limit of the confidence interval of the RMSEA should be around 0 and the upper limit less than 0.08 in order to indicate a good fit (Hooper et al., 2008).

We first calculated separate models for valence and automaticity, respectively, to assess the development of both variables. For automaticity, additionally to a linear slope, we added a quadratic slope (fixing the paths at 0, 1, 4, 9 and so on) since there is evidence for a non-linear growth of habit strength (Lally et al., 2010; Schnauber-Stockmann & Naab, 2019). Regarding the model with valence only, chi-square statistics indicated that there was no significant difference between the postulated model and the data [χ^2 = 61.80, *df* = 50, *p* = 0.122; CFI = 0.89, RMSEA = 0.04 (90 % CI 0.00-0.07)]. The slope mean of valence was -0.03 (*SE* = 0.02, *p* = 0.062), indicating that the linear trend of valence did not differ from zero. There were no inter-individual differences in the linear trend as indicated by a non-significant slope variance of valence (σ^2 < 0.01, *SE* = 0.01, *p* = 0.446). The correlation between intercept and slope of valence was not significant (*r* = 0.02, *p* = 0.392). The model with only automaticity and two latent slope factors revealed acceptable fit indices [CFI = 0.92, RMSEA = 0.07 (90 % CI 0.04-0.10)], with χ^2 = 75.12, *df* = 46, *p* = 0.004. The non-significant slope means of automaticity were 0.13 (*SE* = 0.10, *p* = 0.221) for the linear slope and -0.01 (*SE* = 0.01, *p* = 0.371) for the quadratic slope, respectively, indicating only very marginal changes over time. There were inter-individual differences in growth patterns, given the significant slope variances (linear: σ^2 = 0.45, *SE* = 0.18, *p* = < 0.05; quadratic: σ^2 = 0.01,

SE < 0.01, *p* = < 0.05). The correlation between intercept and slopes of automaticity was not significant (linear: *r* = -0.40, *p* = 0.268; quadratic: *r* = 0.03, *p* = 0.475).

Given the non-significant correlations between intercept and slope within both separate models, we removed the covariance path between intercept and slope for both valence and automaticity in all following models. We calculated separate models for assessing the effects of the intervention on the development of affective responses (Hypothesis 1c) and on the development of automaticity (Hypothesis 1d). One of which examined the effect of the intervention on intercept and slope of valence and the other of which examined the effect of the intervention on intercept and slope of automaticity. Further, we examined whether the intercept and/or slope of valence would have an effect on final habit strength as well as/or on the change of habit strength (Hypothesis 2).

Criteria for investigating habit formation

We were taking into account the essential criteria that must be met in order to investigate habit formation published by Gardner et al. (2022). First, we were focusing on the strengthening of the association between a cue, which might have been the date of the exercise course, and a behavior, i.e., instigating to go exercising.

Second, it was reasonable to expect that this association would increase during the courses. The courses in this study had just started after the semester break, so even if someone was no first-year student and had already taken a similar course, there was a period of time in between when the behavior was not performed cue-congruently in the stable university setting. In addition, drop-out rates in such courses are high (Finne et al., 2019), so at least not all participants are at a stage in the habit formation curve where there is no meaningful growth. Further, the affect-based intervention aimed to result in some kind of “intrinsic reward” that would strengthen habit formation.

Third, operationalizing habit as both a broad construct consisting of frequency, self-identity, and automaticity, as well as as automaticity alone, we were not simply inferring habit from the frequency. Fourth, by applying a structural equation modeling framework, we considered the continuity, non-linearity, and individual growth patterns of habit.

Results

Descriptive analyses

From the total sample size of 135 students and employees, two persons were excluded from the analyses since only data from the initial assessment in week 1 (no weekly or final assessment) was available, and one person was excluded since no data from the initial assessment was available. Thus, data from a total of 132 individuals were included in the analyses. According to an intention-to-treat analysis, no additional subjects were excluded prior to the analyses.

Table 3.1

Group comparison of the initial assessment (week 1)

	Initial assessment (N = 132)				
	Affect (n = 65)	Control (n = 67)			
	%	%	χ^2	*df*	*p*
Gender (female)	27.7	20.9	0.93	1	0.336
Student Status (yes)	95.4	97.0	<0.01	1	1.000
	M (SD)	*M (SD)*	*t*	*df*	*p*
Age	22.68 (2.22)	21.96 (2.24)	1.86	128	0.065
SRHI	3.34 (0.89)	3.36 (0.77)	-0.15	130	0.884
SRBAI	3.23 (1.10)	3.12 (0.97)	0.57	130	0.567
Affective attitude	5.71 (1.07)	5.62 (1.13)	0.47	130	0.637

Note. The variables were measured after the participants had attended the course in the first week of the study. Habit strength was measured on a 5-point Likert scale; affective attitude on a 7-point scale. Statistics reported are percentages for the categorical variables; *M* = Mean; *SD* = standard deviation; χ^2= value of the chi-square test; *t* = value of the t-distribution; *df* = degrees of freedom; *p* = probability value.

Thirteen participants (9.8 %) attended all ten courses, 61 participants (46.2 %) attended the last course (12 participants filled in the final questionnaire one week later, therefore N = 73 final questionnaires were available). For the overall sample of 132 participants, mean participation rate was 6.55 times (SD = 2.63, range 1 to 10). Mean age was 22.31 years (SD = 2.25, range 18 to 29), 32 participants (24.2 %) were female, 127 participants (96.2 %) were students. At week 1, there were no statistically significant differences between the two conditions on sociodemographic data,

habit strength (exercise instigation), and affective attitude (Table 3.1). See Supplementary Table 3.A for correlations of all study variables.

Primary outcomes: Intervention effectiveness

Effect of intervention on affective attitude (Hypothesis 1a)

The 2 x 2 repeated measures ANOVA (see Table 3.2 for means and standard deviations by condition over time) showed neither a significant condition x time interaction ($F(1,71) = 0.12$, $p = 0.727$), nor any significant main effect (main effect of time: $F(1,71) = 0.19$, $p = 0.661$; main effect of group: $F(1,71) = 0.18$, $p = 0.670$). Thus, Hypothesis 1a was not supported.

Table 3.2

Means and standard deviations by condition over time (N = 73)

	Initial assessment		Final assessment	
	Affect	Control	Affect	Control
SRHI	3.41 (0.84)	3.47 (0.78)	3.56 (0.73)	3.65 (0.68)
SRBAI	3.33 (1.08)	3.26 (1.06)	3.54 (1.01)	3.64 (0.70)
Affective attitude	5.70 (0.99)	5.82 (0.10)	5.79 (0.98)	5.83 (0.88)

Note. Habit strength was measured on a 5-point Likert scale; affective attitude on a 7-point scale.

Effect of intervention on habit strength (Hypothesis 1b)

The 2 x 2 repeated measures ANOVA showed no significant condition x time interaction ($F(1,71) = 0.05$, $p = 0.825$). The only significant main effect was the main effect of time ($F(1,71) = 5.20$, $p = 0.026$, $\eta^2 = 0.07$). This means that independent of condition, exercise instigation habit strength as measured with the SRHI significantly increased over time (Table 3.2). The main effect of group was not significant ($F(1,71) = 0.22$, $p = 0.641$). Also when analyzing the SRBAI-scores, the only significant effect was the main effect of time ($F(1,71) = 6.91$, $p = 0.011$, $\eta^2 = 0.09$). In sum, Hypothesis 1b was not supported.

Effect of intervention on affective response to exercise (valence) and automaticity (Hypotheses 1c, d)

The means of the weekly measured variables included in the proposed models are presented in Table 3.3. Throughout all of the weeks, mean affective valence in the affect condition was 7.92 (*SD* = 1.04, range 5 to 10) and 7.64 (*SD* = 1.15, range 4 to 10) in the control condition; mean automaticity in the affect condition was 7.06 (*SD* = 2.27, range 1 to 10) and 7.08 (*SD* = 2.19, range 1 to 10) in the control condition.

Table 3.3

Means of weekly measured variables

Week	1	2	3	4	5	6	7	8	9	10
n	117	97	95	85	81	83	82	51	65	61
Valence	8.04	7.84	7.55	7.76	7.53	7.65	7.62	7.63	7.45	7.95
Automaticity	6.67	7.61	7.26	7.18	7.32	7.58	7.87	7.71	7.54	7.39

Note. $N = 132$ in week 1, n = valid cases. Valence and Automaticity were measured on a 10-point scale.

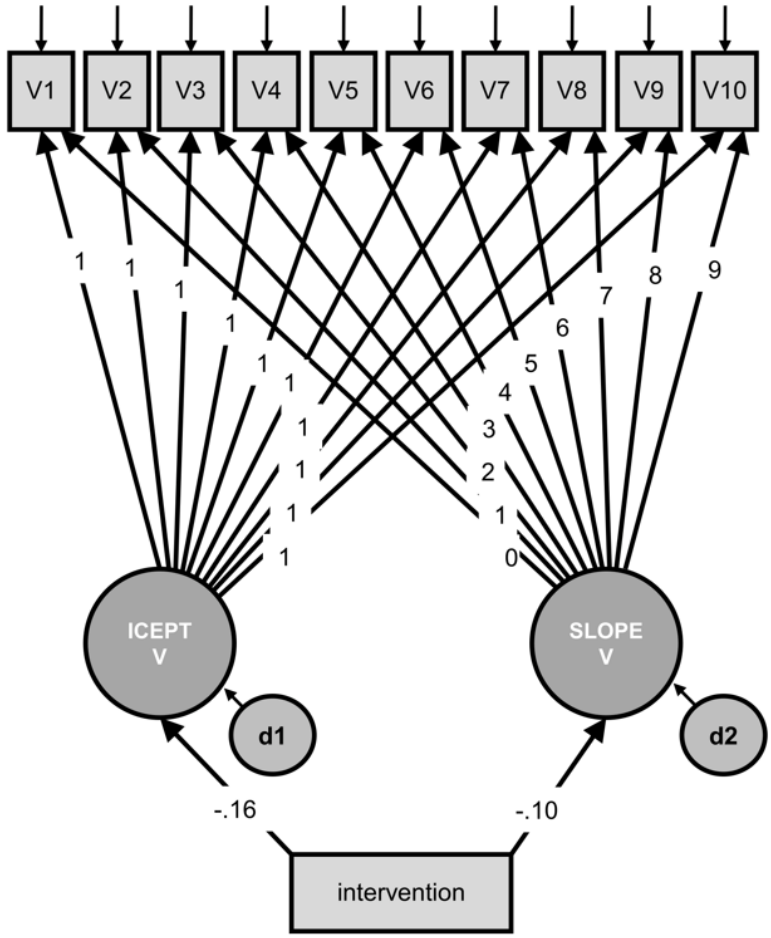
Regarding the model for valence with intervention as a predictor variable (Figure 3.1), chi-square statistics indicated that there was no significant difference between the postulated model and the data [$\chi^2 = 65.22$, $df = 59$, $p = 0.269$; CFI = 0.94; RMSEA = 0.03 (90 % CI 0.00-0.06)]. Given the intervention's non-significant effect on the intercept factor of valence ($\beta = -0.16$, $z = -1.16$, $p = 0.245$), the intervention was not found to be a significant predictor of valence in week 1. Also, according to the intervention's non-significant effect on the slope factor of valence ($\beta = -0.10$, $z = -0.44$, $p = 0.660$), the intervention was not found to be a significant predictor of the rate of change in valence. That is, neither the initial value nor the growth pattern of valence was related to the intervention. Hypothesis 1c was not supported.

The model for automaticity (with a single headed path between the two slopes, Figure 3.2) with intervention as predictor variable revealed acceptable fit indices [CFI = 0.93, RMSEA = 0.06 (90 % CI 0.03-0.09)] with $\chi^2 = 81.23$, $df = 55$, $p = 0.012$. Again, all effects were not significant (intercept: $\beta = -0.15$, $z = -1.12$, $p = 0.262$; linear slope: $\beta = 0.28$, $z = 1.61$, $p = 0.107$; quadratic

slope: β = -0.16, *z* = -0.96, *p* = 0.338), indicating that the intervention neither effected the initial level of automaticity nor its change over time. Hypothesis 1d was not supported.

Figure 3.1

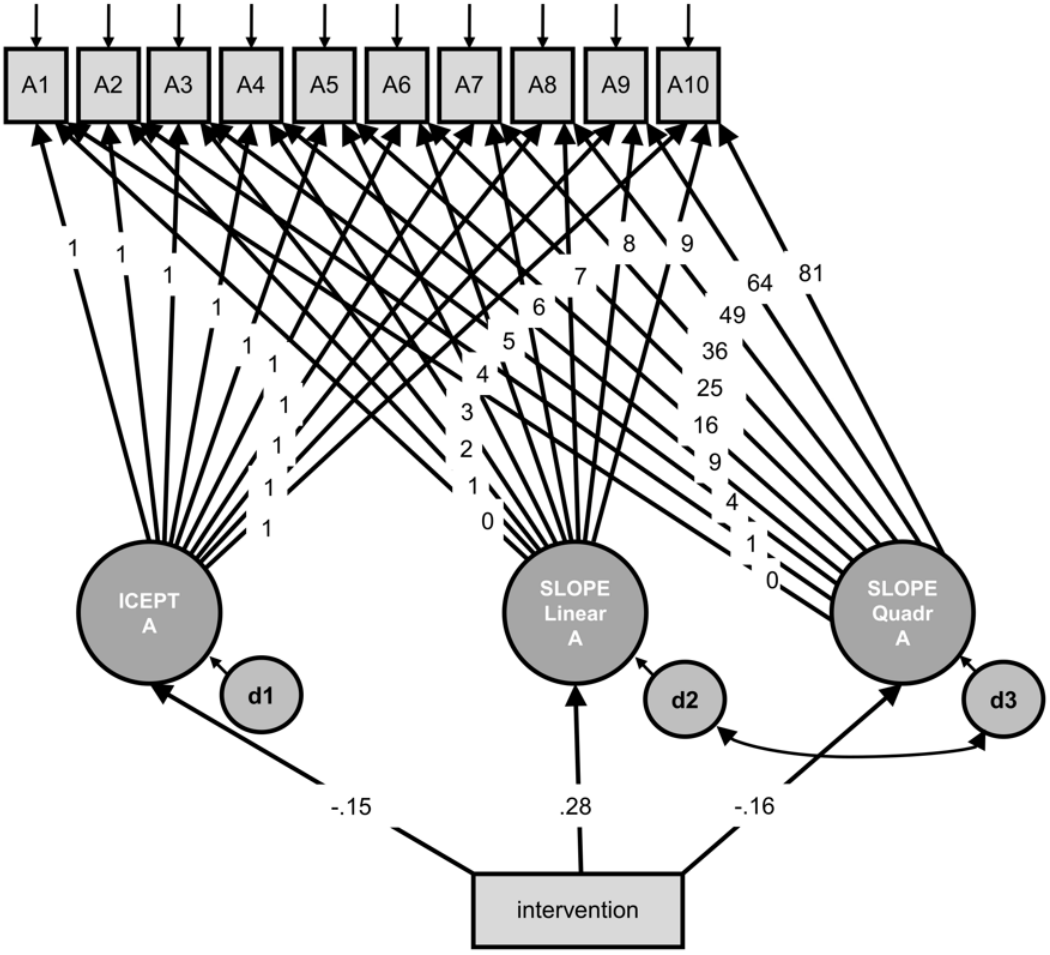
Model for valence with intervention as predictor variable



Note. V1-V10 = observed valence, measured at ten time points, with residuals; ICEPT V = latent intercept of valence, all paths to the observed valence variables were constrained to 1; SLOPE V = latent slope of valence, the paths to the observed valence variables indicate linear growth; d1 and d2 = residuals; intervention = observed predictor variable; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Model fit: $\chi^2 = 65.22$, $df = 59$, $p = 0.269$; CFI = 0.94; RMSEA = 0.03 (90 % CI 0.00-0.06).

Figure 3.2

Model for automaticity with intervention as predictor variable



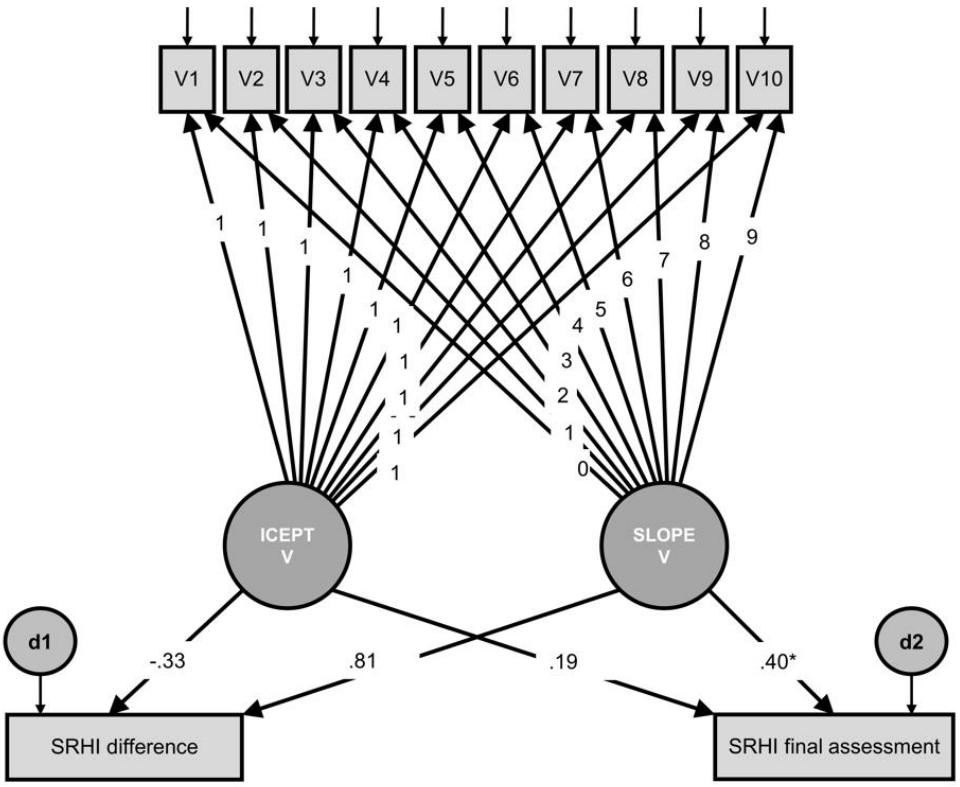
Note. A1-A10 = observed automaticity, measured at ten time points, with residuals; ICEPT A = latent intercept of automaticity, all paths to the observed automaticity variables were constrained to 1; SLOPE Linear A = latent slope of automaticity, the paths to the observed automaticity variables indicate linear growth; SLOPE Quadr A = latent slope of automaticity, the paths to the observed automaticity variables indicate quadratic growth; d1-d3 = residuals; intervention = observed predictor variable. The model revealed acceptable fit indices.

Secondary outcomes: Relationship between valence and habit strength (Hypothesis 2)

Mean change of habit strength (SRHI) was 0.17 (*SD* = 0.62, range -1.25 to 2.50, *N* = 73). The model for Hypothesis 2 is shown in Figure 3.3.

Figure 3.3

Model for valence as a predictor of final habit strength and change in habit strength



Note. V1-V10 = observed valence, measured at ten time points, with residuals; ICEPT V = latent intercept of valence, all paths to the observed valence variables were constrained to 1; SLOPE V = latent slope of valence, the paths to the observed valence variables indicate linear growth; d1 and d2 = residuals; SRHI difference = observed change in habit strength (final assessment minus initial assessment); SRHI final assessment = observed habit strength in the final assessment; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Model fit: $\chi^2 = 74.79$, $df = 68$, $p = 0.268$; CFI = 0.94; RMSEA = 0.03 (90 % CI 0.00-0.06).

Chi-square statistics indicated that there was no significant difference between the postulated model and the data [$\chi^2 = 74.79$, $df = 68$, $p = 0.268$; CFI = 0.94; RMSEA = 0.03 (90 % CI 0.00-0.06)]. The effect of the slope of valence on exercise instigation habit strength measured with the SRHI was significant ($\beta = 0.40$, $z = 2.00$, $p = 0.045$). This means that the rate of change in valence was a significant predictor of the final exercise instigation habit strength score. All

other effects were not significant, indicating that the intercept of valence did not predict final exercise instigation habit strength (β = 0.19, *z* = 1.28, *p* = 0.201) and that neither slope (β = 0.81, *z* = 1.06, *p* = 0.288) nor intercept (β = -0.33, *z* = -1.94, *p* = 0.052) of valence predicted the difference score of exercise instigation habit strength. Also when analyzing the SRBAI-scores we found the effect of the slope of valence on exercise instigation automaticity strength to be significant (β = 0.50, *z* = 2.49, *p* = 0.013). Additionally, here, the intercept (β = -0.41, *z* = -2.37, *p* = 0.018) of valence predicted the difference score of exercise instigation automaticity strength. In sum, Hypothesis 2 was supported.

The non-significant path between the SRHI difference (final minus initial assessment) and the slope of valence should be interpreted with caution. One scenario in which gain scores are valid is where the post-test variance exceeds the pretest variance (May & Hittner, 1997). However, the inter-individual variance of the final SRHI score was lower than that of the initial SRHI score. There is a risk that in the initial assessment the participants related the items used in the SRHI to another course, resulting in a greater variance than in the final week, where it is reasonable that, when answering the SRHI, the participants referred to the current exercise course within the study period. The same is true for the SRBAI difference score.

Discussion

The purpose of this study was, first, to examine whether a trainer-focused affect-based intervention could increase (a) affective attitudes, and (b) exercise instigation habit strength, and influence the development of (c) weekly measured affective responses, and (d) weekly measured automaticity among adult exercise course participants. Second, the study examined the relation between the development of affective responses to exercise and habit strength.

With regard to the first set of Hypotheses (1a-d), the intervention did not show any effect on the affective constructs affective attitude and affective response. This was contrary to what was expected. These hypotheses were mainly based on a study by Jekauc (2015), which successfully manipulated affect with a similar intervention. Regarding habit formation constructs automaticity (SRBAI) and habit strength (SRHI), the affect-based intervention was no more conducive for habit formation than the control intervention. Our assumption that an affect-based intervention would be more beneficial for habit formation than a control intervention was mainly based on a study by Weyland et al. (2020) that suggested a relationship between valence and

automaticity, which led us to conclude that an affect-based intervention might also influence habit formation.

Regarding habit formation constructs, results of the present study showed that exercise instigation habit strength significantly increased over time – independent of condition and when measuring habit with both the SRHI and the SRBAI. That behavior and habit strength increased over three time points for all participants independent of whether they were in self-monitoring or cue-to-action conditions was shown in a study by Mergelsberg et al. (2021). In their study, they wanted to compare effects of different conditions on habit formation of a new health behavior, namely microwaving a sponge or dishcloth, and behavior implementation, but then concluded that all conditions were equally effective. That is, also their habit monitoring condition, in which participants answered the SRHI about the health behavior under study every three days for three weeks, developed a habit equally to the other conditions. In our study, the increase in exercise instigation habit strength might probably have occured due to the weekly self-monitoring of automaticity through the weekly questionnaires.

Another possible reason for the increase in habit strength is that PA behavior is generally more likely to become habitual, considering, for example, the stability of the exercise course's context. A meta-analysis already showed that the highest habit strength, around 60 percent above the SRHI mean, can be found in relation to PA behavior in comparison to dietary behavior (Gardner et al., 2011). Further, the increases in SRHI scores found in this study might also be explained by the behavior repetition itself. The SRHI applied in this study includes items on behavior frequency and, thus, it may be that while frequency has increased, automaticity may not have (but see also Gardner et al., 2012; and Rebar et al., 2018). Regarding automaticity, our study's results differ and therefore it is unclear whether the increase in habit strength is attributable to automaticity: The main effect of time was also significant when analyzing the SRBAI-scores suggesting that exercise instigation automaticity strength significantly increased over time – and not only the frequency of behavior. Conversely, there was no significant growth over time in our study regarding the weekly measured automaticity, supporting the suggestion that the increase in habit strength reflects more of an increase in behavior frequency than in automaticity. That automaticity did not grow significantly is a finding that is contrary to other research that has reported, for example, asymptotic growth in automaticity (Lally et al., 2010). The courses being

analyzed had all just started at the beginning of the semester. Still, it is possible that some courses were offered in a comparable setting the previous semester, which would be a possible explanation for the high values of automaticity already perceived in the initial assessment. On the other hand, given the different results for automaticity, there may have been methodological problems, such as low reliability and validity of automaticity self-reports. As Labrecque and Wood (2015) also noted, unlike the frequency of a behavior, an individual cannot directly observe automaticity. They conclude that automaticity self-reports can only capture inferences about the feeling of performing a behavior, which could misrepresent the underlying inherently unconscious characteristic of habits.

With respect to the affective constructs, the present study revealed no significant growth in valence over time and no inter-individual difference in the growth patterns regarding valence. Thus, a statistical explanation for the ineffectiveness of the intervention may lie in the lack of variance in valence, which can be attributed to two methodological aspects. First, the generally rather high means in valence might be attributed to the affective rebound. The affective rebound describes the consistent finding that people generally feel more positive valenced states after finishing exercise or when resting between exercise-intervals (Hall et al., 2002; Backhouse et al., 2007; Box et al., 2020). Measuring affective responses at several time points during and after exercise is therefore recommended (Ekkekakis et al., 2020). However, this is difficult to implement in real-life settings, such as structured university sport and exercise courses. Given the lack of variance between the persons due to the positive rebound, further gains in valence cannot be achieved easily. Second, a self-selected behavior, as in this study, may reduce inter-individual variance in the reward value, in this case positive affective responses, since individuals might have chosen exercise courses regarding which they anticipated positive affective responses. This argumentation can also be found in Schnauber-Stockmann and Naab (2019), who gave subjects a specific and not self-selected app in order to increase inter-individual variance in the app's reward value to study it as a facilitator of habit formation.

Hypothesis 2 stated that the development of positive affective responses to exercise would be positively related to the development of habit strength. The results should be taken with caution in light of the low variance in valence, but they do suggest that subjects with an increase in valence also had a stronger exercise instigation habit strength reported in the final assessment. Positive

affect might be associated with the formation of habits, as also assumed by Weyland et al. (2020) who found significant effects of valence on automaticity on the between-subject level. Wood and Neal (2016) summarize that uncertain rewards that do not occur every time are most effective for habit formation. Since one cannot be certain of a positive valence as an outcome of the exercise course, the affective response might represent an uncertain reward. Focusing on intrinsic rewards and also applying a latent growth model, one study found that the intercept of intrinsic rewards in the preparation phase (i.e., finding it pleasant) was associated with the intercept of exercise preparation habit strength, but not with its slope (Lee & Yoon, 2019). The authors conclude that rewards occurring especially early are related to habit formation, and the influence of rewards might then decrease during habit change. Also focusing on intrinsic exercise rewards (measured as intrinsic motivation and negative reinforcement), Phillips et al. (2016) underlined the importance of the relationship between habit and rewards for the actual behavior. In particular, they found that exercise habit strength mediated the relation between intrinsic exercise rewards and exercise behavior for individuals who had done regular exercise for at least three months. For individuals who exercised less than three months, however, this relation was mediated by intentions. However, given the different variables, these results are hard to compare and none of these studies assessed acute affective responses per se.

Limitations and future research

A strength of the study is that it examined adults in a real-world setting over a ten-week period with respect to the emergent variables of affect-based constructs and habit, which are promising for behavior change (Conner et al., 2020; Orbell & Verplanken, 2020). Only a few studies actually measured habit strength or automaticity at multiple time points (Feil et al., 2021).

Another strength of this study is that it is an intervention study that intended to manipulate affective responses through exercise trainers. This trainer-focused approach might reach more individuals than interventions that need to be perceived by single individuals, for example exercise course participants. Authors like Ekkekakis and Zenko (2016) argue that exercise psychology should produce efficient implementable interventions for a wide range of settings, not least to increase the impact of the discipline. However, because the intervention did not yield significant results, it is necessary to list possible reasons why the intervention might have failed. We based the intervention on facilitators of positive affective responses to exercise (Wienke &

Jekauc, 2016), but still it is possible that the intervention content was not sufficiently relevant for changes in affect. It is possible that the focus of such an intervention should have been task-oriented teaching styles (Klos et al., 2020) or other affect-based intervention techniques (Chen et al., 2021). In this context, it seems important for future studies to examine which techniques are most effective in manipulating affective constructs – and whether these techniques are also most beneficial for habit formation (see also question 13 of the 21 questions to guide future research by Gardner et al., 2021). Regarding study design, one limitation in this study was that two different interventions were compared, with one intended to serve as a control intervention. Since we speculate that the affect-based intervention might not have focused on the most relevant aspects, future studies should compare similar intervention components in order to gather insights into which contents are effective rather than concluding that an intervention as a whole is (in-) effective as inspired by Gardner et al. (2020a). Another explanation for the ineffectiveness of the intervention is that the initial workshop lasted only one hour and thus may have been too short for any reflection by the exercise trainers on their own behavior.

At the same time, it can also be argued that the intervention did not fail, but that its effect could not be demonstrated for methodological reasons. First, we did not measure whether the exercise trainers designed their exercise courses as recommended by the affect-based intervention. Thus, given this lack of a "manipulation check," it remains unclear whether the present results are due to an insufficient theoretical foundation of the intervention or to an insufficient implementation of the intervention by the exercise trainers. With the goal of verifying actual implementation, future studies could record some of the exercise courses and analyze the videos by asking experts to determine whether the intervention content was applied (see, for example, González-Cutre et al., 2018). Second, possibly, the effect of the intervention was too small to be detected statistically, given the small sample size in which confounding variables that were not controlled for may play a role in masking the intervention effect. One such determinant of affective responses could be, for example, BMI. Obesity can be associated with factors that may result in reduced enjoyment of exercise in obese individuals (Ekkekakis et al., 2017). Notably, the high dropout rate in itself can be interpreted as the absence of the theoretically expected consequences of the intervention, since positive affect was assumed to counteract it. Third, we can conclude that the intervention had no effect on affective valence measured weekly after exercising. It is recommended that future studies expand the measurement time points, i.e.,

measure affective responses during exercise. It is questionable to what extent an intervention, which focuses on situational factors that are to be influenced by an exercise trainer's behavior during the course, influences post-exercise affective responses. Moreover, as far as the predictability of future PA is concerned, affective responses during exercise are shown to be more reliable (Rhodes & Kates, 2015).

Although we found an increase in affective valence and final exercise instigation habit strength to be significantly related, since the affect manipulation in this study was not successful, no conclusions about the direction of this relationship can be drawn. It is possible that positive affective responses enhance habit formation. However, it is also reasonable that the more automatic a behavior is instigated, the more positive the affective responses are that accompany this behavior. However, the latter argument is more likely to be found in relation to execution habit, which was not measured in the present study. Gardner et al. (2020b) hypothesize that execution habit might influence the uptake of future PA via positive affective judgments, among other mechanisms.

Another critical point, in addition to the discussion of the extent to which implicit processes can be recorded by self-report (see for example Gardner & Tang, 2014; Hagger et al., 2015), is the choice of the SRHI item stems. Only recently have recommendations for habit formation tracking studies been published that suggest measuring specific behaviors in light of the specific context in which they occur. For example, by including a potential cue in the item stem of the SRHI/SRBAI (Sniehotta & Presseau, 2012; Gardner et al., 2021; e.g., "Going to the gym after the lecture on Wednesday is something…"). In this study, we assumed that the overall contexts were stable, given that time and place were constant for all exercise courses. Nevertheless, we did not assess the individual cues a person relied on when instigating the behavior.

Further, there was a short Christmas break within the study period (between week 7 and 8), which arguably affected behavior frequency and consistency within a given behavioral sequence.

Conclusion

In conclusion, the present study assessed the importance of affective responses in the formation of instigation habits in exercise contexts and discusses possible mechanisms for affect-based interventions. Although the trainer-focused intervention was not successful in increasing positive affective responses in course participants, we found a significant relationship between the development of weekly affective responses and habit strength at the end of the intervention. We encourage future studies to follow this line of research. In particular, in line with current dual-process approaches, investigating the nature of the relationship between affect and habit might contribute to a better understanding of the processes related to PA maintenance.

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Chapter IV – The moderating role of personality

Study 3: Neuroticism and resilience moderate the relationship between physical activity enjoyment and habit

Slightly modified version of the submitted manuscript:

Weyland, S., Fritsch, J., Kaushal, N., Feil, K., Jekauc, D. (submitted). Neuroticism and resilience moderate the relationship between physical activity enjoyment and habit. *International Journal of Sport and Exercise Psychology.*

Abstract

The aim of this observational study was to examine whether certain personality traits moderate the relationship between physical activity enjoyment and habit. Five hundred seventy eight participants (M_{age} = 29.50 years; 55.7 % female) completed an online survey that included measures of physical activity enjoyment, physical activity habit, Big Five traits (neuroticism, extraversion, and consciousness), and emotional style dimensions (outlook and resilience). The data was analyzed using Hayes' PROCESS macro for SPSS (controlled for demographic variables) with habit as the dependent variable. Results indicate that physical activity enjoyment was positively related to habit. Neuroticism was negatively related to habit, while the other traits examined were positively related to habit. Moderation analyses revealed that the relationship between physical activity enjoyment and habit was stronger for individuals with higher levels of neuroticism compared to those with lower levels of neuroticism. For individuals with higher levels of resilience, the relationship between physical activity enjoyment and habit was lower than for individuals with lower levels of resilience. The other tested moderation effects were not significant. These findings suggest that increasing physical activity enjoyment may be crucial for reinforcing habit in emotionally less stable individuals. Affect-based interventions could greatly benefit these individuals' habits.

Introduction

Embracing a lifestyle of physical activity holds merit, but its superior value lies in its sustenance: committing to consistent physical activity and achieving, if not exceeding, the minimum recommended physical activity threshold can result in a multitude of health advantages and a decreased vulnerability to chronic illnesses (Haskell et al., 2007; Powell et al., 2011). According to recent dual-process theories (e.g., Strobach et al., 2020), in addition to intentions,

habit is considered to be a key variable for the maintenance of physical activity (for reviews see Feil et al., 2021; Gardner et al., 2011). Habit is not just the frequency of a behavior, but a process whereby a cue prompts behavior initiation after a cue-behavior association has been learned (Gardner, 2015; Wood & Rünger, 2016). As habit forms, automaticity becomes a key characteristic of it, which means that habitual behavior is efficiently instigated without thinking, having to consciously remember it and awareness (Gardner et al., 2012).

Affect-related constructs (for a narrative review on affect-related constructs as determinants of physical activity see Stevens et al., 2020) can influence habit formation, i.e., encourage initiation and repetition of the behavior or promote learning of cue-behavior associations (Gardner & Lally, 2018). Similarly, Kaushal and Rhodes (2015) longitudinally observed new gym members and found experience that lead to unpleasant affective judgement diminished exercise habit formation, in that model test that controlled for other habit antecedents. Thus, the continued presence of positive affect-related constructs may encourage the initiation of behavior to remain at an automatic level.

In the context of physical activity, a number of affect-related constructs have been examined in relation to habit. Two longitudinal studies in the exercise context concluded that affective judgement was a relevant determinant especially at the beginning of habit formation (Kaushal & Rhodes, 2015; Kaushal et al., 2017a). In an intervention study that promoted exercise habit formation techniques, in addition to post-intention constructs revealed methods that intended to make exercise more enjoyable contributed to the increase in physical activity in the intervention group than in the control group at eight weeks (Kaushal et al., 2017b). Other work has shown that the affective attitude towards sufficient exercise predicted exercise habit measured two weeks later, in addition to previous behavior and social-cognitive variables (de Bruijn et al., 2014). Further, research demonstrated that the acute affective response to physical activity was related to future physical activity (Rhodes & Kates, 2015), and, in particular, habit strength (Weyland et al., 2020; Weyland et al., 2022).

From both a theoretical and a practical perspective, it is important to emphasize that the strength of the association between affect-related constructs and habit may not be equal for everyone. Affect-related constructs are closely related to the perceived reward value of a behavior. The acute affective response to a behavioral outcome, such as the experience of enjoyment, may influence whether or not the outcome is experienced as “rewarding”, i.e., associated with a reward

unit in the incentive system – and according to the associative-cybernetic model, this reward unit can then reinforce the cue-behavior association characteristic of habit (de Wit & Dickinson, 2009). For instance, enjoyment may contribute to the experience of reward and thus reinforce the habit for one individual, while high levels of enjoyment may not produce a rewarding experience due to saturation for someone else. Consistent with these theoretical assumptions, it is important to examine potential moderators of the relationship between enjoyment and habit at the between-person level. This need is also supported by Teixeira et al. (2022) who found that the relationship between enjoyment and habit was moderated by the exercise intensity traits agreement (i.e., preference for and tolerance of exercise intensity). The authors propose that while recent literature emphasizes the role of enjoyment in regular physical activity, it has neglected to examine traits that moderate the "enjoyment effect" on outcomes like habit. The question of the influence of personality and individual difference factors on habit formation is one of the twenty-one questions to guide future research on habit-based health interventions collected by Gardner et al. (2021). The present study focuses on Big Five personality traits and emotional style dimensions as potential moderators of the postulated enjoyment-habit relationship.

Personality refers to the uniqueness in the tendency to show consistent and enduring patterns of thinking, feeling, and behaving (McCrae et al., 2000). The "Big Five" is one of the most prominent personality models that defines personality is comprised of five traits that include neuroticism (i.e., when highly expressed, the tendency to be worrying, nervous, emotionally unstable, and vulnerable), extraversion (i.e., when highly expressed, the tendency to be sociable, affectionate, energetic, and talkative), openness (i.e., when highly expressed, the tendency to be original, creative, perceptive, and reflective), agreeableness (i.e., when highly expressed, the tendency to be soft hearted, forgiving, and generous), and conscientiousness (i.e., when highly expressed, the tendency to be careful, well organized, reliable, and hardworking; McCrae & Costa, 1987). In the context of physical activity, a meta-analysis revealed extraversion and conscientiousness were positively and neuroticism negatively related to physical activity (Rhodes & Smith, 2006). This highlights relevant personality traits to investigate in the present study.

High levels of neuroticism are generally associated with lower levels of physical activity (Rhodes & Pfaeffli, 2012; Rhodes & Smith, 2006). Furthermore, Courneya and Hellsten (1998) found individuals exhibiting high levels of neuroticism displayed an increased propensity to experience apprehension over potential embarrassment during assessments of physical fitness.

Moreover, these individuals encountered challenges in mustering the motivation and energy necessary for engaging in regular physical activity. Also, Courneya and Hellsten (1998) found an association between neuroticism and less favorable motivations for participating in regular exercise. Individuals high in neuroticism were more likely to be motivated by concerns about physical appearance and weight management, rather than deriving enjoyment from the activity. Appearance/weight motives have been shown to increase external behavioral regulation, which in turn has been associated with less exercise participation (Ingledew & Markland, 2008). With particular relevance for the present study, individuals high in neuroticism were found to generally experience low levels of physical activity enjoyment (Engels et al., 2022). Thus, on one hand, individuals high in neuroticism tend to face barriers, to have suboptimal motivation, and to enjoy physical activity less. On the other hand, however, it can be surmised that especially for individuals high in neuroticism, the regular experience of enjoyment is imperative to overcome these unfavorable conditions (see also Baumeister et al., 2001). Thus, the relationship between physical activity enjoyment and habit may be stronger for individuals high in neuroticism than for those low in neuroticism.

The association between extraversion and physical activity has been further investigated to explain this relationship. Individuals scoring high on this personality trait tended to enjoy physical activity regardless of whether the physical activity satisfied the psychological need of social relatedness in the study by Engels et al. (2022). Thus, it is possible that individuals high in extraversion might tend to take the advantages for granted, perceiving them as less salient and not particularly extraordinary, given their consistent experience of positive affect (see also Costa & McCrae, 1980). Consequently, the relationship between physical activity enjoyment and habit may be weaker for individuals high in extraversion and stronger for those low in extraversion, assuming that the latter's enjoyment influences their behavior and ultimately their habit more.

Findings of conscientiousness have been interesting as although this has been positively associated with physical activity (Rhodes & Smith, 2006), this trait was negatively related to habit in a study that analyzed various behaviors, including exercise (McCloskey & Johnson, 2021). Gardner et al. (2021) discussed this finding in relation to the overlap between conscientiousness and self-control (O'Gorman & Baxter, 2002). On one hand, consistent with the finding that conscientiousness was associated with lower habit strength, it can be concluded that people high in self-control might be less likely to initiate their behavior in an automatic way because self-

control is more of an explicit process (see also Strobach et al., 2020). On the other hand, habits should be more likely to be facilitated by self-control, since the formation of "beneficial habits" might help people high in self-control in progressing towards desired life goals (Galla & Duckworth, 2015). Upon further analysis, McCloskey and Johnson (2021) found that the negative relationship between conscientiousness and exercise automaticity weakened when individuals high in conscientiousness perceived exercising as more rewarding. They conclude that while more conscientious people have lower automaticity, presumably because they are more inclined to deliberate, the perception of reward may facilitate their automaticity formation. Thus, the relationship between physical activity enjoyment and habit may be stronger for individuals high in conscientiousness than for those low in conscientiousness.

The emotional style theory is another approach to describing the consistent pattern of responding to live experiences that is based on neuroscience (Davidson, 1993; Davidson & Begley, 2012; Jekauc et al., 2021). It posits that a person's emotional style is determined by an individual combination of six dimensions. Outlook involves the skill to maintain a positive emotional state, whereas resilience entails the ability to swiftly recover from negative emotions. Social intuition encompasses the capacity to accurately interpret nonverbal cues in social interactions. Self-awareness refers to the adeptness in correctly understanding bodily signals associated with emotions. Sensitivity to context highlights the capability to adapt emotion regulation according to the prevailing social environment. Attention denotes the skill to effectively concentrate one's focus.

In terms of emotional style, in the present study we focus on the two dimensions of outlook and resilience because, by definition, they are related to the duration of emotions (Davidson & Begley, 2012). Regarding outlook, Kesebir et al. (2019) describe that this dimension refers to acute positive affective responses that can be sustained over time. Thus, for an individual high in outlook, positive affective responses might be longer processed, rather than fading quickly, and referred to as affective judgements (see also Stevens et al., 2020). Moreover, outlook refers to a generally optimistic view. Therefore, individuals high in outlook may be more likely to anticipate enjoyment in relation to future physical activity (see also Feil et al., 2022). Both affective judgements and anticipated enjoyment may be related to habit strength. Thus, the relationship between physical activity enjoyment and habit may be stronger for individuals high in outlook than for those low in outlook.

With regard to individuals low in resilience, it can be assumed that they do not quickly overcome negative affective experiences, such as embarrassment during physical activity. This negative experience may constitute a barrier for future physical activity, similar to individuals high in neuroticism (see also Courneya & Hellsten, 1998). Assuming that enjoyment is all the more important for them, the relationship between physical activity enjoyment and habit may be stronger for individuals low in resilience than for those high in resilience.

In sum, affect-related constructs and habit have been shown to be positively related in the context of physical activity (e.g., Teixeira et al., 2022; Weyland et al., 2020). However, based on aforementioned studies, it is not conclusive that the strength of this relationship is the same for everyone. The purpose of the present study was to explore whether personality traits and emotional style dimensions moderate the relationship between physical activity enjoyment and habit. We hypothesized that physical activity enjoyment would be positively related to habit. Further, we predicted that their association would be moderated by neuroticism, extraversion, and conscientiousness as well as by the emotional style dimensions outlook and resilience.

Materials and methods

Procedures

The present cross-sectional observational study was registered with an analysis plan at open science framework (OSF) registries prior to the data analysis on December 14, 2022 (https://osf.io/8w6cf). Data collection was ongoing at the time of registration; it had started at the end of December 2021 and lasted until December 21, 2022. The study was conducted as an online survey, using the online tool SoSci Survey. The study was reviewed and approved by the ethics committee and data security commissioner at Karlsruhe Institute of Technology. Informed consent was obtained from all participants. Participants were informed of data protection measures and the voluntary and anonymous nature of their participation in the study.

Participants

Participants were recruited through social media, personal outreach, and spreading the participation link in university courses. Participants were instructed to relate enjoyment and habit to a specific physical activity behavior they participate in, regardless of how often they do it, to ensure that enjoyment and habit refer to the same physical activity. Thus, individuals who could

not specify a particular physical activity behavior were asked in the introductory text to the survey not to participate in the study. In addition, individuals who could not state any physical activity behavior were not included in the analysis. This was the case for five persons. In addition, the participants had to be over 18 years old to be included.

Measures

We measured physical activity enjoyment, physical activity habit, personality traits, and emotional style dimensions in a cross-sectional study design. As for possible covariates, demographic variables (gender and age) were also collected.

Physical activity enjoyment

Physical activity enjoyment was measured with PACES-S (Chen et al., 2021). This short version of the Physical Activity Enjoyment Scale (PACES, Kendzierski & DeCarlo, 1991) focuses on the subjective experience of enjoyment. Fritsch et al. (2022) reported good psychometric properties of PACES-S in German adult populations. The scale includes four items related to the item stem "Practicing my activity…" (e.g., "I enjoy it") to be answered on a five-point Likert scale, ranging from (1) strongly disagree to (5) strongly agree. Physical activity enjoyment was calculated as the mean of the four items, whereby higher values indicate greater levels of enjoyment. Cronbach's alpha was $\alpha = 0.87$.

Physical activity habit

Physical activity habit was measured with the SRBAI (Gardner et al., 2012). This automaticity subscale of the Self-Report Habit Index (SRHI, Verplanken & Orbell, 2003) measures automatic activation of a behavior as the central feature of habit that was found to be related to future behavior (Gardner et al., 2012; Phillips & Gardner, 2016). As such, the SRBAI showed predictive validity, and also, its reliability and convergent validity were reported (Gardner et al., 2012). A German version of the original SRHI was also validated (Thurn et al., 2014). The SRBAI includes four items related to the item stem "Deciding to practice my activity is something…" (e.g, "I do automatically") to be answered on a seven-point Likert scale, ranging from (1) strongly disagree to (7) strongly agree. In this study, the item stem was chosen to capture the so-called instigation habit, i.e. the degree to which the decision to initiate a behavior is automated, which was found to predict the frequency of exercise (Phillips & Gardner, 2016).

Physical activity habit was calculated as the mean of the four items, whereby higher values indicate greater levels of habit. Cronbach's alpha was $\alpha = 0.85$.

Big Five personality traits

Big Five personality traits were measured with the NEO-FFI-30 (Körner et al., 2008). This short version of the German translation of the 60-item NEO-Five-Factor Inventory (Borkenau & Ostendorf, 1993; Costa & McCrae, 1989) is based on the five factor model of personality (Costa & McCrae, 1989). Satisfactory reliability, factorial and construct validity of the NEO-FFI-30 were reported for a German population (Körner et al., 2008). The whole inventory includes 30 items evenly distributed among the five personality traits to be answered on a five-point Likert scale, ranging from (1) strong rejection to (5) strong agreement. After reverse-coding, the scores for each personality trait were calculated as the mean of the respective five items, with higher scores indicating greater levels of the trait. In this study, the personality traits under investigation were neuroticism, extraversion, and conscientiousness. We did not analyze the other two big five personality traits openness and agreeableness. Cronbach's alpha was $\alpha = 0.85$ for neuroticism, $\alpha = 0.75$ for extraversion, and $\alpha = 0.73$ for conscientiousness.

Emotional style dimensions

Emotional style dimensions were measured with the Emotional Style Questionnaire (ESQ, Kesebir et al., 2019). Its validity and reliability were also supported for a German population (Jekauc et al., 2021). The whole inventory includes 24 items evenly distributed among the six emotional style dimensions to be answered on a seven-point Likert scale, ranging from (1) strongly disagree to (7) strongly agree. After reverse-coding, the scores for each emotional style dimension were calculated as the mean of the respective four items, with higher scores indicating greater levels of the dimension. In this study, the emotional style dimensions under investigation were outlook and resilience. We did not analyze the other four emotional style dimensions social intuition, self-awareness, sensitivity to context, and attention. Cronbach's alpha was $\alpha = 0.78$ for outlook and $\alpha = 0.73$ for resilience.

Statistical analyses

An a priori power analysis using G Power 3.1.9.7 indicated that when using linear multiple regression (fixed model; R^2 increase) with five predictors, and an alpha error level of

0.05, a sample of 395 participants would be sufficient to detect a small effect of $f^2 = 0.02$, with a power of 0.80. For each personality trait or emotional style dimension, we calculated separate regression models. In each separate regression, the individual five predictors were: the main effect of the independent variable enjoyment, the main effect of the moderator (Big Five trait/emotional style dimension), the interaction between the two main effects, and the two covariates age and gender.

As a preliminary analysis, we checked patterns of missing values with Little's MCAR test (Little, 1988). In this study, z-scores were utilized to standardize the individual scores. The z-scores were calculated by subtracting the mean from individual scores and dividing the result by the standard deviation (Field, 2013). The assumptions for a moderation analysis, namely independence of errors in estimation, linear relationships between the variables, normal distribution of errors, and homoscedasticity (Hayes, 2022), were checked. To test whether physical activity enjoyment and physical activity habit were positively related and to test personality traits and emotional style dimensions as a moderator of this relationship, we applied Hayes' PROCESS macro (Hayes, 2022) for SPSS (IBM SPSS Statistics 26, IBM Corp., Armonk, N.Y., USA). In all regressions, we used physical activity habit as the dependent variable and we included age and gender as covariates. We examined whether the interaction between physical activity enjoyment and the personality traits/emotional style dimensions independently contributed to variance explanation in addition to the main effects and covariates. Model 1 specification was chosen, which included a single moderator (either personality trait or emotional style dimension) between the independent variable (i.e., physical activity enjoyment) and the dependent variable (i.e., physical activity habit). Conditional effects of the focal predictor (physical activity enjoyment) were analyzed at the following values of the moderator: mean and plus/minus one standard deviation from the mean. Since only five individuals indicated either being diverse or not wanting to specify gender, we dichotomized the variable gender for purely statistical reasons and ran all regressions without these five cases. We additionally ran all regressions without the two covariates age and gender, thus, including these five cases, and found that the significant effects were the same as those observed in the regression analyses which included the covariates. The threshold for significance was 0.05 for all analyses.

Results

Descriptive analyses

A total of 607 respondents participated in the survey. Among them, 12 were under the age of 18 and were therefore not included in the analysis. Moreover, additional 17 individuals did not complete all relevant measures. To test the pattern of missing data, Little's MCAR test was performed and yielded a non-significant result (χ^2 = 37.96; *df* = 27; *p* = 0.079). This finding indicates that the missing data did not show a systematic pattern. Following the process of listwise deletion, the complete dataset included information from 578 participants. Thus, the minimum required sample size based in the power analysis was exceeded.

Table 4.1

Means, standard deviations, and correlations among all included study variables

	1	2	3	4	5	6	7	8	9
1. Gender	-								
2. Age	-.08	-							
3. Enjoyment	.02	.09*	-						
4. Habit	-.11**	-.01	.47***	-					
5. Neuroticism	.20***	-.14***	-.24***	-.21***	-				
6. Extraversion	.05	-.07	.34***	.31***	-.38***	-			
7. Conscientiousness	.18***	.07	.20***	.17***	-.34***	.22***	-		
8. Outlook	.03	.01	.26***	.22***	-.59***	.55***	.25***	-	
9. Resilience	-.13**	.09*	.23***	.23***	-.62***	.41***	.18***	.65***	-
M (%)	55.7[a]	29.50	4.42	4.67	2.55	3.50	4.07	4.91	4.38
SD		12.55	.68	1.51	.80	.61	.54	1.14	1.08

Note. *N* = 578. Regarding gender, masculine was coded as 0 and female as 1, thus, column 1 pertains solely to *N* = 573 subjects. [a]percentage female. *p < .05; **p < .01; ***p < .001.

Mean age was 29.50 years (*SD* = 12.55, range from 18 to 79 years), and 55.7 % said their gender was female, 43.4 % said it was male, 0.7 % said it was diverse, and one person preferred not to provide any information. The highest educational attainment of 42.6 % was a college degree and of 34.6 % a high school diploma. The largest proportion of participants (21.8 %) identified fitness activities (e.g., exercising at the gym or doing workouts at home) as the preferred physical activity to which the individual related the survey, followed by 16.3 % soccer, and 11.9 % jogging or walking. The remainder included a diverse range of physical activities such as volleyball,

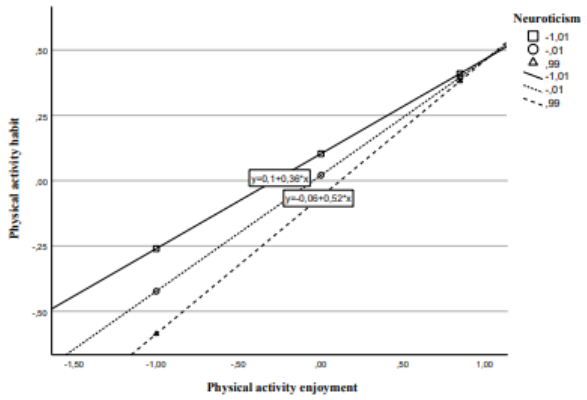
bouldering, gymnastics, dancing, or tennis. On average, the participants had been doing their chosen physical activity for 12.33 years (*SD* = 10.67; range from 0 to 68 years) and were doing it 9.80 days a month (*SD* = 5.90, range from 0 to 30 days) for 90.55 minutes (*SD* = 54.92, range 15 to 480 minutes). The descriptive results and correlations among all study variables are shown in Table 4.1.

Neuroticism

First, we examined whether neuroticism moderated the relationship between physical activity enjoyment and physical activity habit (see Table 4.2). In this model ($F(5,567) = 39.34$, $R^2 = 0.26$, $p < 0.001$), physical activity enjoyment was significantly positively related to physical activity habit (β = 0.44, *SE* = 0.04, $p < 0.001$), and neuroticism was significantly negatively related to physical activity habit (β = -0.08, *SE* = 0.04, $p = 0.033$). Further, the interaction between physical activity enjoyment and neuroticism was significantly positively related to physical activity habit (β = 0.08, *SE* = 0.03, $p = 0.013$). The interaction effect explained 0.8 % of the variance of physical activity habit ($F(1,567) = 6.22$, $p = 0.013$).

Figure 4.1

Results for neuroticism as the moderator variable



Note. Simple slopes for the relationship between physical activity enjoyment and physical activity habit at neuroticism levels -1 SD below the mean, mean, and +1 SD above the mean.

For individuals approximately one standard deviation higher than average on neuroticism, the relationship between physical activity enjoyment and physical activity habit was stronger (β = 0.52, 95 % CI [0.43, 0.61]) than for individuals approximately one standard deviation lower than average on neuroticism (β = 0.36, 95 % CI [0.26, 0.47]). Thus, we concluded that neuroticism moderated the relationship between physical activity enjoyment and physical activity habit (see Figure 4.1).

Table 4.2

Results of the moderation analyses

	β	***SE***	***t***	***p***	***Model summary***
Results of the moderation analysis with neuroticism as the moderator variable					
Constant	.318	.105	3.045	.002	$F(5,567) = 39.340$, $R^2 = .258$, $p < .001$
Enjoyment	.444	.038	11.777	<.001	
Neuroticism	-.083	.039	-2.144	.033	
Interaction	.081	.032	2.493	.013	
Age	-.006	.003	-2.013	.045	
Gender	-.225	.075	-3.011	.003	
Results of the moderation analysis with extraversion as the moderator variable					
Constant	.226	.106	2.145	.032	$F(5,567) = 41.630$, $R^2 = .269$, $p < .001$
Enjoyment	.439	.039	11.180	<.001	
Extraversion	.168	.039	4.335	<.001	
Interaction	.060	.033	1.802	.072	
Age	-.004	.003	-1.217	.224	
Gender	-.255	.073	-3.521	<.001	
Results of the moderation analysis with conscientiousness as the moderator variable					
Constant	.339	.106	3.204	.001	$F(5,567) = 38.486$, $R^2 = .253$, $p < .001$
Enjoyment	.456	.037	12.203	<.001	
Conscientiousness	.110	.038	2.862	.004	
Interaction	-.006	.030	-.190	.850	
Age	-.006	.003	-2.029	.043	
Gender	-.292	.075	-3.907	<.001	
Results of the moderation analysis with outlook as the moderator variable					
Constant	.323	.105	3.068	.002	$F(5,567) = 39.070$, $R^2 = .256$, $p < .001$
Enjoyment	.438	.038	11.463	<.001	
Outlook	.100	.038	2.668	.008	
Interaction	-.061	.035	-1.773	.077	
Age	-.005	.003	-1.877	.061	
Gender	-.262	.073	-3.578	<.001	
Results of the moderation analysis with resilience as the moderator variable					
Constant	.312	.104	2.987	.003	$F(5,567) = 39.618$, $R^2 = .259$, $p < .001$
Enjoyment	.440	.038	11.704	<.001	
Resilience	.104	.038	2.756	.006	
Interaction	-.070	.033	-2.092	.037	
Age	-.006	.003	-1.936	.053	
Gender	-.232	.074	-3.154	.002	

Extraversion

Second, we examined whether extraversion moderated the relationship between physical activity enjoyment and physical activity habit (see Table 4.2). In this model ($F(5,567) = 41.63$, $R^2 = 0.27$, $p < 0.001$), physical activity enjoyment ($\beta = 0.44$, $SE = 0.04$, $p < 0.001$) and extraversion ($\beta = 0.17$, $SE = 0.04$, $p < 0.001$) were significantly positively related to physical activity habit. However, the interaction between physical activity enjoyment and extraversion was not significantly related to physical activity habit ($\beta = 0.06$, $SE = 0.03$, $p = 0.072$). Thus, we concluded that extraversion did not moderate the relationship between physical activity enjoyment and physical activity habit.

Conscientiousness

Third, we examined whether conscientiousness moderated the relationship between physical activity enjoyment and physical activity habit (see Table 4.2). In this model ($F(5,567) = 38.49$, $R^2 = 0.25$, $p < 0.001$), physical activity enjoyment ($\beta = 0.46$, $SE = 0.04$, $p < 0.001$) and conscientiousness ($\beta = 0.11$, $SE = 0.04$, $p = 0.004$) were significantly positively related to physical activity habit. However, the interaction between physical activity enjoyment and conscientiousness was not significantly related to physical activity habit ($\beta = -0.01$, $SE = 0.03$, $p = 0.850$). Thus, we concluded that conscientiousness did not moderate the relationship between physical activity enjoyment and physical activity habit.

Outlook

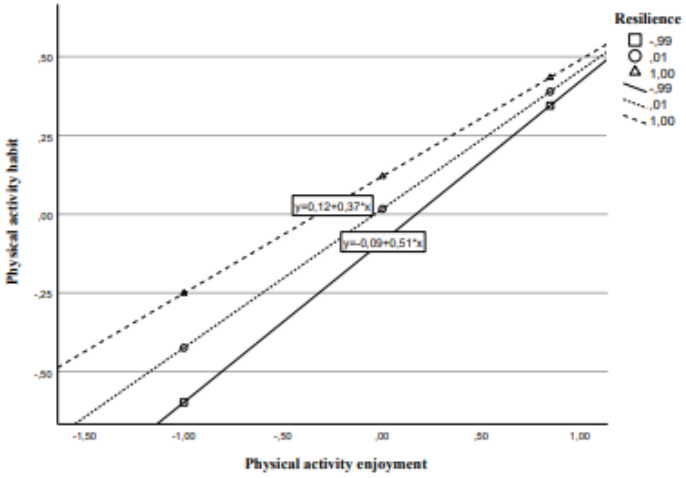
Fourth, we examined whether outlook moderated the relationship between physical activity enjoyment and physical activity habit (see Table 4.2). In this model ($F(5,567) = 39.07$, $R^2 = 0.26$, $p < 0.001$), physical activity enjoyment ($\beta = 0.49$, $SE = 0.04$, $p < 0.001$) and outlook ($\beta = 0.10$, $SE = 0.04$, $p = 0.008$) were significantly positively related to physical activity habit. However, the interaction between physical activity enjoyment and outlook was not significantly associated with physical activity habit ($\beta = -0.06$, $SE = 0.04$, $p = 0.077$). Thus, we concluded that outlook did not moderate the relationship between physical activity enjoyment and physical activity habit.

Resilience

Finally, we examined whether resilience moderated the relationship between physical activity enjoyment and physical activity habit (see Table 4.2). In this model ($F(5,567) = 39.62$, $R^2 = 0.26$, $p < 0.001$), physical activity enjoyment (β = 0.44, $SE = 0.04$, $p < 0.001$) and resilience (β = 0.10, $SE = 0.04$, $p = 0.006$) were significantly positively related to physical activity habit. Further, the interaction between physical activity enjoyment and resilience was significantly negatively related to physical activity habit (β = -0.07, $SE = 0.03$, $p = 0.037$). The interaction effect explained 0.6 % of the variance of physical activity habit ($F(1,567) = 4.38$, $p = 0.037$). For individuals approximately one standard deviation higher than average on resilience, the relationship between physical activity enjoyment and physical activity habit was lower (β = 0.37, 95 % CI [0.26, 0.48]) than for individuals approximately one standard deviation lower than average on resilience (β = 0.51, 95 % CI [0.42, 0.60]). Thus, we concluded that resilience moderated the relationship between physical activity enjoyment and physical activity habit (see Figure 4.2).

Figure 4.2

Results for resilience as the moderator variable



Note. Simple slopes for the relationship between physical activity enjoyment and physical activity habit at resilience levels -1 SD below the mean, mean, and +1 SD above the mean.

Discussion

The purpose of this study was to explore whether the Big Five personality traits neuroticism, extraversion, and conscientiousness as well as the emotional style dimensions outlook and resilience moderate the relationship between physical activity enjoyment and habit. As hypothesized, physical activity enjoyment and habit were positively related in the texted model. With the exception of neuroticism, which correlated negatively, all personality traits and emotional style dimensions examined in the present study correlated positively with physical activity habit. Moderation tests revealed significant effects only for neuroticism and resilience.

Findings of the present study showed a positive relationship between physical activity enjoyment and physical activity habit, which is consistent with previous research, demonstrating a relationship between a wide variety of affect-related constructs and habit (e.g., Teixeira et al., 2022; Weyland et al., 2022). Considering the role of behavior in the relationship between physical activity enjoyment and habit, the "law of effect" describes that satisfaction could influence habit strength by making the behavior more likely to be performed again, because the connection between stimulus and response can be reinforced by reward (Thorndike, 1911). Thus, physical activity enjoyment may serve to sustain behavior and accelerate the learning of a cue-behavior association, both of which are stages in habit formation (Gardner & Lally, 2018). Phillips and Mullan (2022) even suggest that persistent and intrinsic rewards are necessary ingredients for sustained habit formation of complex behaviors such as exercise (but see also Gardner & Lally, 2022).

The positive relationship between extraversion, conscientiousness, outlook, and resilience and physical activity habit as well as the negative relationship between neuroticism and physical activity habit can be integrated into research and considerations that these constructs are also related to physical activity. Regarding the Big Five traits, in a meta-analysis, extraversion, neuroticism, and conscientiousness were related to physical activity (Rhodes & Smith, 2006). Given the relation between habit and physical activity (Feil et al., 2021), it is reasonable to suspect that these traits might also be relevant for habit strength. With regards to outlook and resilience, it can be assumed that individuals high in these dimensions experience more positive and less negative emotions (Davidson & Begley, 2012). This overall heightened propensity to encounter positive emotions could potentially elucidate why these individuals are more inclined to develop

a habit. Yet, some studies also suggest that there may be no consistent pattern between personality and habit (e.g., Judah, 2015; Wood et al., 2002).

Further, in this study, the relationship between physical activity enjoyment and habit was found to be stronger for individuals high in neuroticism than for individuals low in neuroticism. This finding is particularly relevant considering that in this study, neuroticism was shown to be generally negatively associated with physical activity habit, which is consistent with the negative correlation between neuroticism and physical activity (Rhodes & Smith, 2006). One explanation for this finding could be that individuals high in neuroticism are generally more dependent on enjoying their activity to build a habit. Neuroticism is associated with less physical activity enjoyment (e.g., Engels et al., 2022), and more negative affect in general (Costa & McCrae, 1980). Further, it was shown that it requires certain circumstances, such as the satisfaction of basic psychological needs, for individuals high in neuroticism to experience enjoyment (Engels et al., 2022). It can be assumed that the experience of enjoyment is a pleasant exception to their otherwise rather negative affectivity. Given that especially uncertain rewards are assumed to be relevant for habit formation (Wood & Neal, 2016), enjoyment during physical activity may be a nice exception for them. Moreover, individuals high in neuroticism are also more likely to be afraid of embarrassment in the face of physical evaluation (Courneya & Hellsten, 1998). Considering Lewin's force-field analysis (Lewin, 1951), physical activity enjoyment can represent a driving force drowning out restraining forces such as fear of embarrassment in relation to being physically active or not (see also Brand & Ekkekakis, 2018). Thus, one can conclude that physical activity enjoyment is all the more important to strengthen their habit when it tips the balance of forces in favor of the driving forces.

Additionally, this study found that the relationship between physical activity enjoyment and habit was stronger for individuals low in resilience than for individuals high in resilience. This finding fits with the results on neuroticism, considering the negative correlation between resilience and neuroticism (Kesebir et al., 2019). For people low in resilience, recovery from negative emotions is slower, and they are frequently hampered by adversity (Davidson & Begley, 2012; Kesebir et al., 2019). Consequently, individuals low in resilience may rely more on finding enjoyment in their physical activity to develop a habit. This enjoyment can serve as a driving force and an unexpected reward, countering their otherwise rather negative emotional state (see also Lewin, 1951; Wood & Neal, 2016). For people high in resilience, physical activity enjoyment

may be less important in terms of habit strength because they take the experience of positive emotions for granted, and due to its longevity, the value of this reward might decrease (see also Costa & McCrae, 1980).

This study further showed that outlook, extraversion, and conscientiousness did not significantly moderate the relationship between physical activity enjoyment and habit. Regarding outlook, the longevity of positive emotions implies emotional stability (Davidson & Begley, 2012; Kesebir et al., 2019). The finding that outlook does not moderate the relationship between physical activity enjoyment and habit is supported by our finding that moderating effects were more likely to be found for those traits associated with negative affectivity (i.e., high neuroticism, low resilience). For individuals who tend to experience more negative emotions, physical activity enjoyment seems to counteract the negativity that typically arises, which is also supported by the argument of Baumeister et al. (2001) on the stronger influence of bad emotions compared to good emotions. For an individual who tends to experience more positive emotions, the additional benefit of physical activity enjoyment may be less relevant.

With regards to extraversion, although its main effect on physical activity habit was significant, the moderation effect was not found to be significant. Future studies could investigate need for affect (Maio & Esses, 2001) and other factors associated with extraversion such as reward responsiveness or fun seeking (Carver & White, 1994) or its finer facet traits such as sensation seeking and activity (see also Rhodes & Smith, 2006; Rhodes & Pfaeffli, 2012) and examine whether these variables moderate the enjoyment-habit relationship.

Regarding conscientiousness, individuals who tend to be well-organized and dutiful may not benefit more or less from physical activity enjoyment as they may form cue-behavior associations, simply because of the consistent repetition of behavior in stable settings. In their work on the individual difference factor “grit”, Duckworth et al. (2007) found that conscientiousness was associated with grit, i.e., persistence and craving for long-term goals. As mentioned by Woolley and Fishbach (2017), this could mean that for gritty or conscientious individuals, enjoyment as an immediate reward is less important because they stay the course regardless of any affective experiences (see also Duckworth et al., 2007). Other determinants, such as health benefits of physical activity, may be more critical for their habit strength (Courneya & Hellsten, 1998). However, Ingledew et al. (2004) found that conscientiousness was positively related to intrinsic regulation and speculate that individuals high in conscientiousness seek to

discover a way to make health-related behaviors satisfying. This highlights the need for future studies that longitudinally examine how the relationships between enjoyment, habit, and personality develop along the different stages of habit formation.

Regarding the covariates in the present study, the results suggest that younger participants and male individuals tend to have higher physical activity habit scores. As age increases, the context undergoes changes; for instance, Wood et al. (2005) discovered that transitioning to a different university can lead to a decrease in the engagement of habitual behaviors. In terms of gender, research shows that male individuals are more likely to meet physical activity guidelines compared to their female counterparts (e.g., Finger et al., 2017), so that this could be associated with them also having higher physical activity habit scores.

Strengths and limitations

This study presents notable strengths as it examined two constructs relevant to the maintenance of physical activity, enjoyment (e.g., Fritsch et al., 2022) and habit (e.g., Feil et al., 2021), in a sufficiently large sample and incorporates a new approach to describing personality, the emotional style theory (Davidson & Begley, 2012). However, the cross-sectional design only allows for an analysis of the relationship between the current level of physical activity enjoyment and ongoing automaticity and does not allow for an examination of habit formation. Another limitation is to be seen in the rather athletic sample. Participants particularly reported high average values for physical activity enjoyment, which was also evident in other studies (e.g., Chen et al., 2021; Fritsch et al., 2022).

Conclusions

The present study explored the relationship between physical activity enjoyment, physical activity habit, and the Big Five personality traits neuroticism, extraversion, and conscientiousness as well as the emotional style dimensions outlook and resilience. Our findings suggest that physical activity enjoyment has a strong association with habit. Further, the positive relationship between physical activity enjoyment and habit appears to be a generalizable one, with no moderating effect of any personality trait reversing the relationship to the negative. In nuances, for individuals high in neuroticism or low in resilience, the relationship between physical activity enjoyment and habit was stronger than for individuals scoring low on neuroticism or high on

resilience. Thus, affect-based interventions are recommended for all personality types, but may be particularly effective for individuals with a general negative affectivity.

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Chapter V – Psychometric properties

Study 4: Validation and invariance testing of the English Short Physical Activity Enjoyment Scale

Slightly modified version of the submitted manuscript:

Weyland, S., Kaushal, N., Fritsch, J., & Jekauc, D. (submitted). Validation and invariance testing of the English Short Physical Activity Enjoyment Scale. *BMC Psychology.*

Abstract

Background. Enjoyment is recognized as a determinant of physical activity habits. The enjoyment of engaging in physical activity can be measured with the Physical Activity Enjoyment Scale (PACES). Later versions of this scale have been shortened to capture the component of subjective feeling, which has been validated using German-speaking samples. The aim of this study was to examine internal consistency, factorial validity, criterion-related validity, test-retest reliability, and measurement invariance (across gender and languages) in an English-speaking population.

Methods. Data on physical activity enjoyment and self-reported physical activity were collected through an online survey with a test-retest design (n = 276,189 female, M = 42.55, SD = 16.81 years). In addition, a German-speaking sample (n = 1017, 497 female, M = 29.77, SD = 13.54 years) was analyzed to assess measurement invariance with respect to language.

Results. McDonald's omega at time 1 was $\omega = 0.95$. Confirmatory factor analysis showed a good model fit based on the CFI value (χ^2 = 19.8, df = 2, $p < 0.05$; CFI = 0.984; RMSEA = 0.180, 90 % CI [0.113-0.256]). The criterion-related validity for light physical activity was $r(107) = 0.26$ ($p < 0.05$). The 7-day retest reliability was $r(199) = 0.69$ ($p < 0.05$). Further, the results supported measurement invariance across gender and partial measurement invariance across languages.

Conclusions. Overall, the English PACES-S demonstrated good psychometric properties specifically for light intensity of physical activity, and can serve as an economical instrument to assess physical activity enjoyment.

Introduction

Promoting the repetition of physical activity behavior is a central concern within the field of exercise psychology, as it is essential to continuously engage in physical activity to reap the associated health benefits (Reiner et al., 2013; Rhodes et al., 2017). This necessity is underscored by the fact that increased levels of overall physical activity and reduced sedentary time were associated with a decrease in the risk of premature mortality among middle-aged and older adults (Ekelund et al., 2019). However, dropout in physical activity programs continues to remain as a significant challenge despite these distal rewarding consequences (Finne et al., 2019). This highlights the importance of immediate advantages, such as perceived enjoyment, in maintaining or even making physical activity habitual (Kaushal & Rhodes, 2015; Teixeira et al., 2022; Weyland et al., 2020). The association between physical activity enjoyment and physical activity was also evident in a meta-analysis (Rhodes et al., 2009).

In terms of measuring affective determinants, it is imperative to distinguish between automatic affective responses and conscious emotions (Baumeister et al., 2007). Affective responses stemming from automatic processes are elicited from a stimulus that bypasses cognitive reflection. This automatic affective response can be differentiated by its valence ranging from positive to negative (Russell, 1980). In contrast, emotions are manifested in the conscious processes based on cognitive appraisal of an observed stimulus and are thus comparatively slower to develop. (Baumeister et al., 2007). Their greater complexity compared to automatic affective responses is also evident in theories that posit emotions to be composed of various components, namely cognitive appraisals, neurophysiological processes, motivational tendencies, motor expressions, and subjective feelings (Scherer, 2010).

The unique methods on how affective determinants are formulated in each processes also necessitates distinct approaches to measure them (Zenko & Ladwig, 2021). For instance, affective responses in the automatic processes can be measured by administering the Feeling Scale (asking “How do you feel right now?”), which is an established instrument that can be employed multiple times during an exercise session (Hardy & Rejeski, 1989). This approach makes it possible to depict the valence of the affective response when exercising. From individual patterns of the Feeling Scale values, conclusions can then be drawn regarding which intervals of the exercise induced the experience of pleasure or displeasure (Backhouse et al., 2007). In contrast, measuring

cognitively appraised emotions can be conducted by administering a scale post-exercise/physical activity session, such as the "Physical Activity Enjoyment Scale" (PACES; "Please rate how you feel at the moment about the physical activity you have been doing"), which was developed and validated across two studies (Kendzierski & DeCarlo, 1991).

Furthermore, it is important to consider not only acute affective or emotional experiences (i.e., automatic affective responses and conscious emotions), but also how they manifest in cognitive processing such as reflection or learning (Baumeister et al., 2007; Brand & Ekkekakis, 2018). PACES is also appropriate for the use in studies that seek to measure a general cognitive reflection on the overall enjoyment expected from engaging in physical activity based on past emotional experiences (Rhodes et al., 2009). For example, the item stem "When I am active" can be used to ask how the participants feel during physical activity in general (Jekauc et al., 2019).

PACES is therefore widely used for measuring physical activity enjoyment (Stevens et al., 2020). Though overtime, researchers have noted some limitations in the scale (for an overview see also Chen et al., 2021). For example, validation studies revealed methodological problems of the common variance of negatively and positively formulated items (Jekauc et al., 2020; Jekauc et al., 2013; Motl et al., 2001). Interestingly the scale's original creators have raised the question of whether enjoyment should be viewed as a unidimensional construct (Kendzierski & DeCarlo, 1991), which lead to excluding items that were associated with preconditions or consequences of enjoyment (e.g., "it makes me depressed"), rather than the experience of enjoyment itself (e.g., "I enjoy it") (Raedeke, 2007). Another study which recruited older adults to reflect age-related changes in emotion regulation and emotion judgement was conducted to further refine the scale (Mullen et al., 2011). Here, a panel of experts was instructed to select only items related to psychological and social well-being. The resulting 8-item version was subjected to a factor analysis in another study, with the two factors that produced a better model fit than a unidimensional model being labeled "fun" (i.e., pleasurable entertainment) and "satisfaction" (i.e., momentary experience) by the authors (Rodrigues et al., 2021).

PACES-S takes the next step towards scale refinement and efficiency (Chen et al., 2021). It measures the cognitive reflection of the conscious emotion physical activity enjoyment with the associated subjective feeling considered its central emotional component (Baumeister et al., 2007; Chen et al., 2021; Scherer, 2010). While PACES-S was initially validated using data from youth

participants (Chen et al., 2021), a subsequent validation study also demonstrated good reliability and validity of the instrument for an adult population (Fritsch et al., 2022). Further, previous tests support PACES-S to be used invariantly across genders (Fritsch et al., 2022).

Overall, PACES-S presents convincing strengths, including lower participant item burden (4 item scale), and validity across the age range and between genders. However, the two validation studies were limited to German-speaking populations (Chen et al., 2021; Fritsch et al., 2022). Given its potential for use in large-scale cross-cultural studies, it is important to investigate whether the underlying factorial structure, factor loadings, measurement intercepts, and residuals are consistent across languages to rule out bias due to measurement error (Wu et al., 2007).

The purpose of this study was to validate an English version of PACES-S. The primary objective of this study was to test psychometric properties which included the internal consistency, factorial validity, criterion-related validity, test-retest reliability, and gender invariance of PACES-S in an English-speaking population. The secondary objective was to assess whether the measure is invariant across English- and German-speaking populations.

Materials and methods

Procedure

The psychometric properties of PACES-S within an English-speaking sample (Sample 1) were investigated using a test-retest design, gathering self-report data through online questionnaires. The two measurement points were separated by a one-week interval. Physical activity enjoyment and sociodemographic information were evaluated during the initial measurement, while the second measurement focused on assessing physical activity enjoyment and self-reported physical activity. Ethical clearance was secured from the university's ethics committee, and approval from the data security commissioner was obtained. All participants provided written informed consent prior to their involvement in the study.

To conduct an invariance analysis across languages, we additionally examined self-report data on physical activity enjoyment obtained from a German cross-sectional study, utilizing paper-and-pencil questionnaires (Sample 2). This particular sample was previously incorporated in the aforementioned investigation of the psychometric properties of PACES-S within an adult German population (Fritsch et al., 2022). Ethical approval was secured from the university's

ethics committee, and consent from the data security commissioner was obtained. All participants provided written informed consent prior to their involvement in the study.

Sample 1

English-speaking participants were recruited through social media. Inclusion in the study required only two criteria: (a) being a minimum of 18 years old and (b) being fluent in the English language. The study comprised a total of 276 participants (189 female, 86 male, 1 with missing data) with an average age of 42.55 years (*SD* = 16.81, ranging from 18 to 85 years). From those participants, 202 (137 female, 64 male, 1 with missing data) individuals with a mean age of 46.25 years (*SD* = 17.81; range = 20 to 85 years) took part in the second measurement for the test-retest reliability.

Sample 2

German-speaking participants were recruited from university courses, fitness gyms, or sports clubs. To be included in the study, only two criteria needed to be met: (a) being a minimum of 18 years old and (b) being fluent in the German language. The study comprised a total of 1017 participants (497 female, 2 with missing data) with an average age of 29.77 years (*SD* = 13.54, ranging from 18 to 83 years).

Measures

PACES-S

Physical activity enjoyment was measured in both samples. Regarding Sample 1, we used a English version of the PACES short version (PACES-S) (Chen et al., 2021), with the item stem “When I am physically active“, that were answered with the four items “I like it”, “I find it pleasurable”, “It is very pleasant”, and “It feels good” on a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. In German (Sample 2), the item stem was “Mich zu bewegen” (literally translated “being physically active”). Overall enjoyment was calculated as the mean of the four items, with higher values indicating higher levels of enjoyment. Two prior investigations have affirmed the psychometric properties of the German PACES-S in both a youth (Chen et al., 2021) and an adult population (Fritsch et al., 2022). Regarding reliability, the latter evaluated McDonald’s omega in three studies and concluded that the level of internal consistency

was acceptable to good (values between 0.78 and 0.88). Further, it demonstrated moderate test-retest reliability (r = 0.73). Concerning factorial validity, the three studies supported the unidimensional structure of the instrument using confirmatory factor analysis (e.g. χ^2 = 10.0; df = 2; $p < 0.01$; CFI = 0.992; RMSEA = 0.063, latent factor loadings between 0.63 and 0.75). In terms of criterion-related validity, physical activity enjoyment was significantly positively correlated with self-reported physical activity (r = 0.40). Moreover, the investigation showed the measurement's invariance across gender.

International Physical Activity Questionnaire

In Sample 1, self-reported physical activity was assessed based on relevant items from the modified International Physical Activity Questionnaire (IPAQ, Craig et al., 2003), which referred to the last two weeks. Participants were asked about the number of days per week and the average number of minutes per session they engaged in light (defined as any physical activity that does not cause a noticeable change in breathing) and moderate (defined as any physical activity that is not exhausting or only makes one breathe somewhat harder than normal) physical activity. The product of the days per week and the amount of minutes per session yielded the average minutes per week that participants were physically active in the two different categories of physical activity.

Statistical Analysis

The present paper contains data from two samples. First, we examined psychometric properties (i.e., internal consistency, factorial validity, criterion-related validity, test-retest reliability, and gender invariance) of PACES-S in an English-speaking sample. Second, we additionally utilized a dataset from a German-speaking sample to conduct invariance analysis across languages.

As a first step, Little's MCAR test (Little, 1988) was performed to check patterns of missing values. In addition, all physical activity information (assessed with the IPAQ) was checked for plausibility. If days per week exceeded 7, the value was corrected to 7. Questionable values for the amount of minutes per session (e.g., 2 minutes of light physical activity per session) were neither corrected nor deleted. Correlations were calculated once with and once without the implausible values or once with and once without the corrected values in order to check the

robustness of the results. Further, the descriptive statistics mean (M) and standard deviation (SD) were calculated and the differences in the means between the two samples were tested for significance using the Welch-test (see also Rasch et al., 2011). The threshold for significance was .05 for all analyses.

Internal consistency

To evaluate internal consistency, we determined McDonald's omega using the SPSS macro developed by Hayes and Coutts (Hayes & Coutts, 2020).

Factorial validity

In order to assess the unidimensional factor structure identified in previous studies of the German short version (Chen et al., 2021; Fritsch et al., 2022), a confirmatory factor analysis (CFA) was performed using full-information maximum likelihood estimation in IBM SPSS AMOS 28 (Arbuckle, 2019). This estimation method was chosen as it allows for an unbiased assessment of missing data (Jekauc et al., 2012). Overall model fit was evaluated using the χ^2-statistic. Here, a non-significant p-value indicates a good fit for the model (Barrett, 2007). However, for large samples, the test is highly sensitive, detecting even minor deviations between the observed and model-implied covariance matrices (Bollen, 1989; Hu & Bentler, 1999). As a result, it can reject the null hypothesis of a good model fit even when the model's inaccuracies are negligible. Therefore, we additionally used the comparative fit index (CFI), which assesses the relative improvement in fit by comparing the proposed model to a baseline model, and values in the range of 0.90 to 0.95 are considered indicative of an acceptable model fit, while values exceeding 0.95 suggest a good model fit (Hu & Bentler, 1999). Further, we applied the root mean square error of approximation (RMSEA) as an indicator of how closely the model fits the data, with values below 0.05 indicating of a good model fit and values between 0.05 and 0.08 indicating an acceptable model fit (Browne & Cudeck, 1993). Additionally, for a good model fit, the 90 % confidence interval around the RMSEA point estimate should encompass zero (Hooper et al., 2008).

Criterion-related validity

To assess criterion-related validity, the respective correlations between physical activity enjoyment measured with PACES-S and the two categories of physical activity (i.e., light and moderate physical activity) were calculated.

Test-retest reliability

To assess test-retest reliability, we determined the Pearson product-moment correlation between PACES-S scores obtained during the first and second measurements.

Measurement invariance for gender

A multi-group confirmatory factor analysis (CFA) was conducted by testing four nested models using IBM SPSS AMOS 28 (Arbuckle, 2019) to examine the measurement invariance for gender (male vs. female) (Wu et al., 2007). As such, certain parameters (e.g., factor-loading regression paths) are systematically examined in a reasonably ordered and progressively restrictive manner, starting with an unconstrained model to test the validity of factorial structure, also known as configural invariance (Model A) (Byrne, 2004; Putnick & Bornstein, 2016). In the following models, cross-group equality constraints were imposed as follows (Wu et al., 2007): In Model B, the factor loadings were constrained equal across groups. In Model C, the constraints of the previous model were retained and additionally, the measurement intercepts were constrained to equality. Finally, in Model D, in addition to factor loadings and measurement intercepts, also the residuals (i.e., regression residual variances for all items) were constrained equal (Wu et al., 2007). As such, Model B tested metric invariance, Model C tested scalar invariance, and Model D tested residual invariance (Putnick & Bornstein, 2016).

Model fit parameters of all models were simultaneously estimated for both groups (Byrne, 2004). This involved the consideration of χ^2 difference tests and change in Comparative Fit Index-values (ΔCFI) as an alternative criterion for evaluating measurement invariance (Cheung & Rensvold, 2002). If the χ^2 for model comparison is not statistically significant or ΔCFI-values are $\leq .01$, the hypothesis of invariance is maintained. However, if a model had to be rejected according to these criteria, partial invariance models (e.g., partial metric invariance model) were tested. These models allow certain parameters (e.g., factor loadings) to differ between groups and this

freely estimated subset of parameters may reveal non-invariant items (Byrne, 2004; Byrne et al., 1989; Putnick & Bornstein, 2016).

Measurement invariance across languages

The same procedure as described above for multi-group CFA was applied to examine the two samples, German-speaking and English-speaking participants, in order to assess measurement invariance across languages.

Results

Descriptive statistics

In Sample 1, the percentage of missing values was 0.4 % for items 1 and 2, 1.8 % for item 3 and 1.4 % for item 4 in the first measurement. In sum, for the four items, 11 values (0.996 %) distributed among 5 subjects were missing. The Little's MCAR test was significant ($\chi^2 = 43.2$, $df = 5$, $p < 0.05$), indicating that missingness in the data was related to the data. Applying listwise deletion, we removed the participant who had no values for PACES-S and imputed values for the remaining four participants with missing values using the expectation-maximization algorithm (EM algorithm; Jekauc et al., 2012; Little & Rubin, 2019).

In the second measurement, the percentage of missing values was 0 % for items 1 and 2 and 0.5 % for items 3 and 4. In sum, for two of the four items, 2 values (0.249 %) distributed among 2 subjects were missing. The Little's MCAR test was not significant ($\chi^2 = 7.6$, $df = 6$, $p = 0.27$), indicating that missingness in the data was not related to the data. We imputed values for the two participants with missing values using the expectation-maximization algorithm again (EM algorithm; Jekauc et al., 2012; Little & Rubin, 2019).

Regarding Sample 2, the percentage of missing values was 0 % for items 1 and 4 and 0.1 % for items 2 and 3. In sum, for two of the four items, 2 values (0.049 %) distributed among 2 subjects were missing. The Little's MCAR test was not significant ($\chi^2 = 12.1$, $df = 6$, $p = 0.06$), indicating that missingness in the data was not related to the data. Again, we imputed values for the two participants with missing values using the expectation-maximization algorithm (EM algorithm; Jekauc et al., 2012; Little & Rubin, 2019).

Means and standard deviations of the individual PACES-S items and the overall scale in Sample 1 (for both measurement times) and Sample 2 are shown in Table 5.1. There was a significant difference ($t(309.3) = 11.31$, $p < 0.05$) between PACES-S values of Sample 1 in the first measurement (English) and Sample 2 (German), with mean PACES-S values 0.78 points (95 %-CI [0.64, 0.91]) lower in Sample 1. There was also a significant difference ($t(215.8) = 9.09$, $p < 0.05$) between PACES-S values of Sample 1 in the second measurement (English) and Sample 2 (German), with mean PACES-S values 0.79 points (95 %-CI [0.62, 0.96]) lower in Sample 1.

Table 5.1

Descriptive statistics

	Sample 1				**Sample 2**	
	M₁	***SD₁***	***M₂***	***SD₂***	***M***	***SD***
When I am physically active I like it.	3.82	1.19	3.97	1.28	4.71	0.55
When I am physically active I find it pleasurable.	3.65	1.19	3.56	1.31	4.37	0.75
When I am physically active it is very pleasant.	3.49	1.19	3.34	1.35	4.20	0.83
When I am physically active it feels good.	3.77	1.19	3.84	1.29	4.57	0.61
PACES-S	3.69	1.11	3.68	1.20	4.46	0.53

Note. *M1* = mean at first measurement; *SD1* = standard deviation at first measurement; *M2* = mean at second measurement; *SD2* = standard deviation at second measurement.

Regarding self-reported physical activity, 13 individuals reported more than 7 days per week and were corrected to 7. Six individuals reported questionable values for minutes per session (< 10 minutes), but these values were retained. For light physical activity, the mean was M = 158.42 minutes per week (SD = 222.77) and for moderate physical activity, the mean was M = 110.71 minutes per week (SD = 104.79).

Psychometric properties

Internal consistency

Concerning the reliability, the values for McDonald's omega (ω = 0.95 at the first measurement; ω = 0.94 at the second measurement) indicated an excellent internal consistency of PACES-S (Cicchetti, 1994).

Factorial validity

Regarding the factorial validity of PACES-S, the model showed a good fit to the data based on the CFI value, which was close to 1 (χ^2 = 19.8, *df* = 2, $p < 0.05$; CFI = 0.984; RMSEA = 0.180, 90 % CI [0.113-0.256]). However, the χ^2-test was significant and the 90 % confidence interval for RMSEA did not cover 0, but given the high sensitivity of the χ^2-test (Hu & Bentler, 1999) and the low degrees of freedom, this does not necessarily imply that the model would not fit (Kenny et al., 2015). Further, all individual items significantly loaded on the latent factor (see Table 5.2 for factor loadings) with an explained variance between R^2 = 0.781 and R^2 = 0.882.

Table 5.2

Standardized regression weights and explained variance

	Factor loadings	R^2
Item 1	0.884	0.781
Item 2	0.939	0.882
Item 3	0.904	0.818
Item 4	0.894	0.799

Note. R^2 = squared factor loadings; Factor loadings = standardized regression weights.

Criterion-related validity

In terms of the criterion-related validity, the correlation between light physical activity and PACES-S [$r(107) = 0.26$, $p < 0.05$] but not between moderate physical activity and PACES-S [$r(96) = 0.01$, $p = 0.91$] was significant. These results were the same when the individuals with the corrected values (when days per week > 7 days) or implausible values (minutes per session < 10 minutes) were excluded.

Test-retest reliability

Regarding test-retest reliability, the correlation between PACES-S scores obtained during the first and second measurement was significant [$r(199) = 0.69$, $p < 0.05$].

Measurement invariance for gender

Regarding gender invariance, as shown in Table 5.3, the χ^2-difference test was not significant for any model (Models B to D). Further, because the difference in CFI did not exceed 0.01 for any comparison, the results suggest that the instrument is invariant across gender (Cheung & Rensvold, 2002). Table 5.3 also shows that RMSEA was not always within the recommended ranges (Browne & Cudeck, 1993), but given the small sample size and low degrees of freedom, this does not necessarily imply that the model would not fit (Kenny et al., 2015).

Table 5.3

Analysis of invariance across gender

Model	χ^2	*df*	*p*	CFI	RMSEA	ΔCFI	$\Delta\chi^2$	Δdf	*p*
Model A	26.6	4	< 0.05	0.979	0.114				
Model B	28.7	7	< 0.05	0.979	0.107	0.000	2.1	3	.55
Model C	30.5	10	< 0.05	0.981	0.087	0.002	1.8	3	.61
Model D	36.7	14	< 0.05	0.979	0.077	0.002	6.2	4	.18

Note. χ^2 = chi-square; *df* = degrees of freedom; *p* = probability value; CFI = Comparative Fit Index; RMESA = Root Mean Square of Approximation; ΔCFI = difference in CFI; $\Delta\chi^2$ =difference in chi-square; Δdf = difference in degrees of freedom.

Measurement invariance across languages

Regarding language invariance, the first row of Table 5.4 shows that Model A, which tested configural invariance, had a good model fit based on the CFI value and an acceptable model fit based on the RMSEA value, which is an indication of the equivalence of model form (Putnick & Bornstein, 2016). However, as shown in the second row, the difference in CFI for the comparison between Model A and B_1 exceeded 0.01, and the χ^2-difference test was significant, indicating metric noninvariance. As a way of dealing with metric noninvariance, factor loading

constraints were relaxed until partial metric invariance was found (Putnick & Bornstein, 2016). Following a forward approach, we first removed all factor loading constraints except for item 2, i.e., the item with the first factor loading to be estimated (Byrne, 2004; Putnick & Bornstein, 2016). The model fit still indicated noninvariance (model not shown in Table 5.4). Therefore, the factor loading of item 2 was freely estimated rather than constrained to be equal in the next model and only the factor loading of item 3 was constrained to be equal, but the model fit still indicated noninvariance. Thus, the factor loadings of items 2 and 3 were freely estimated rather than constrained to be equal and only the factor loading of item 4 was constrained to be equal in the next model, Model B_2 (see Table 5.4). The difference in CFI for the comparison between Model A and B_2 did not exceed 0.01, and the χ^2-difference test was not significant, indicating partial metric invariance with the factor loading parameter of item 4 being equal across groups (Byrne, 2004). In sum, we concluded that items 2 and 3 were noninvariant, but that item 4 was invariant (Byrne, 2004). As such, only the equality constraints for item 4 were maintained when moving on to Model C. Subsequently, scalar invariance (Model C) and residual invariance (Model D) were found. Regarding the comparisons between Model B_2 and C as well as Model C and D, while the χ^2-difference tests were significant, the differences in CFI did not or only slightly exceed 0.01, supporting invariance (Cheung & Rensvold, 2002). In sum, the results suggest that the instrument is partially invariant across languages.

Table 5.4

Analysis of invariance across languages

Model	χ^2	*df*	*p*	CFI	RMSEA	ΔCFI	$\Delta\chi^2$	Δdf	*p*
Model A	29.8	4	<.05	0.988	0.071				
Model B_1	89.7	7	<.05	0.962	0.096	0.026	59.9	3	<.05
Model B_2	32.0	5	<.05	0.987	0.065	0.001	2.2	1	0.14
Model C	36.9	6	<.05	0.986	0.063	0.001	4.9	1	<.05
Model D	61.8	8	<.05	0.975	0.072	0.011	24.9	2	<.05

Note. χ^2 = chi-square; *df* = degrees of freedom; *p* = probability value; CFI = Comparative Fit Index; RMESA = Root Mean Square of Approximation; ΔCFI = difference in CFI; $\Delta\chi^2$ =difference in chi-square; Δdf = difference in degrees of freedom.

Discussion

The purpose of this study was to test the psychometric properties of PACES-S (Chen et al., 2021; Fritsch et al., 2022) in an English-speaking population and to examine its measurement invariance compared to a German-speaking sample. When employing PACES-S in diverse settings, it is important to test the measurement's invariance across various population attributes. Overall, the psychometric tests met reliability and validity criteria. In terms of reliability, the results indicate excellent internal consistency and acceptable test-retest reliability. Regarding factorial validity, the results point to a good model fit based on the CFI value. Additionally, the results for criterion-related validity indicate a significant positive relationship with light, but not moderate physical activity. With regard to the measurement invariance, the instrument appears to be invariant across gender, but invariance across languages was only partially evident.

The reliability values obtained in this study, namely an McDonald's omega exceeding 0.90 at both measurement points, were higher than the values found in a validation study of PACES-S in German-speaking adults (between 0.78 and 0.88) (Fritsch et al., 2022). The authors attributed the acceptable but not excellent values to the possibility of altered variance due to a restriction of range, given the recruitment of two of their samples in sports contexts (Fife et al., 2012). Notably, the English-speaking sample used in the present study included not only individuals engaged in exercise contexts, and the mean scores of PACES-S were significantly lower than those of the German-speaking sample, which had also been used in the previous validation study. In sum, our values were more comparable to the excellent values for internal consistency of the long version of PACES (Kendzierski & DeCarlo, 1991). Further, the test-retest reliability ($r = 0.69$) was slightly below the recommended value of 0.70 (Cicchetti, 1994), but still comparable to the results of the study on PACES-S in German adults (Fritsch et al., 2022) and to a study on the long version (Jekauc et al., 2013).

Regarding factorial validity, a good model fit was revealed based on the CFI value (Hu & Bentler, 1999), while the χ^2-test was significant and the RMSEA value was above 0.08. However, the sensitivity of the χ^2-test is very high (Hu & Bentler, 1999) and the RMSEA can also underestimate the model fit when the degrees of freedom is low (Kenny et al., 2015), which was the case in the present study. In general, our results tend to support the assumption of the unidimensional structure of PACES-S, as also emphasized in the study on German adults (Fritsch

et al., 2022). The question of whether enjoyment is a unidimensional construct or whether it can be divided into components was already raised in the study on the development of the original long-version PACES (Kendzierski & DeCarlo, 1991). Certain items associated with preconditions or consequences of enjoyment were excluded from PACES in previous studies, focusing on the experience of enjoyment itself (Raedeke, 2007). Following a similar approach, PACES-S was developed with the aim to only include those items that reflect the subjective experience of enjoyment as the most essential component of an emotion (Chen et al., 2021; Scherer, 2010). Our results tend to support that PACES-S consists of only one latent factor that could represent the cognitive reflection about the overall subjective experience of physical activity enjoyment (Baumeister et al., 2007). However, since the model fit was not excellent, it is necessary to assess this tendency with larger samples in future studies.

In terms of the criterion-related validity, the results indicate that PACES-S is positively correlated with light, but not moderate physical activity. In contrast, previous studies have found an association between moderate to vigorous physical activity and physical activity enjoyment when using PACES-S (Fritsch et al., 2022) and the long version (Jekauc et al., 2020) in German adults. It is important to note differences in the samples that may explain these findings. For example, while the average number of minutes of moderate to vigorous physical activity per week in the previous validation study of PACES-S in German adults was about 200 minutes, in contrast, the average for moderate physical activity in the present study was only about 111 minutes per week. This could be explained by the fact that the mean age in the previous study was 22.30 (*SD* = 3.25, range = 18 to 31) and in the present study 42.55 years (*SD* = 16.81, range = 18 to 85).

Tests for measurement invariance found PACES-S to be invariant across gender, which aligns with findings in the previous validation study with German-speaking participants (Fritsch et al., 2022).

Finally, the measurement invariance analyses showed that invariance across languages appears to be partial. In a first step, this study tended to demonstrate configural invariance, meaning that the basic model structure (4 items loading on a latent factor) of the construct was acceptable for both groups (Putnick & Bornstein, 2016). In the second step, metric invariance was examined. Metric invariance would mean that the contributions of each item (i.e., factor loading) to the latent factor (i.e., the construct of physical activity enjoyment) are similar across the two

groups (Putnick & Bornstein, 2016). However, the model fit of the metric invariance model was significantly worse than that of the configural invariance model. This finding of metric noninvariance suggests that at least one factor loading was not equivalent across the two groups (Putnick & Bornstein, 2016) and that there may be disagreement between the two groups about the manifestation of the construct (Cheung & Rensvold, 2002). How much the frequently occurring finding of metric noninvariance affects group comparisons depends on the number of invariant items – with a small number of invariant items no problematic bias is to be expected (Byrne et al., 1989; Cheung & Rensvold, 2002). Therefore, it is recommended to relax the constraints of overall construct-level metric invariance (i.e., equality of *all* factor loadings) at the item level (i.e., identification of metric noninvariant items to detect partial metric invariance) (Byrne et al., 1989; Cheung & Rensvold, 2002). In the present study, there was evidence that item 2 "When I am physically active I find it pleasurable" (German: "Mich zu bewegen genieße ich") and item 3 "When I am physically active it is very pleasant" (German: "Mich zu bewegen ist sehr angenehm") may be the metric noninvariant items. These items may contribute more to the construct of physical activity enjoyment in the English-speaking than in the German-speaking sample. This may be due to the linguistic proximity between the words of the items. It could be that the words "pleasurable" and "pleasant" are linguistically closer in English and are seen more as representatives of the category "enjoyment", which is in fact defined as an emotion associated with feelings of "pleasure" (Chen et al., 2021). In contrast, in German, the words "genießen" and "angenehm sein" may be linguistically further apart and belong to different linguistic categories than "Freude". However, this can only be speculated here and would be the subject of future research, preferably from the qualitative research stream.

In the third and fourth step, both scalar and residual invariance tended to be supported for the metric invariant items 1 and 4. This means that the mean differences in physical activity enjoyment capture all mean differences in the common variance of the items and that the sum of the variance of the items that is not shared with the latent factor and the error variance is comparable in both groups (Putnick & Bornstein, 2016). Therefore, PACES-S fulfills the conditions for comparing latent means (Cheung & Rensvold, 2002).

Strengths and limitations

The validation of an English version of PACES-S presents several strengths worth noting. In addition to other psychometric properties, measurement invariance across languages was examined using structural equation modeling. Specifically, configural, metric, and scalar invariance were tested as prerequisites for comparing latent means, as well as residual invariance, which was often omitted in other studies (Putnick & Bornstein, 2016). By considering partial invariance models, metrically noninvariant items were uncovered. While the present study remains speculative in the interpretation of this finding, future studies could explore the linguistic comparability of PACES-S in greater depth, both at the content level using qualitative studies and at the formal level using artificial intelligence. Regarding the latter, the use of the web program "Survey Quality Predictor 3.0" (see also Saris & Gallhofer, 2014) seems promising. This tool could be used to reveal formal differences resulting from translations, to suggest corrections and finally to estimate the quality of items, so that it could contribute to greater comparability of items across languages.

A limitation of this study was that the scale demonstrated stronger psychometric properties towards lower intensities of physical activity. Additional tests are warranted to confirm if the measure would demonstrate predictive validity for higher intensities of physical activity.

Another limitation of the present study is the smaller sample size of the English-speaking sample compared to the German-speaking sample. However, given the greater variance in terms of physical activity enjoyment, the English-speaking sample seems to be more representative than the larger German-speaking sample recruited from a sports context. Future studies could consider matching samples on variables such as age or amount of physical activity to make them more comparable, differing only in terms of language. Further, the use of self-report data for physical activity to test the criterion-related validity constitutes a limitation of the present study, given the discrepancy between self-reported and device-based measures of physical activity (Wunsch et al., 2021).

Conclusion

In conclusion, the results of the present study supported psychometric properties of PACES-S, including excellent internal consistency and acceptable test-retest reliability, as well as factorial validity, criterion-related validity regarding light physical activity, and measurement invariance across gender. Partial measurement invariance across languages was also demonstrated. This scale serves an English version of the previously validated German language PACES-S measure (Chen et al., 2021; Fritsch et al., 2022). These scales can assist in conducting cross-group comparative research with minimized measurement bias. In addition, this more economical version of PACES, consisting of only 4 items, is an instrument suitable for large-scale or ambulatory assessment studies. Further research is encouraged to assess if the scale can predict higher intensities of physical activity, and would exhibit residual invariance across languages.

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The relationship between affect-related constructs and physical activity habit

Chapter VI – General Discussion

Discussion of the findings: What are the results and how do they fit with the literature?

This PhD aimed to examine insights from animal studies regarding the relationship between affective responses and habit (e.g., Thorndike, 1911) in the real-world context of physical activity. The overarching research question was whether affect-related constructs (e.g., acute affective response or physical activity enjoyment) and physical activity instigation habit are related. The results are discussed below based on the literature.

An attempt to answer question 1: Is the affective response related to habit formation?

It was found that there was a direct relationship between affective responses and the formation of instigation habits at the between-subject level (Study 1; Weyland et al., 2020). In other words, individuals who generally reported a more positive affective response also exhibited higher levels of habit. As can be inferred from the explanations provided in the definition of habit (Gardner, 2015; Gardner et al., 2012), this means that these individuals were more likely to make the decision to attend a university sports or gym course automatically, or on "autopilot", without the need for conscious deliberation. Furthermore, within the scope of this PhD, it was also observed that the development of affective responses was associated with the final habit strength at the end of a semester of weekly university exercise courses (Study 2; Weyland et al., 2022). Likewise, in our cross-sectional analysis, physical activity enjoyment was associated with habit (Study 3; Weyland, Fritsch et al., submitted).

In the course of theoretically contextualizing these results, it is first worth mentioning that these findings confirmed the postulated relationship between affective responses and habit formation by the PAAM model (Strobach et al., 2020), which can also be explained by the ART (Brand & Ekkekakis, 2018), in that affective valuations accompany behavioral impulses. As such, positive affective responses may contribute to keeping behavioral decisions at an automatic level, rather than being deliberatively weighed and intentionally controlled through cognitive resources (see also Michie & West, 2013). Regarding more specific habit models, the relationship between affect-related constructs and habit can be integrated into the framework for habit formation

(Gardner & Lally, 2018) when considering the assumption that affective responses determine whether a behavioral outcome is perceived as rewarding or not (de Wit & Dickinson, 2009). If a reward is perceived, it can strengthen the cue-behavior association specific to habit (Gardner, 2015) and make the behavior more likely to occur in the presence of the cue on subsequent occasions (de Wit & Dickinson, 2009; Thorndike, 1911).

Considering that these theoretical reflections quite clearly suggest a relationship between affect-related constructs and habit, there has already been some research in the context of health psychology and, more specifically, in the context of sport and exercise psychology. However, it is noteworthy that affect-related constructs in this context are often examined as affective judgment (see also Stevens et al., 2020), while the present PhD, especially in the first two studies, incorporated the affective response per se. A study on "affect" and habit, for example, is the prospective one conducted by de Bruijn et al. (2014) with the aim of exploring variables that influence exercise automaticity measured two weeks later when controlling for past behavior. Several social-cognitive variables emerged as predictors of exercise automaticity, exerting an influence beyond that of previous behavior. Specifically, factors such as planning, perceived behavioral control, and affective attitude contributed significantly to the regression model with automaticity as dependent variable. Within the habit antecedent model examined in the longitudinal study by Kaushal and Rhodes (2015), several factors, including consistency, low behavioral complexity, environment, and affective judgments, were identified as predictors of habit formation among new gym members. Particularly noteworthy was the observation that affective judgments exhibited the highest predictive power at baseline, while consistency emerged as the key predictor of changes in habit throughout the study period. However, despite labeling their measure as "reward", it actually pertains to querying how exercise is judged, without taking into account whether participants experienced genuine pleasure during or immediately after exercise, which would have been closer to an immediate "reward" (see also de Wit & Dickinson, 2009). In a similar vein, while the study by McCloskey and Johnson (2021) aimed to establish a connection between intrinsic rewards and automaticity for various health behaviors, the actual inquiry revolved around the overall level of pleasure derived from the behavior, rather than examining the immediate experience during the behavior itself.

However, assuming that it is the acute hedonic experience that is associated with the perception of a reward (de Wit & Dickinson, 2009), it seems insufficient to solely ask about an affective judgment regarding physical activity, as cognitive processing can be susceptible to biases or the affective forecasting error (Loehr & Baldwin, 2014; Zenko & Ladwig, 2021). Further, in the realm of attitudes research, it is important to note that a distinction exists between implicit and explicit attitudes. A study of eating behavior conducted by Conner et al. (2007) revealed an interesting dynamic: habit moderated the relationship between implicit attitudes and behavior in such a way that when habits were strong, implicit attitudes exerted a stronger influence on behavior. This raises questions regarding the examination of explicit affective attitudes and their association with habit, as habit did not moderate the relationship between explicit attitudes and behavior in the study by Conner et al. (2007). As shown above, the explicit affective attitude may be related to habit in such a way that people who hold positive affective attitudes also report higher habit strength. However, if it is the implicit attitude that is ultimately related to their behavior, it is important to focus on more implicit, spontaneous sensations such as affective responses and not merely inquire about explicit attitudes.

An attempt to answer question 2: Can we manipulate affect-related constructs?

In line with this perspective, the affect-based intervention evaluated within the scope of this PhD aimed to influence the affective experiences of the participants of weekly university sports and exercise courses (Study 2; Weyland et al., 2022). As such, the intervention differed from other studies in which, for example, affect-related text messages (e.g., “regular physical activity often improves the way one feels about their body/appearance”) were used to improve affective attitudes in order to increase self-reported physical activity (Conner et al., 2011). In the realm of health psychology, there are intervention frameworks that are based on the idea that interventions that focus solely on explicitly modifying participants’ cognitive structures, such as targeting their attitudes, have negligible impact on the subconscious regulatory processes that underlie habitual behaviors (Papies, 2016). Papies (2016) posits that what is required are interventions that harness an understanding of how specific situations activate cognitive structures unintentionally. Consequently, interventions should either manipulate cues (e.g., nudging, see also Forberger et al., 2019) or address context-specific mental frameworks (e.g., implementation intentions, see also Gollwitzer & Sheeran, 2006). While the latter necessitates active involvement from individual participants within an intervention and thus lacks scalability, cue-based

interventions can be regarded as more "discrete" interventions (see also Chevance et al., 2018). In these cases, participants need not consciously contemplate the intervention, as its essence lies primarily in altering the environmental context. Consequently, environment-based interventions offer a higher degree of scalability.

Rather than focusing on explicit constructs, the present intervention targeted factors that research had shown to be associated with positive affective experiences in the context of physical activity (Wienke & Jekauc, 2016) and that have similarities with the self-determination theory (Deci & Ryan, 2008). To manipulate these situational factors without altering the design of each individual sports and exercise course unit, the approach of training the exercise trainers of the respective courses in relation to these factors appeared promising. Firstly, Strauch et al. (2019) showed the importance of the trainer and their competence in relation to affective experiences. Secondly, a trainer intervention with the focus on changing the situated exercise environment was considered scalable because not every course participant had to undergo an intervention (see also Papies, 2016). Thirdly, successful approaches in the literature indicate the potential to manipulate affect-related constructs through trainer interventions (e.g., Jekauc, 2015) or situational factors related to self-determination theory (Vazou et al., 2019; see also Weyland, 2021a). Therefore, the finding that the affect-based intervention for exercise trainers was not successful in eliciting an interaction between group and time regarding various affect-related constructs represents a surprising result that can be discussed both in terms of intervention content and, probably even more importantly, methodologically. These limitations will be discussed in more detail in the section "Limitations and recommendations regarding affect-based interventions", while the next section begins by examining how individual differences can impact the effectiveness of affect-based interventions. These discussions provide a transition into the exploration of the role of personality, both in generating affective experiences and in their relationship with habit formation or maintenance.

An attempt to answer question 3: The same effects for everyone?

When recommending affect-based interventions to not only promote affective responses to physical activity but also related habits, the question arises as to which factors can influence the effectiveness of such interventions on the participants' side. For example, Engels and Freund (2020) examined the effects of cooperative games on enjoyment in physical education. They

found that the intervention featuring weekly games integrated at the start of each lesson could only promote enjoyment with a small effect. In a later work, Engels et al. (2022) refer to such interventions as “one-fits-all solutions”. In fact, Engels and Freund (2020) had already discussed whether their cooperative game-based intervention was not equally effective for all students but might have an effect on specific target groups. They suggest that cooperative games might be more effective for students who typically experience lower levels of enjoyment in physical education. Later on, it was found that Big Five personality traits moderate the relationship between basic psychological needs and physical activity enjoyment, which also suggests that an intervention that promotes social relatedness, for example, may not equally contribute to increased enjoyment in all individuals (Engels et al., 2022). Therefore, personality can be an explanation for the effectiveness of affect-based interventions – and for the case of the relationship between affect-related constructs and habit, personality also seems to be of explanatory value: Does each individual need the same level of positive affective responses to form or maintain a habit? Because if this were not the case, personality would not only explain under what specific conditions an individual experiences positive affective responses within an intervention but also the extent to which this affective response subsequently influences habit.

There is an ongoing debate in the literature regarding whether intrinsic reward is necessary or merely beneficial for habit formation and maintenance (Phillips & Mullan, 2023). Phillips and Mullan (2023) primarily consider the complexity of the behavior to be habituated when discussing this topic and hypothesize that continuous intrinsic reward may be required for complex habitual behaviors. However, a fruitful question for discussion might not only be *whether* a reward is necessary but for *whom*. While behavior-related (e.g., reward value) and actor-related (e.g., personality) factors are often distinguished when it comes to determinants of habit formation, theoretically, these factors could interact as reward value is not objectively definable (see also Gardner et al., 2021). Depending on individual differences or personality, the reward value of a behavioral outcome may be perceived differently. When considering the associative-cybernetic model (de Wit & Dickinson, 2009), it appears that the affective response is related to whether an behavioral outcome will serve as a reward or not, which is not synonymous with every objectively “positive” outcome being a reward – the outcome must actually *feel* rewarding for the actor. In this context, the same level of physical activity enjoyment could, therefore, still have varying effects on the resulting reward value, depending, for example, on the salience of this experience

or saturation (see also Costa & McCrae, 1980). Imagine someone who constantly experiences enjoyment in various behaviors and someone who rarely experiences enjoyment. While the absolute level of enjoyment measured in relation to physical activity may be the same for both, for the person who experiences enjoyment rarely, the value of this unexpected reward could be higher simply because they have not become as habituated to this sensation.

In the literature, enjoyment, specifically affective judgment (Kaushal et al., 2017) or intrinsic motivation (Phillips et al., 2016), is often used as an operationalization of reward. So even if one assumes that enjoyment is considered the same reward by everyone and using "affect" and "reward" nearly synonymously would be appropriate, the associative-cybernetic model still postulates the mediation pathway (de Wit & Dickinson, 2009). Accordingly, reward strengthens habit by associating the cue not only with the behavior but also with the incentive to act, making it more likely to be executed (see also Wiedemann et al., 2014). Nevertheless, if an individual perceives many rewards in life, they may opt for a different behavior associated with an equally rewarding outcome when confronted with the cue, while an individual who perceives fewer rewards may be more inclined to pursue the exceptional incentive to act. To illustrate this complex train of thought, here is an example. The cue might be "Feierabend (closing time)". For someone who receives rewards from various behaviors, there is now a cornucopia of behavioral options to choose from, all of which are worth doing because they all represent rewards – one of these options could be physical activity, but it is unclear whether it will be chosen. On the other hand, for someone who rarely receives behavioral rewards, the choice might be clearly physical activity, if it was last associated with physical activity enjoyment and represents a reward (and probably even the only reward). In this example, both individuals would again have the same level of physical activity enjoyment, yet they might develop habits of varying strengths.

The cross-sectional approach employed in this PhD to consider personality (Study 3; Weyland, Fritsch et al., submitted) cannot definitively answer whether physical activity enjoyment affects habit formation or maintenance differently based on personality, as causality cannot be inferred and results only apply to ongoing habits (see also Gardner et al., 2021). Therefore, this discussion remains speculative at this point, opening up avenues for future research ideas, but it leads to the following preliminary conclusion:

Taken together, this PhD research strongly supports a relationship between affect-related constructs in relation to physical activity and the formation of habits. Furthermore, the positive association between physical activity enjoyment and habit appears to be consistent across various personality traits, with none of them reversing the relationship to a negative one (Study 3; Weyland, Fritsch et al., submitted). However, there might be subtle nuances: individuals with high levels of neuroticism or low levels of resilience exhibited a more pronounced link between physical activity enjoyment and habit compared to those with low levels of neuroticism or high levels of resilience. As a result, one might recommend affect-based interventions for individuals of all personality types, but they may yield particularly significant benefits for individuals who generally experience negative affectivity.

An attempt to answer question 4: How to measure physical activity enjoyment?

In order to be prepared for these future research ideas, it is essential to think about the appropriate measurement instruments. On the one hand, it is of course necessary to consider what the construct to be measured actually is and which instrument is appropriate to capture it (see also Zenko & Ladwig, 2021). However, it is not only important to consider which construct is to be measured (e.g. acute affective response or more general physical activity enjoyment), but also whether it is possible to measure this construct in a measurement invariant way across different groups or measurement time points. Thus, in addition to reliability and validity, measurement invariance must also be examined. This is important in order to be able to conclude, for example, when comparing mean differences between several groups, that these measured and calculated differences really reflect differences at the construct level and are not caused by measurement bias. Only if a construct operates in the same way across groups from a psychometric point of view is it guaranteed to have the same meaning or theoretical structure for different groups (see also Byrne, 2004; Putnick & Bornstein, 2016). Despite the fact that measurement invariance is such an important part of instrument analysis, Byrne (2004) mentions that it is rarely tested and even refers to this analysis as “a road less traveled” in her paper of the same name. Therefore, by demonstrating the (partial) measurement invariance of an English version of the short Physical Activity Enjoyment Scale (Weyland, Kaushal et al., submitted), we add an important aspect to the literature on its psychometric properties (Chen et al., 2021; Fritsch et al., 2022).

From a theoretical perspective, this is all the more important in light of emotion theories within psychological constructivism, which postulate that in the process of categorizing emotions, there are universal components such as the distinction into bipolar affect dimensions, but there are also culture-specific language categories for emotions (Russell, 1991; Russell & Barrett, 1999). Consequently, these contextual variations necessitate the examination of measures across cultural settings to ensure validity and reliability in capturing the nuanced emotional constructs.

Affect and Habit 2.0: Where do we go from here?

Given its limitations, what path does this PhD pave?

Limitations and recommendations regarding affect-related constructs

While it is advantageous that in two studies of this PhD, affective responses during the immediate situation in the sports facility were assessed, the self-report methodology has limitations. Affective phenomena encompass not only subjective feelings that can be categorized and communicated but also an expressive component, for instance (Scherer, 2010). In future studies, alternative methods could help mitigate the bias associated with self-reporting. For example, objective observations of a person's current affective state could be employed (Fritsch et al., 2018; Fritsch, Seiler et al., 2023).

For the future, there are several reasons to recommend gathering ecological valid longitudinal data on individuals' real-life processes in real-time applying "ambulatory assessment" methods like electronic diaries or ambulatory movement assessments (Reichert et al., 2020). This approach allows for the investigation of within-person processes not only for those who were present at the location of the sports and exercise course during a conventional paper-based survey but also for those who were absent. Latest theories explaining physical activity and inactivity zoom in on the moment of encountering an exercise-related stimulus (e.g., Brand & Ekkekakis, 2018). Therefore, not only is the experienced affective response during physical activity important, but also the affect-related constructs that occurred in the very moment of deciding against physical activity. Relatedly, the interplay between factors that promote physical activity and those that favor sedentary behavior was examined in a study by Cheval et al. (2015), who discovered that intentions did not predict devise-based measured physical activity in individuals with high impulsive approach tendencies toward sedentary behaviors. Therefore, if one were to focus only on constructs related to physical activity and ignore implicit constructs

associated with alternative behaviors, it would not accurately capture the complex picture of decision-making.

Additionally, this range of methods enables researchers to extend beyond the structured course setting and delve into the participants' everyday lives, for instance, by employing an interactive multimodal ambulatory monitoring approach measuring their affective responses accelerometer triggered during or after a physical activity sequence (Ebner-Priemer et al., 2013).

In the same breath, recommending "momentary" assessment raises the question of when is the "moment" to measure affect-related constructs (for recommendations regarding affect-measurement see also Zenko & Ladwig, 2021). Regarding the reward value in the context of habit formation, it is certainly justified to assess hedonic experiences in the acute moment, that is, the affective response to physical activity as implemented in this PhD (see also de Wit & Dickinson, 2009). However, especially in the context of dual-process models, it would be advisable for future research to capture various affect-related constructs with precise timing, for example as summarized in the framework by Stevens et al. (2020) or as defined by Baumeister et al. (2007). In the immediate event and shortly thereafter, one can assess core affective responses multiple times using the Feeling Scale (e.g., Ekkekakis et al., 2008; Hardy & Rejeski, 1989). Then, one can measure both the automatic and reflective processing of this affective experience: The former could, for instance, involve the use of an implicit association test to capture implicit affective attitudes (e.g., Phipps et al., 2021), and the latter could range from remembered affect to anticipated affect to affective judgment (e.g., Feil et al., 2022; Rhodes et al., 2009; Zenko et al., 2016). Here, it is also crucial to always pay attention to what the measurement precisely refers to: For example, what object should be inserted into the item stem of the Physical Activity Enjoyment Scale (Kendzierski & DeCarlo, 1991)? Should a general judgment regarding physical activity be queried (e.g., Jekauc et al., 2020), or is it about the enjoyment immediately felt after a physical activity behavior in relation to that physical activity (e.g., Zenko et al., 2016)?

In any case, positive affect-related constructs in this PhD were viewed as dependent on the behavior – asking how participants felt in the immediate moment of the behavior or how much enjoyment the behavior gave them overall. The affect-related stimulus, the object of the emotion, was thus the behavior itself, which was not further differentiated. However, not all physical activity behaviors are equal – for example, physical activity in a green environment might

contribute even more to positive affect-related constructs than exercise on a mat following a digital fitness video (see also Wienke & Jekauc, 2016). In other collaborative work, the benefits of green exercise have already been extensively discussed (Mnich et al., 2019).

Moreover, it is worth mentioning that affect-related constructs do not exclusively pertain to the physical activity itself; the pre-existing incidental affect (e.g., mood, but see also Stevens et al., 2020) also plays a role in the complex interplay of various affect-related constructs when predicting physical behavior (Niermann et al., 2016; Timm et al., 2023). The more of these affective phenomena one can capture with validated measures, the better we will understand how it transitions from acute enjoyment during physical activity to decision-making or habit formation.

Limitations and recommendations regarding affect-based interventions

However, even if researchers manage to measure affect-related constructs more accurately, in real-time, and in relation to not only physical activity but also alternative behaviors, a challenge persists: altering those related to physical activity for the better. Although the present intervention evaluated within the scope of this PhD proved ineffective in terms of affecting affect-related constructs, this approach is noteworthy for its innovation.

From the finding that evidence-based interventions only achieve small effects in promoting physical activity motivation, authors like Ekkekakis and Zenko (2016) or Brand and Ekkekakis (2018) do not conclude that it does not matter whether interventions are based on theory and evidence because they are all equally ineffective. Instead, they suggest that the discipline has relied too heavily on one-sided social-cognitive theories as its foundation. It may be important to base interventions on theories, but the theories could neglect important aspects. Therefore, it seemed reasonable to base an intervention on affect-based evidence (Wienke & Jekauc, 2016).

However, a limiting factor in the effectiveness of the intervention may have been the inconsistent application of a theory, especially since the intervention evaluated in this PhD blended multiple approaches (i.e., we included an additional factor to further emphasize the role of the exercise trainer, as inspired by the findings of Strauch et al., 2019). In their meta-analysis on whether the application of theory improves the effectiveness of physical activity and dietary interventions, Prestwich et al. (2014) conclude that the theories used are often not implemented

consistently. For example, careful consideration of potential mediators, such as behavior change techniques (e.g., Michie et al., 2011), is often lacking. They also note that constructing an intervention based on multiple theories appears to be slightly less effective than constructing an intervention based on a single theory.

What alternative content could our intervention have included? As mentioned by the authors of the chapter on "affect-based interventions" in "The Handbook of Behavior Change" (Conner et al., 2020), such interventions can be categorized into those that aim to directly modify affective responses per se and those that target affect processing. They provide examples for both approaches to manipulate affective experience (for example exergames, see also Vernadakis et al., 2014) and affect processing (for example text messages targeting affective attitudes towards physical activity, see also Sirriyeh et al., 2010). Regarding anticipated affect, a meta-analysis concluded that interventions targeting affective forecasting impact health behavior but not the related anticipated emotions (Ellis et al., 2018). There are more encouraging meta-analytic results available for the realm of physical activity, suggesting that interventions targeting affect-related constructs can increase physical activity levels through positive affective variables (Chen et al., 2020). In sum, this allows for future research to evaluate numerous variations in the content of affect-based interventions. In particular, it would be beneficial not only to test an intervention against a control, but also to compare different intervention techniques against each other. In this way, it becomes clearer which specific intervention contents ultimately produce positive effects on the outcome variables (but see also the chapter on habit interventions in the Handbook of Behavior Change by Gardner, Rebar et al., 2020). It would certainly also be advisable in the future to assess the competencies of the exercise trainers with our validated questionnaire in order to see whether an intervention has had an effect on them (Fritsch, Weyland et al., 2023; Strauch et al., 2023).

Taking a step back: In this PhD research, why was an affect-based intervention offered to the exercise trainers in the first place? On the one hand, it was to provide a scalable intervention from which the participants could benefit. From a methodological perspective, however, it was primarily to manipulate affective responses in order to investigate whether participants in the "affect condition" were more likely to form habits than those in the control condition. Unfortunately, since this manipulation was not successful, we cannot conclusively answer this

question, and uncertainty remains regarding causality: While in this PhD research, the development of affective responses was indeed associated with habit strength; does this mean that habits form *because* individuals enjoyed being physically active? Or could it also mean that individuals had more positive affective responses because their habits developed over time? It is entirely plausible that physical activity initiated habitually is also more enjoyable. This could be explained, for example, by the assumption that habits are part of our identity (Verplanken & Orbell, 2003) and that it feels good to act in line with one's self-schema because then, no cognitive dissonance occurs (see also Banting et al., 2009; Festinger, 1978). Further, Avni-Babad (2011) found that experienced travelers feel safer on flights than inexperienced ones, even though both objectively have no control over the flight's safety. The author concludes that routines provide people with a sense of confidence, safety, and well-being (Avni-Babad, 2011), which can be aligned with self-determination theory (Deci & Ryan, 2008) in order to formulate a hypothesis for future research: Habitual physical activity could increase perceived competence and thus, be related to physical activity enjoyment (see also Engels et al., 2022).

Limitations and recommendations regarding habit

Nevertheless, it is important to emphasize that, in the first two studies of this PhD (Weyland et al., 2020; Weyland et al., 2022), a longitudinal approach was used to investigate the formation of a new habit (in contrast to studying ongoing habits) within individuals, making an effort to at least approach the conditions for analyzing causality. A further discussion of the limitations and recommendations concerning habit will be presented following the guidelines for tracking real-world habit formation by Gardner et al. (2022).

Regarding the criteria by Gardner et al. (2022) related to habit measurement, in the two habit formation studies within this PhD, five out of six were met. The definition of habit by Gardner (2015) was considered by assessing habit with the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) or its shorter version, the Self-Report Behavioural Automaticity Index (SRBAI; Gardner et al., 2012), rather than solely inferring habit from the frequency of behavior. This is crucial since it has been shown that habits can vary in strength, even with the same number of behavioral repetitions (Lally et al., 2010).

Additionally, the requirements for an adequate behavior reference and appropriate specificity were fulfilled. The item stem included the concept of instigation habit because it

inquired about how automatic the participant's decision-making process was when deciding to attend a specific university sports and exercise course (see also Gardner et al., 2016). As such, it did not ask about execution (how automatic the subsequent physical activity was executed after the decision was made) or a "global", higher-order physical activity habit (see also Phillips & Mullan, 2023). This approach ensured the same specificity between the determinant (i.e., affective response to the physical activity course) and the dependent variable (i.e., physical activity course instigation habit).

However, Phillips and Mullan (2023) argue that the complexity of behavioral execution plays a role in habit formation, because the rewards for instigation ultimately correspond to the rewards for execution. They explain that one cannot experience intrinsic rewards for the instigation of exercise without going through the performance that produces the intrinsic rewards. At this point, it is essential to raise the critical question of whether the affective response to a just-performed physical activity behavior exclusively promotes the instigation habit to choose the same course again next time or if it further fosters the execution habit of repeating the same action patterns to recreate the same affective experience. Indeed, what is enjoyable about physical activity is not the instigation but the execution. The role of affective responses in the formation of instigation versus execution habits and their relationship to behavioral frequency can thus be further explored in future research with behaviors of varying complexity (see also Gardner, 2022).

When it comes to commenting on the SRBAI-item stem for instigation habit, it is further worth noting that it might sound counterintuitive to naive participants. Although the item stem "Deciding to exercise is something…" (e.g., "…I do automatically."), was examined for its face validity in a pilot study (Phillips & Gardner, 2016), it is important to note that the term "deciding" can also be understood as something that is not inherently automatic. Rather, it can be understood in terms of a rational decision as a result of a type-2 process in which reflective evaluations lead to intentions (e.g., Brand & Ekkekakis, 2018). As Gardner et al. (2016) also noted, in this context, "decision" is more about "selection of action", meaning choosing to start with behavior A rather than behavior B. However, we must be aware that participants may not be familiar with such nuances. Therefore, both more qualitative research and validation studies on the German version of the Self-Report Behavioural Automaticity Index are necessary. Interestingly, in a pre-registered study by Ljubic et al. (2023), the following question was included in addition to the SRBAI: "How

long did it take for you to decide whether or not to attend the course?" Further, Gardner et al. (2022, p. 6) wrote: "Optimal behaviour measures will likely correspond most closely with the level at which people typically construe their own actions." To meet this demand, a recommendation for future research would be to use qualitative methods to explore how individuals perceive the steps involved in initiating and engaging in physical activity. This could help tailor the item stem of the SRBAI optimally.

Simultaneously, it is worth mentioning that perceived cues of individuals could be surveyed and integrated into the item stem (e.g., "Behavior X in Context Y is something I do without thinking"; see also Sniehotta & Presseau, 2012) to better differentiate emerging habit-specific automaticity from other forms of automaticity and to understand the cue-behavior associations more comprehensively. In fact, the recommendation for the cue-specificity of the habit measures (Gardner et al., 2022) was not implemented in this PhD, but it would be of interest for future studies.

Keeping in mind that this PhD repeatedly referred back to Thorndike (1911), who arrived at his findings through animal studies, it is also worth taking a look at the methodology used by animal researchers to study habitual versus goal-directed behavioral control. Recently, Watson et al. (2023) took a paradigm from animal research and redesigned it ("symmetrical outcome-revaluation paradigm") to make it suitable for studying human stimulus-response associations that are viewed as independent of the momentary outcome-desirability of the behavior (see also de Wit & Dickinson, 2009). In view of this characteristic, the paradigm makes use of so-called "slips of action", i.e., accidental, inappropriate responses that are triggered by stimuli regardless of the current motivation. In playful laboratory experiments as conducted by Watson et al. (2023), this includes pressing a key in the face of a stimulus, even though it has been communicated in the meantime that showing this response will result in points being deducted in the game. However, this keystroke was previously learned to achieve an outcome in the training phase, which then may have led to a stimulus-response association. If the response to the stimulus, which actually signals a devalued outcome in the test trial, persists under time pressure, this supports habitual control. Interestingly, Watson et al. (2023) also measured self-reported automaticity with the SRBAI ("This response (responding or not responding) was something I did automatically"). In fact, the SRBAI can be criticized as asking explicitly about a construct that is actually implicit

(e.g., Hagger et al., 2015). However, in the study by Watson et al. (2023), SRBAI scores were indeed related to performance in the test trials: Participants who reported more automaticity in their responses after a long training period seemed to find it more difficult not to show that response when it actually had no value in the test trial. In other words, they were actually more likely to respond with a habitually controlled response. The finding that test performance and subjective measures were related argues for the future use of the SRBAI in settings where controlled experimental manipulation, as in this paradigm, is simply not possible for the sake of ecological validity (Watson et al., 2023).

Since the limitations sections of the papers in this PhD have been sufficiently self-condemning about the use of self-report methods to capture habits, here is a thought experiment: Imagine an animal that is invisible. The only way to investigate the property of "invisibility" would be to make it visible. Obviously, this would be a problem, because the moment you make the animal visible, it no longer shows the property to be investigated. But that is not the case with habits. The moment the researcher explicitly asks about a habit, the implicit cue-behavior association does not vanish; the underlying mechanism remains. In this respect, memory distortions and similar biases may of course complicate the research (and only to a certain extent, because in and of itself it is also about how individuals perceive their habits, not whether they objectively have any), but they do not take away the benefit of the individual's habit.

Limitations and recommendations regarding individual difference variables in relation to habit

The third study in the context of this PhD addressed the recommendations of Teixeira et al. (2022) and Gardner et al. (2021). Teixeira et al. (2022) suggested exploring the factors that influence the relationship between physical activity enjoyment and habit, while Gardner et al. (2021) advocated a broader discussion of the role of personality and individual difference factors in habit formation for future research. In this regard, one notable strength of this study was its inclusion not only of Big Five personality traits (McCrae & Costa, 1987) but also of emotional style dimensions, which offer a more specific perspective on individual differences and their connection to affective experiences (Davidson & Begley, 2012).

While the study provides initial insights into the significance of personality, it is important to acknowledge that it has limitations due to its cross-sectional design. In a cross-sectional study,

individuals across various habit formation stages are averaged. It can be assumed that enjoyment plays a role throughout all habit formation stages, for example, at the beginning to reinforce the cue-behavior association (see also de Wit & Dickinson, 2009) and once the habit is formed to maintain it (see also Phillips & Mullan, 2023). However, the momentary relationship between physical activity enjoyment and actual habit strength would not be present in individuals at the beginning of the habit formation process. This is because physical activity enjoyment may be high, but the habit is not yet established. In this case, it is to be expected that intrinsic rewards are initially associated with intention and only later, in the course of behavior maintenance, with habits (Phillips et al., 2016). Thus, to gain a more comprehensive understanding of whether the importance of physical activity enjoyment varies across different personality types in the habit formation process, a longitudinal study would be necessary (see also Gardner et al., 2022).

Additionally, it should be noted that there are, of course, a variety of other individual difference variables that may serve as moderators in the relationship between physical activity enjoyment and habit. To name just two: There may be individuals who generally approach affective experiences or view affect-related constructs as valuable determinants of their behavior, given their higher levels of "need for affect", so enjoyment would potentially contribute more strongly to habit formation for these individuals (see also Maio & Esses, 2001). For instance, if someone experiences enjoyment during physical activity and holds the belief that affective experiences should guide behavior, the likelihood may increase that this person develops a habit through repeated engagement in the behavior. A second variable to consider is "grit", as individuals who persist in pursuing their long-term goals regardless of challenges may find that enjoyment plays a lesser role in habit formation (see also Duckworth et al., 2007). If, for example, someone exhibits high levels of grit or perseverance, that individual might still form a habit even in the absence of immediate rewards like perceived enjoyment, as the behavior remains worthwhile for them, considering the long-term health benefits (see also Woolley & Fishbach, 2017). Relatedly, high trait impulsivity may increase the influence of impulsive processes or immediate rewards on behavior (Cheval et al., 2016).

The recently pre-registered study by de Wit et al. (2023) is certainly a noteworthy project in this context. This is a replication and extension of the study by Lally et al. (2010), which modeled habit formation. Not only will habit formation be modeled, but individual differences

(i.e., conscientiousness, impulsivity, and personal need for structure) and rewards (i.e., anticipated enjoyment) will also be taken into account to examine the extent to which they influence habit formation. While such large-scale international studies are desirable for the future, it is regrettable that in this pre-registered study, only habit was recorded daily over a 12-week period, with reward being assessed only at the beginning and end (de Wit et al., 2023). Consequently, there will be no data on the actual acute affective experience.

Critical evaluation of the theoretical role of affect-related constructs in relation to habit

At this point, a critical analysis was undertaken to address specific methodological limitations and recommendations regarding the affect-related constructs within this PhD. However, the discussion now extends to a broader context. The question is not only about the methodological issues related to affect-related constructs but also about the general alternatives to affect-related constructs based on theory. In other words, the discussion now explores how affective phenomena distinguish themselves or exhibit limitations.

The affective experience can lead to a stronger association between cue and behavior, thus contributing to habit formation (de Wit & Dickinson, 2009). Functioning as an immediate advantage or reward, it establishes a direct connection to subsequent behavior upon encountering the cue, thereby facilitating behavior re-execution (Thorndike, 1911). This is distinct from being associated with the intention to initiate long-term desirable behavior in the first place, a premise suggested in the context of delayed rewards such as health benefits (Woolley & Fishbach, 2017). Hence, affect-related constructs possess the valuable capability to directly impact habit formation.

However, beyond intrinsic and extrinsic rewards, the broader theme of rewards is just one facet of the multifaceted determinants of habit formation. Alongside rewards, other critical determinants encompass consistency (since repetition of the behavior alone is not sufficient), behavioral complexity (dividing behavior sequences into initiation and execution), and cues (e.g., their salience; Lally & Gardner, 2013). Future studies could benefit from exploring the dynamic interplay of these determinants, akin to the methodology employed in the research by Kaushal and Rhodes (2015), to understand how their importance evolves throughout the process of habit formation. For instance, Kaushal and Rhodes (2015) found in a longitudinal study on new gym member's habit formation, that at baseline, the only predictors of habit strength were affective judgments (i.e., reward) and consistency. When analyzing the trajectory, however, they found that

consistency, low behavioral complexity, environment (i.e., cue), and reward predicted changes in habit strength across 12 weeks (descending order of strength). These results could be seen as a compromise between two perspectives: one suggesting that habits become independent of current motivational states in the long term (Neal et al., 2011), while others argue that habits related to complex behavior can decay in the absence of sustained rewards (Phillips & Mullan, 2023). Habits may indeed require ongoing rewards, but these may become less crucial over time, such that habit can bridge motivational losses (see also Rebar et al., 2014).

Finally, to better understand the interplay between affect-related constructs, habit, and subsequent health benefits, it would also be advisable to examine the consequences of both affective developments and emerging habits on health-related quality of life (see also Wunsch et al., 2021).

Critical evaluation of the construct habit

In our studies, there is often a ceiling effect on affect-related constructs, with participants consistently reporting high levels of affective responses to physical activity in longitudinal studies (e.g., Weyland et al., 2022). Moreover, in our cross-sectional studies, they indicate high levels of physical activity enjoyment (e.g., Fritsch et al., 2022). Nevertheless, it is evident that both regularly and unregularly active individuals struggle with *negative* anticipated emotions (Feil et al., 2022), which could explain fluctuations in intention (see also Rebar et al., 2014). Therefore, it is all the more important to additionally consider the variable habit.

Simply put: Why is it not sufficient to focus solely on intentions, nor to focus solely on habits? Why is there a need to consider the unique interplay of both representatives of the implicit and explicit processes? In the course of a critical examination of theories regarding the habit-intention interaction (e.g., Landis et al., 1978; Triandis, 1977) and based on their systematic review, Gardner, Lally et al. (2020) derive the following hypotheses: The relationship between intention and behavior, and the role of habit in this relationship, varies with intention directionality (i.e., intention to do behavior x vs. intention to do behavior(s) not-x) and strength (from weak to strong), as well as momentary self-control (diminished vs. not diminished). Consequently, if we only target intention strength regarding physical activity (as our target behavior x) in practice and research and leave habit out of the equation, it is entirely possible that, irrespective of physical activity instigation habit strength, highest intention strength could lead to a high frequency of

behavior – but only in an ideal world where individuals have self-control at every moment. However, a more realistic perspective reveals that intentions are not always equally strong (Conroy et al., 2013), and individuals do not always have self-control (Neal et al., 2013), so the role of habit in maintaining behavior becomes important and interesting, at least in these scenarios.

According to Gardner, Lally et al. (2020), in a scenario where there is still sufficient self-control, but the strength of the intention decreases, the frequency of the behavior will decrease for individuals with weak or moderate habits for the behavior, but it could be maintained for those with strong habits (see also Rebar et al., 2014). In this case, habit may moderate the intention-behavior relationship (Gardner et al., 2011), or more precisely, it can overcome fluctuating intentions and initiate behavior regardless of dips in motivation, as also summarized by Rebar et al. (2020). In prospective studies, intentions are often measured only once before the behavior, when they may still be strong, and analyzed at the between-person level (e.g., de Bruijn et al., 2012), but they may be weaker at the critical moment and vary within individuals, making this "compensatory role" (Gardner, Lally et al., 2020, p. 17) of habit particularly important (Conroy et al., 2013; Rebar et al., 2014).

The second scenario outlined by Gardner, Lally et al. (2020) involves a decline in self-control, in which individuals with weak or moderate habits for the behavior fail to manifest a strong intention to engage in the behavior as actual behavior (see also Neal et al., 2013). This is similar to the colloquial battle with one's inner resistance or demons ("innerer Schweinehund"): You may have the intention, but in the very moment, you must "activate" it and resist opposing habits, which requires more cognitive effort than simply giving in to an opposing cue-triggered habit (Neal et al., 2012) – probably too high a barrier when self-control resources are depleted (see also Michie & West, 2013). In such a moment, having a strong or weak intention becomes secondary because you will not be physically active either way. According to Gardner, Lally et al. (2020), in such situations, a strong habit keeps behavior at a consistently high frequency, regardless of intention strength. Here, it is possible that the intention matches the behavior, but the behavior is still not caused by the intention, but rather triggered by habit (Gardner, 2009; Neal et al., 2012). As also mentioned by Gardner (2009), failing to consider habit in such cases can lead to distorted statements regarding the intention-behavior relationship.

So, one should not neglect habit – but is it sufficient, then, to consider only habit? Is the intention irrelevant? Certainly not. First, habit must be formed, and as previously explained, this occurs through the repeated implementation of intentional behavior (Gardner & Lally, 2018). Second, as outlined by Gardner, Lally et al. (2020), if self-control is not diminished and the intention suddenly shifts in the opposite direction (i.e., intention to do behavior(s) not-x), with the individual explicitly intending *not* to be physically active, even the strongest habit may not prevent a decrease in behavior frequency. However, research that demonstrates individuals are capable of resisting habits under the intentional expenditure of self-control tends to be more related to "bad habits" (e.g., Quinn et al., 2010).

The study of the interplay between goals or intentions and habit is further complicated by the following considerations and findings: In the studies by Neal et al. (2012), robust habits were triggered by contextual cues associated with past performance (e.g., locations), whereas current goals did not trigger habits. Neal et al. (2012) discuss that, nevertheless, habits sometimes seem to be associated with goals, as individuals may perceive their habits to be guided by specific objectives. Another indication of this human tendency to view behavior as purposeful lies in the study "We infer rather than perceive the moment we decided to act" by Banks and Isham (2009). The authors of this study conclude that models that assume a conscious intention is first formed, which then serves as the immediate cause of subsequent behavior, are too simplistic – because the generation of responses appears to be largely unconscious, with the perceived moment of action guiding our inferences about the moment of decision (Banks & Isham, 2009). Applied to physical activity by Rebar et al. (2014), this could mean that someone observes themselves being consistently physically active and infers that this is likely due to intention. To test underlying mechanisms, more qualitative research seems necessary. Otherwise, studies exploring the subjective experience of habits are particularly likely to reveal that habitual performance is influenced by goals or intentions. While the intention may be present, whether it ultimately causally corresponds with the behavior, or if it was merely a cue that triggered the behavior, while the intention was inferred retrospectively, needs further exploration in future research. Further, it should also be noted that whether behavior is driven by habits or intentions also depends on the specific environment. For habits, it is crucial to be in a familiar setting where the triggering cues are present since otherwise, the behavior returns to being under intentional control (Wood et al., 2005).

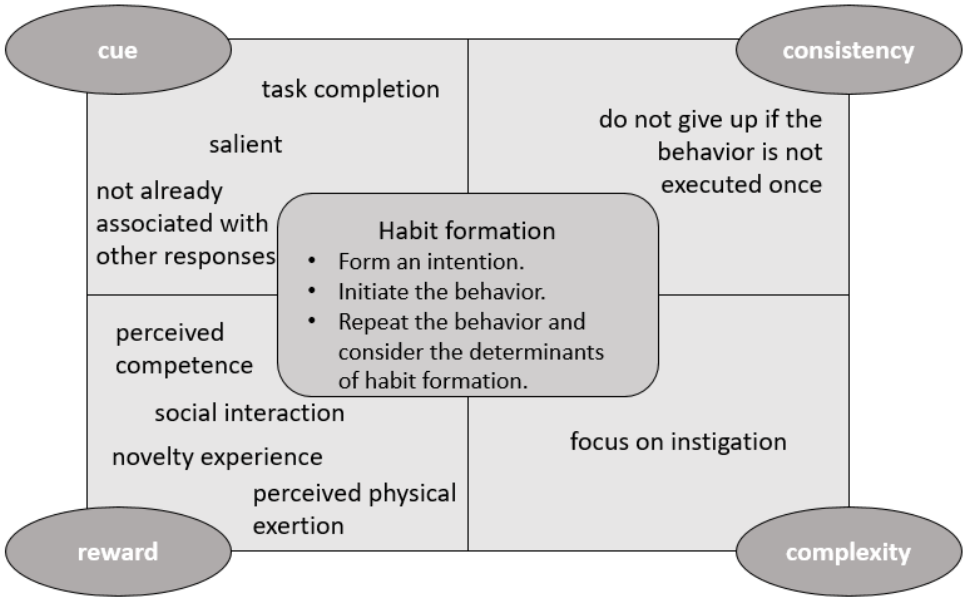
Now that the utility of habit in the context of intentional behavior has been critically reexamined, we should take another step back to critically consider the following question: Is there really a direct influence of habit on behavior as complex as physical activity (or especially exercising)? Alternatively, as Valois et al. (1988) suggest, could it be that there is no direct influence, but rather a mediating effect when combined with intention: "exercising requires will from the individual and psychological 'hard work' and will not be performed under an automatic process even when the habit of exercising is established" (Valois et al., 1988, p. 471). However, the understanding of what habit is differs here from the one described in this PhD, as Valois et al. (1988) perceive it as the sheer frequency of a behavior. Once habit is understood as a process where a cue triggers everything from impulse to behavior (Gardner, 2015), it becomes apparent that habit can determine any kind of behavior, even complex behavior (see also Aarts et al., 1997; Gardner, 2022). The distinction between instigation and execution habit further highlights this (Gardner et al., 2016). An instigation habit, which means choosing a behavior without deliberation, or in other words the automated selection of the very first step in a sequence of actions, is effective in predicting future behavior regardless of how many following steps this sequence of actions may consist of (Gardner, 2022). This means that an instigation habit can predict both simple and complex behavior, and thus, physical activity or exercise can also be habitually initiated: People go to the gym out of habit, and as they have consistently made the same decision in the past, it gradually stops feeling like a cognitive decision, it is triggered without much deliberation, unlike the first time when there might have been more consideration (see also Aarts et al., 1997). While the specific execution of this behavior may still require planning and not be completely automatic, this is not an indication of failure in the habit literature, it is simply indicative of a missing execution habit. Importantly, as this falls under the domain of instigation habits, a missing execution habit does not significantly affect the prediction of future behavior (Gardner, 2022; Phillips & Gardner, 2016). Therefore, the complexity of behavior does not determine whether instigation habit can be a determinant of behavior or not – However, it does influence whether or how quickly habit forms (see also Lally & Gardner, 2013).

Implications for practice

How is it possible to form a habit? What do we say to people who want to be more physically active but cannot bring themselves to do it? Intend. Initiate. Repeat. And see Figure 6.1.

Figure 6.1

Tips for habit formation



Note. Own presentation inspired by Lally and Gardner's (2013) explanations of the determinants of habit formation; Gardner and Lally's (2018) framework for understanding habit formation and its determinants; and the study on factors that promote positive affective responses related to physical activity by Wienke and Jekauc (2016).

Intend. Habits arise from intentional behavior, and therefore, self-control is needed to gather motivation initially (see also Gardner & Lally, 2018; Strobach et al., 2020). This emphasizes the crucial role of intention. Therefore, as also discussed by Gardner (2022), it is not advisable to advocate for the complete automation of the entire process from decision-making to behavior execution, detached from intentional elements. First, while instigation habit may predict behavior (Gardner, 2022), its effectiveness relies on maintaining a positive intention: If the intention turns negative, it has the potential to disrupt habitual behavior (Gardner, Lally et al., 2020). Second, regarding execution habit it should be acknowledged that the diversity inherent in physical activity behaviors contributes to their positive affective experiences (Wienke & Jekauc, 2016). Consequently, it is recommended to habituate the decision-making process ("I automatically decide to go for a run") while simultaneously upholding a positive intention. The strength of this intention may fluctuate, but it should consistently lean towards the positive ("I

intend to engage in running"). Additionally, diversifying the execution, such as exploring alternative running routes, is preferable to strict execution habits.

Initiate. Leaving people alone with their intentions would, of course, be short-sighted, so the follow-up question is this: What advice do we give for implementing the intention? First, it would certainly be beneficial to support people in not living at the edge all the time, in taking care of themselves, and perhaps in avoiding those situations altogether, through better emotion regulation, more flow experience, and better concentration, where we are too exhausted to act intentionally or resist impulses (but see also our mindfulness program by Jekauc et al., 2022). Second, the field of implementation intentions offers promising approaches on how, from the perspective of volition, it is possible to mentally link "if (e.g., the cue x occurs)" with "then (e.g., follows behavior y") and thereby pave the way for a certain level of automaticity when translating intentions into behavior (Gollwitzer & Sheeran, 2006).

Repeat. Here, it is important to realize that Kaushal and Rhodes (2015) determined that forming a habit required engaging in exercise a minimum of four times per week for a duration of six weeks. This, of course, is a considerable commitment, which leads on to the specific implications arising from this PhD because of its focus on affect-related constructs and habit. The following conclusion is addressed to people who are interested in the tips resulting from this PhD and the literature consulted (see also a video, Weyland, 2020; and a blog post, Weyland, 2021b, for a popular science presentation of habit formation tips).

You should find a physical activity behavior that you really enjoy. Something you would do even if you did not get likes on social media or applause from your partner. A behavior that satisfies your need for perceived competence, social interaction, physical exertion, and novelty experiences (see also Wienke & Jekauc, 2016). It is not just a matter of judging the behavior to be healthy or having a positive affective opinion about it. Your mere knowledge of any benefits will not lead to the desired strengthening of the cue-behavior association if the behavior does not actually feel good at the critical moment (see also de Wit & Dickinson, 2009). The point is that it is easier to perform a behavior again when it feels good, because then you do not have to trick your neurons with some reward that might occur sometime in a few months, but they connect "voluntarily", for purely hedonic reasons (Thorndike, 1911). It is really a matter of listening to yourself. Further, it may be important to consider what characteristics make up your own

personality, as this may also influence how important the experience of positive affective responses actually is to you.

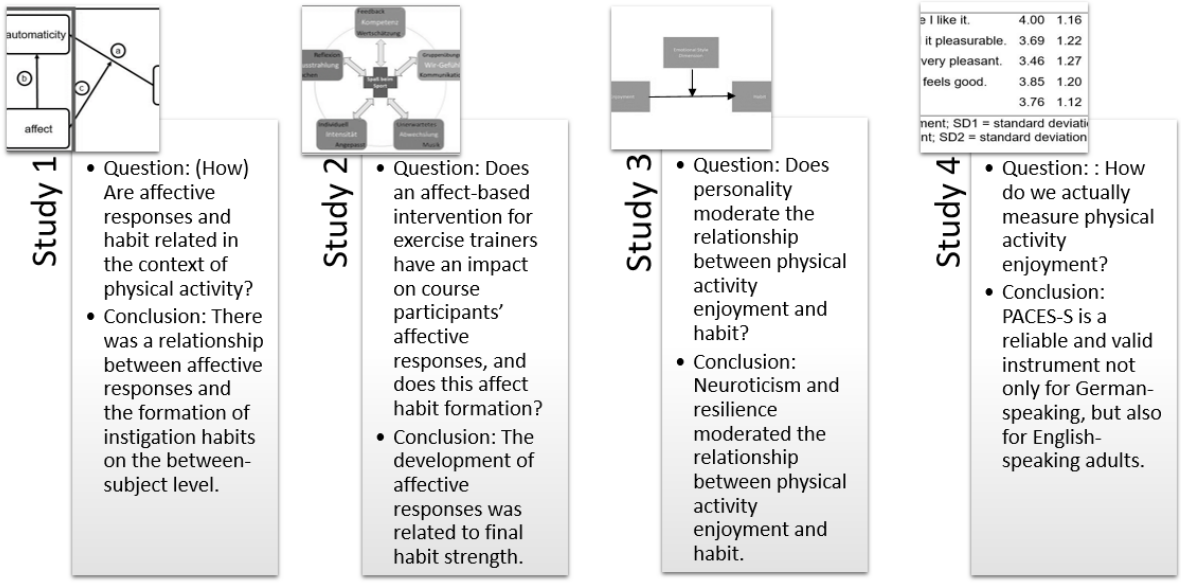
And see Figure 6.1. Of course, the affect-related constructs examined in this PhD are only a small part of the spectrum of determinants of habit formation (i.e., reward). Other tips are summarized in Figure 6.1. These are derived from Lally and Gardner (2013) explanations. With regard to cues, for example, attention should be paid to their salience and to the fact that they occur frequently but are not already associated with other behaviors. For example, task completion is appropriate, i.e., the integration of a habitual behavior into a set of already established habits so that it is triggered on an event-based basis. In addition, with regard to the determinant consistency, it should be noted that a few missed opportunities to perform the behavior do not necessarily impede habit formation, although overall consistency must of course be considered. Further, as mentioned earlier, complexity can be reduced by focusing on initiation.

Zoomed out: Closing remarks

To conclude, the questions raised by the individual studies presented in this PhD will be answered briefly (see also Figure 6.2).

Figure 6.2

Conclusion



Note. Questions and conclusions of all included PhD studies.

Study 1: (How) Are affective responses and habit related in the context of physical activity?

There were significant effects of affective responses on habit on the between-subject level. Affective responses did not moderate the relation between behavior frequency and habit.

Study 2: Does an affect-based intervention for exercise trainers have an impact on course participants' affective responses, and does this affect habit formation?

The affect-bases intervention for exercise trainers did not have any effect on the development of course participants' affective responses. However, the latter was associated with their final habit strength.

Study 3: Does personality moderate the relationship between physical activity enjoyment and habit?

The relation between physical activity enjoyment and habit was stronger for individuals with higher levels of neuroticism compared to those with lower levels. Further, the relation between physical activity enjoyment and habit was lower for individuals with higher levels of resilience compared to those with lower levels.

Study 4: How do we actually measure physical activity enjoyment?

PACES-S appears to be a reliable and valid instrument, and its economy and measurement invariance across gender and (partially) across languages make it suitable for use in large-scale studies with multilingual participants.

Now that the findings, limitations and future study ideas as well as the general usefulness of affect-related constructs and habit have been discussed and the conclusions drawn, let us close by zooming out – away from the individual. According to ecological models, individuals with their affective, automatic, or reflective psychological developments are situated in sociocultural and physical environments, so that in addition to the intrapersonal level there are also the interpersonal, organizational, community, and public policy levels (Sallis & Owen, 2015). At each of these levels there are factors whose interaction can ultimately explain behavior change most effectively. Therefore, interventions that address multiple levels are needed.

With regard to social structures, it is worth mentioning, for example, that the determinants of leisure time behavior also include “habitus”, e.g, thought or behavioral patterns internalized through socialization (Jekauc et al., 2018; Lamprecht & Stamm, 1998). Depending on social status, there may be a class-specific habitus that determines the maintenance of physical activity or exercise behavior (Jekauc et al., 2018). Habits can therefore also be extended to sociocultural environments. And affect-related constructs do not occur in a vacuum either, but develop within social structures. For example, if a student enjoys physical education but does not have parental support to join a sports club, it is not enough to focus on the individual’s physical activity enjoyment, as social support is also necessary and further contributes to it (regarding perceived social support see also Fritsch, Nigg et al., 2023). If a university student experiences positive affective responses to a university exercise course but still carries the baggage of previous unpleasant physical education experiences (regarding physical education memories see also Ladwig et al., 2018), the latest positive affective responses will struggle with the previous experiences encoded as negative affect (see also Brand & Ekkekakis, 2018). Therefore, it would be important to design physical education in such a way that it contributes to the positive association between physical activity and enjoyment.

Further, considering the physical environment is also important. If a student has a habit of cycling to school, but the road to school has no bike lane, it is not enough to focus on the individual habit formation alone since a safe cycling infrastructure is also needed (for a review on perceived physical environment see also Klos et al., 2023). A motivated individual needs a motivating environment.

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Supplementary material

Figure 3.A

Summarizing laminated diagram (affect intervention)

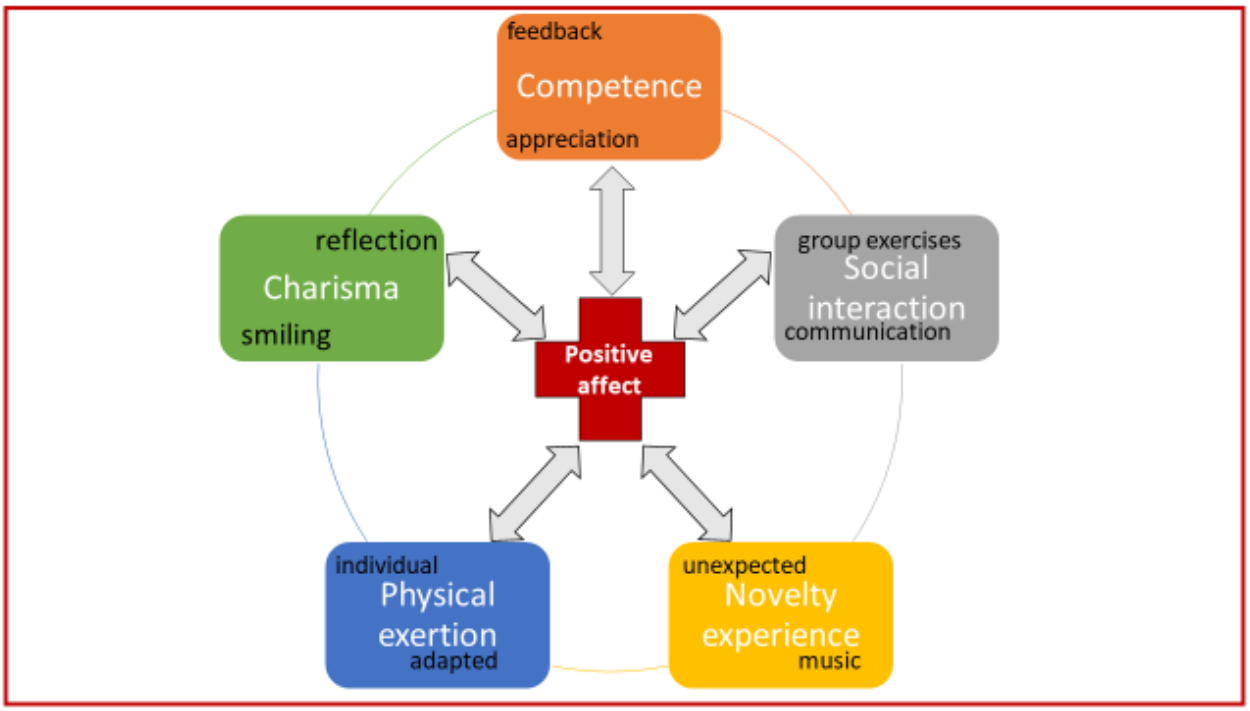
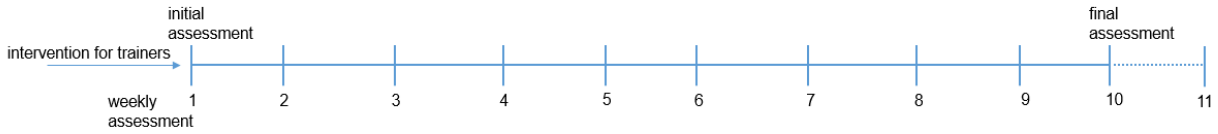


Figure 3.B

Overview of measures and assessment times



week 1: initial assessment

- Habit strength (exercise instigation)
- Affective attitude

week 1 to 10: weekly short assessment

- Automaticity
- Affective valence

week 10 (possibly to week 11): final assessment

- Habit strength (exercise instigation)
- Affective attitude

Appendix 3.A

Information booklet

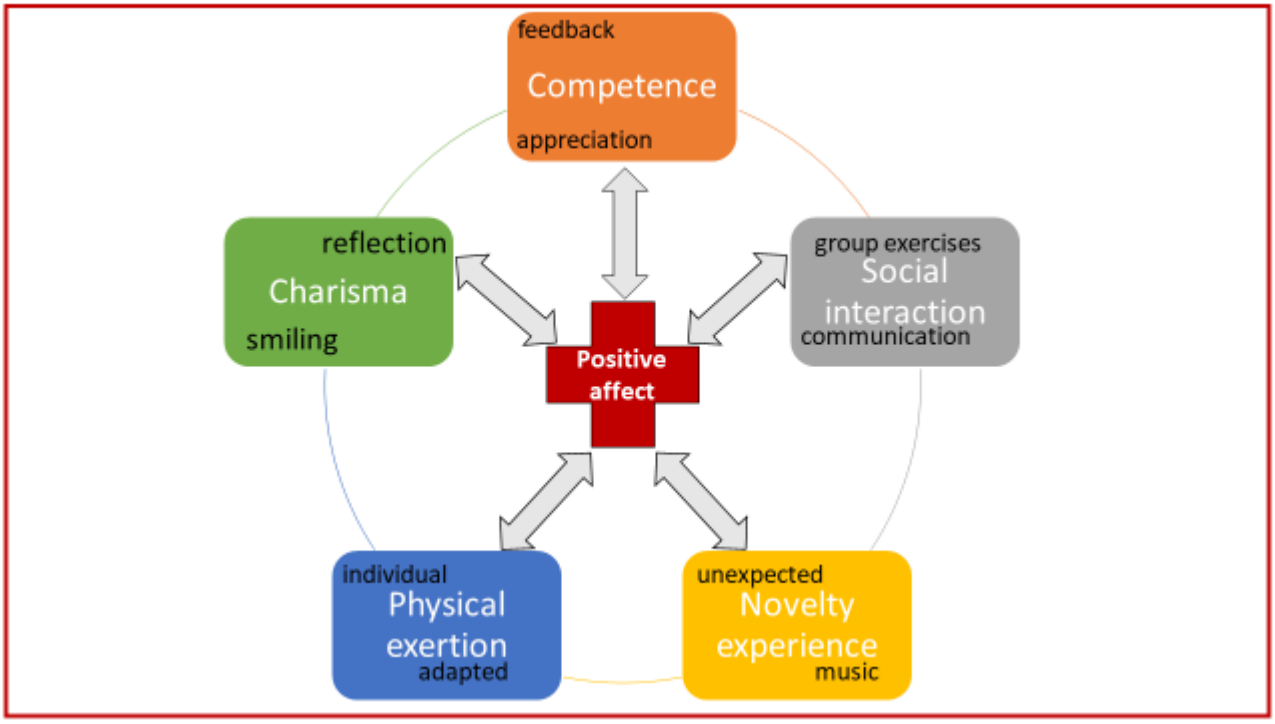
How sport can be even more fun

Physical activity is good for your health. So far, so good. That’s no big surprise and most people are aware of it. Therefore, you should exercise more often, be more physically active in your everyday life, and sit less, especially after work. In addition, you should eat plenty of fruit, avoid sugar and meat, drink plenty of water, and go outside more often to breathe fresh air. So many things to keep in mind. However, a Friday evening on the sofa with beer and crisps is a lot of fun. The gym smelling of sweat just can’t keep up, and there is always tomorrow. So many people intend to replace their unhealthy habits with good ones and want to lead a healthier life, but then fail to transfer these intentions into behavioral changes. And who can blame them? Who has never personally experienced this before? After all, it's not that simple. If we assume that we strive to have a good time and to get the most out of life, then it's obvious that we prefer the sofa to sport, as being physically active is not quite as much fun.

But sport does not have to lose this competition with the sofa! Exercising or doing sport should be beneficial to health, but above all it should be fun. After all, if it is accompanied by enjoyment and pleasure, people are more likely to repeatedly engage in physical activity. Who wants to sit at home when it is so much more fun to give it your all together with nice people, to go all out, but also to get to know your own limit, to experience new activities, and to enjoy the good feeling of being in the shower after a sense of achievement in training?

Well, good, so exercising is supposed to be fun, sure. It’s not like you as a trainer did not already know that. And of course it’s not exactly your intention to stand on the sidelines as grumpily as possible and maltreating the course’s participants. We don't assume this of you, either. But even if you’ve already created an appealing course program, there are certainly still a few simple adjustments that can be made to make it even more fun. Sometimes, you may simply lack the time to prepare the ideal program. Sometimes, there might be a lack of new ideas, and sometimes, you might just have come home from a stressful day and thus have no energy left to spread joy in your course. We take all this into account and want to give a few simple, feasible impulses that will not only make the course more fun for the athletes, but also more fun for you as a trainer. Because that is not to be neglected: you should also enjoy everything.

Five factors are described below. The behavior of each of these categories can increase the level of fun. However, it is not necessary to implement all the behaviors described in every single course session. You may decide to try one behavior one week and another the next. Some of the ideas mentioned may not appeal to you personally, because they just don't fit you as an individual. That's okay, no one wants to completely change you and force behaviors onto you that alienate you. From everything listed below, pick what you feel like doing, what makes sense to you, and what you might have wanted to try anyway.



Competence

Provide positive feedback

Set realistic goals (individually and in the group)

Appreciation

Adapted challenges

Competition

Praise development

This is not about your competence as a coach, we don't doubt that at all. This is about the perceived competence of the athletes. In other words, it's about them having the impression that

they’re really good at what they do, that they're really successful at sports. Winning is fun, being good is fun. And when we are endorsed in what we do, we like to do it again.

In order for the athlete to know exactly, and without doubting herself, that she is good, she needs her coach’s feedback. Generally speaking, emphasizing the positive makes for a better mood than always focusing on what is not yet working so well. It helps to divide a movement into small steps. Even if three out of four individual steps are not yet perfect, it is worthwhile to positively emphasize the part that is already working really well. If the ultimate goal is a long throw or a perfect jump, this can only be achieved when everything perfectly fits into place. That would be at the very end of an intensive training period. The worst case would be if the athlete never reaches this ultimate goal. Along the way, it is important to aim for small, more realistic goals and to give praise when these milestones have been reached. Especially when the individual is not in their best form yet, it can help to focus on the group and praise its progress as a whole.

In addition to providing positive feedback, appreciation is an important factor. This involves, for example, paying close attention to how the athlete behaves in training, what improvements have been made and how intensively she trains. Even if something doesn’t work out, you can appreciate the commitment and perseverance. Again, communicate! The athlete will certainly be happy to hear that her commitment in training has been noticed and appreciated. A guiding principle here can be, “Don’t criticize, accept.” This means that one must also sometimes accept that the targeted performance has not been achieved, without immediately highlighting this in a negative way. Of course, the point is not to gloss over everything. But even stagnation or setbacks can be communicated in an appreciative rather than critical manner. Appreciation is also conveyed by respecting other opinions and showing interest in them, by listening persistently. This conveys to the athletes that, with their opinions, they can contribute something to the training, that they are therefore worth something and give off a sense of competence. For example, when faced with a new challenge, athletes can be asked for their ideas on how to solve it, rather than providing the answer as a coach. When it comes to providing positive feedback and appreciating athletes, it is of course also important to enable progress in training in the first place so that it can then be praised. No one should be under or over challenged. The skill is to ideally dose the challenges for each individual. One person tries to complete the exercise in five minutes, the other in six. The competition with time or other small competitions that are built into the training (e.g., achieving

a certain number of repetitions) spurs them on and makes progress visible. Through such specific competitions, you can quite clearly see when someone has improved. These constant, small individual improvements are a success that should be rewarded!

Social interaction

Group/partner exercises
Interdependence
Encourage communication
Push each other
Rituals
Social Events

Sure, some people simply enjoy being alone whilst going out for a walk. It’s quiet, they don’t have to talk to anyone and they can switch off. But the moment the participants in your course decide to go to an exercise course in which others are also taking part, it is obvious that they will not be alone. The opposite becomes true: being alone within a group is frustrating. When the others form a team and you yourself have the impression that you don’t really belong, it’s hard. After all, it’s really fun to form a team. Together, individual exercises may be more successful, the good mood of the others pushes the individual. *Me* turns into *us*. In addition, it’s harder to quit the course when the others are counting on you.

One example of course elements that strengthen the sense of togetherness is group exercises. This is obvious in team sports. You can also do exercises in pairs that are actually individual. To avoid the unpleasant feeling of someone not finding a partner, as a trainer, you can also divide up the teams yourself. There are two possibilities with group exercises: several athletes try to reach a goal together or they compete with each other. Both can promote fun. In the case of group competitions, however, the losing team should also be appreciated and under no circumstances should it be humiliated. It is also important to mix up the teams from time to time so that two competing subgroups do not form within one course group.

Here, too, the key is communication at eye level. Conflicts in the course should always be addressed and discussed immediately. Again, it is about appreciation and trust. That's why it's important to promote communication, to encourage participants, and to address things.

However, it is not only the coach who has the task of providing positive feedback. Athletes can also praise each other. They may be uncomfortable with this at first, or they may simply not think of it, because they may not be used to praising others. Therefore, right at the beginning, the coach should encourage the athletes to push each other. This can include clapping or singing, because singing together creates a sense of community. Here again, it is important that no one is ever laughed at!

Moreover, rituals can contribute to a sense of togetherness. For example, greeting each other or bidding each other farewell can always be done with the same words, to which the group forms a circle. Also, cheering can be done through a battle cry which is the same every time.

Of course, social activities outside of the course can also bring the group together. If it seems appropriate and the group is ready to meet outside of the sports facility, such activities can be supported by the trainer. The important thing is that no one is excluded. If someone didn't want to or couldn't attend the social event, he or she should still be considered an equal team member during training. This can also be addressed by the coach to take the pressure out of having to participate in social events.

Novelty experience

Music
Unexpected
New accents
Medium level of variety
Nature experiences
Mindfulness

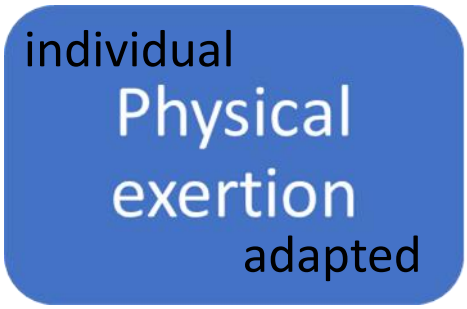
By novelty experience we mean tackling boredom, meaning the course remains exciting, as every now and then something happens that no one expects. This creates excitement and curiosity that makes the participants want to come back next time. And, no wonder, it is of course more fun to experience something new more often.

In concrete terms, this can, for example, involve music or either funny or motivating videos shown during the warm-up. It is also a possibility to go outside into nature for a sport that usually takes

place indoors. For a sport that takes place outdoors anyway, you could at least try new ways. Also, innovative exercises can make the course more diverse. Therefore, it can be tactically wise to not do all the different exercises in the first few course sessions, but to keep a few fun ones up your sleeve to show off once in a while. A good example for an unexpected novel experience are mindfulness practices. It doesn't have to be a meditative journey through the body if the group doesn't seem receptive to it. More "atypical" exercises are also possible, such as trying to line up a boiled egg or trying to find a walnut that someone had chosen from a bowl full of walnuts after mixing them all up. Another idea to add variety is to have one of the participants design and lead a warm-up exercise. It is surprising what exercise he or she comes up with and also the coach shows that he or she trusts the participant to have a certain competence. Anything that is unexpected and seems appropriate can provide variety!

It is important that despite the effort to provide variety, a certain routine is also created. It is therefore important to find a balance between habits and the unexpected.

Physical exertion



Medium intensity

Individually adapted to fitness level

Observe

Really testing yourself and pushing yourself to your limits can be fun. That feeling of falling into bed afterwards, completely exhausted, is priceless. But everything should be done with moderation and purpose. Of course, no one should collapse and be so exhausted that they think to themselves, "thanks, never again". Overstraining is bad, but so is under-straining. If the intensity of the training is just right for the individual, the experience of competence increases and it is simply more fun. When the body is neither too exhausted nor not challenged at all, a specific feeling sets in which the athletes would like to experience again. To achieve this, it is helpful to observe each athlete closely and determine his or her individual fitness level. Who needs which

time for which exercise? Who can repeat which exercise and how often? Whenever possible, the intensity of the training should be tailored to their fitness level.

Charisma

Positive emotions

Radiate enthusiasm

Reflection before the training

1 minute time

Emotions are contagious! And that’s not a bad thing at all; on the contrary, when one person laughs, the other joins in and suddenly no one can contain themselves. Enthusiasm is also transmitted very quickly. If the training is supposed to be fun, it is helpful for the trainer to also radiate fun, because if someone conveys positivity, the others want to be trained by him or her again and again. And yes, that's not always easy. It’s also not about pretending or laughing artificially.

What can help to radiate positivity is to take a minute before each training. This prevents you from rushing straight from your own everyday life into the training session and thus transferring this stress to the others. In this minute, you can briefly reflect on your current state and how you feel. Once you have noticed your own affective state, it is important not to judge it, not to get angry when you are stressed. It is important to realize that the stress does not have to be a hindrance, you can still do very good training. To overcome your own affective state, it is important to know it. If you are receptive to good music, after the short reflection, you can listen to motivating music that gets you in the mood for training. As silly as it sounds: as a trainer, you have to get through the training, one way or the other, that is, whether with a smile on your face or a stress-distorted frown. And it is often the case that the positive affective state automatically comes with the smile - not least because the athletes reflect the smile of the trainer and the trainer then looks into smiling faces. And this creates a positive cycle!

Appendix 3.B

Results of the analyses of missing values

Descriptive analyses of missing values (item-nonresponses) revealed that for the 12 SRHI items for exercise instigation habit strength at week 1 (N = 132), 10 values (0.63 %) distributed among 9 subjects were missing; for the three affective attitude items at week 1, 3 values (0.76 %) distributed among 1 subject were missing. Among those participants who filled in the final questionnaire (N = 73), the analyses for the 12 SRHI items for exercise instigation habit strength revealed that 20 values (2.28 %) distributed among 7 subjects were missing; for the three affective attitude items, 3 values (1.37 %) distributed among 1 subject were missing. None of the Little's MCAR tests, each calculated for all scales at both time points, was significant, suggesting that data were missing completely at random. It was therefore appropriate to use the expectation-maximization algorithm for data imputation to avoid list wise deletion in the case of analyses of variance (Dempster et al., 1977) and to use full-information maximum-likelihood estimation in the case of latent growth curve modeling (Arbuckle, 1996; Jekauc et al., 2012).

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Table 3.A

Means, standard deviations, and correlations among all included study variables (N = 73)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Sociodemographic information													
1. Gender	-												
2. Age	-0.09	-											
3. Student status	0.08	-0.16	-										
Initial Assessment (week 1)													
4. SRHI week 1	0.17	0.02	-0.01	-									
5. SRBAI week 1	0.18	0.05	0.03	0.89***	-								
6. Affective attitude week 1	0.15	-0.13	-0.01	0.60***	0.61***	-							
Weekly questionnaire													
7. Mean valence	0.04	0.03	0.05	0.32**	0.37**	0.35**	-						
8. Mean automaticity	-0.10	-0.00	0.14	0.32**	0.40***	0.31**	0.42***	-					
Final assessment (week 10)													
9. SRHI week 10	-0.04	-0.02	0.11	0.67***	0.53***	0.56***	0.27*	0.52***	-				
10. SRHI difference	-0.26*	-0.05	0.14	-0.54***	-0.55***	-0.15	-0.11	0.17	0.27*	-			
11. SRBAI week 10	-0.08	-0.03	0.21	0.52***	0.53***	0.43***	0.29*	0.73***	0.84***	0.28*	-		
12. SRBAI difference	-0.27*	-0.09	0.16	-0.52***	-0.63***	-0.28*	-0.15	0.23	0.18	0.86***	0.33**	-	
13. Affective attitude week 10	0.00	-0.08	-0.04	0.46***	0.41***	0.54***	0.43***	0.41***	0.51***	-0.01	0.47***	-0.03	-
M (%)	17.8[a]	22.50	95.9[b]	3.44	3.30	5.76	7.81	7.53	3.60	0.17	3.60	0.29	5.81
SD		2.15		0.81	1.06	0.99	1.00	1.95	0.70	0.62	0.88	0.95	0.93

[a]percentage female. [b]percentage yes. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.