Freie Universität Berlin

How to Predict and Promote the Maintenance of a Healthy Lifestyle: From Behaviour Initiation to Habituation

Dissertation zur Erlangung des akademischen Grades
Doktorin der Philosophie (Dr. phil.)

am Fachbereich Erziehungswissenschaft und Psychologie
der Freien Universität Berlin

vorgelegt von Dipl.-Psych. Lena Fleig

Berlin, März 2012

Erstgutachterin: Prof. Dr. Sonia Lippke

Zweitgutachter: Prof. Dr. Ralf Schwarzer

Disputation: 25.05.2012

Table of Contents

	Danksagung / Acknowledgement	III
	Abstract	IV
	Zusammenfassung	V
Chapter 1	Introduction	1
Chapter 2	Exercise Maintenance after Rehabilitation: How Experience Can Make a Difference	26
Chapter 3	Intervention Effects of Exercise Self-regulation on Physical Exercise and Eating Fruits and Vegetables: A Longitudinal Study in Orthopaedic and Cardiac Rehabilitation Patients	45
Chapter 4	Beyond Goal Intentions: Processes of Habit Formation in the Exercise Domain	64
	Study 1 How Goal Intentions Guide Exercise Habits: A Field Study in University Students	69
	Study 2 Developing Exercise Habits after Rehabilitation Treatment	72
Chapter 5	Telephone-delivered Booster Sessions Help Maintain Self-regulation, Physical Exercise, and Habit Strength: A Long-term Follow-up in Medical Rehabilitation	83
Chapter 6	General Discussion	104
	Curriculum Vitae	136
	List of Publications	138
	Erklärung zur Dissertation	142

Danksagung / Acknowledgement

For reasons of data protection, the acknowledgements are not included in this version.

Abstract

Health behaviour is central to the development, prevention and management of chronic diseases. Yet, for health behavior to result in true health benefits, it needs to be maintained and practiced on a regular basis. The achievement of *sustained* health benefits is not an effortless task and lies in the way individuals master the self-regulatory challenges involved in health behaviour maintenance.

The primary goal of this dissertation was, therefore, to advance theory and research on the prediction and promotion of health behaviour maintenance. The second aim of this thesis was to unveil theory-based mechanisms of changing more than one health behaviour (i.e., multiple health behaviour change). The research questions were examined in three observational and two quasi-experimental studies in various settings (university, medical rehabilitation) and across different health behaviours (physical exercise, healthy nutrition).

Results from this dissertation suggest that experience-related variables (exercise outcome experiences, satisfaction, and self-efficacy) and self-regulatory strategies (action planning, action control) facilitate additively to repeated behaviour engagement. Moreover, the present thesis provides accumulated evidence that healthy habit formation can be promoted by self-regulatory strategies, such as action planning, which in turn promotes frequent behaviour engagement. Finally, findings provide initial support that an increase in habit strength, due to a single health behaviour intervention, is positively associated with engagement in other health behaviours.

Mechanisms of behaviour maintenance may be better understood by incorporating both experience-related variables and habit strength into social-cognition models. Interventions, particularly those embedded in medical rehabilitation, can be improved by combining experience-based (i.e., recall of positive experiences) and self-regulation (i.e., generation of action plans, self-monitoring) components. Further insight into the processes of long-term behaviour change can be facilitated through evaluating interventions in terms of habit strength in addition to behaviour. Habituation may also play a key role in changing more than one health behaviour, and should be further investigated in relation to multiple health behaviour concepts, such as transfer and ego-depletion. Future studies may consider pursuing the theoretical rationale of the empirical studies, and employ the introduced behaviour change techniques, procedures and evaluation strategies to further the development of effective theory- and evidence-based health behaviour interventions.

Zusammenfassung

Von der Verhaltensinitiierung bis zur Gewohnheitsbildung: Wie kann ein gesunder Lebensstil nachhaltig gefördert werden?

Durch ihr Gesundheitsverhalten können Menschen aktiv zur Prävention und Rehabilitation von chronischen Krankheiten beitragen (Fisher et al., 2011). Regelmäßige körperliche Aktivität und eine gesunde Ernährung nehmen dabei eine Schlüsselfunktion in der Behandlung von kardiovaskulären Krankheiten (Dalal, Zawanda, Jolly, Moxham, & Taylor, 2010; Lavie, Milani, & Ventura, 2009) und Muskel- und Skeletterkrankungen ein (Conn, Hafdahl, Minor, & Nielson, 2008; Van Baar, Assendelft, Dekker, Oostendorp, & Bijlsma, 1999).

Doch nur wenn die Veränderung des Lebensstils von Dauer ist, wirkt sich das auch nachhaltig auf die Gesundheit aus (Eyre et al., 2004; Hayes & Kriska, 2008). Wenn Patienten beispielsweise aus der medizinischen Rehabilitation entlassen werden, stehen sie vor der Herausforderung, auch im Alltag körperlich aktiv zu bleiben und sich weiterhin gesund zu ernähren. Warum gelingt es einigen Personen, ihr Verhalten aufrechtzuerhalten und gesunde Gewohnheiten zu entwickeln, während andere immer wieder gegen ihren inneren Schweinehund ankämpfen müssen? Warum bleiben einige Personen am Ball, während andere einfach das Handtuch werfen? Aus praktischer Sicht stellt sich die Frage, wie sowohl gesunde als auch bereits erkrankte Personen dabei unterstützt werden können, ihr Gesundheitsverhalten nicht nur kurzfristig zu ändern, sondern eine gesunde Lebensweise zur Gewohnheit zu machen.

Bislang hat sich die Forschung überwiegend auf die psychologischen Faktoren konzentriert, die bei der Motivationsbildung und der anfänglichen Verhaltensausübung eine Rolle spielen (z.B. Risikowahrnehmung, Erwartungen; Schwarzer, 2008; Schwarzer, Lippke, & Luszczynska, 2011). Die psychologischen Prozesse, die sich nach der Verhaltensinitiierung entfalten, blieben bisher eher unberücksichtigt (Rothman, 2000; Rothman, Baldwin, & Hertel, 2004; Rothman, Sheeran, & Wood, 2009). Zudem befindet sich die Theoriebildung und Forschung, die über die Veränderung *eines* Gesundheitsverhaltens hinausgeht – die sogenannte multiple Verhaltensänderung - noch in der Anfangsphase (Morabia & Costanza, 2010; Prochaska, Spring, & Nigg, 2008; Spring, Moller, & Coons, 2012).

Das primäre Ziel dieser Dissertation ist es, jene psychologischen Prozesse, die bei der Aufrechterhaltung eines Gesundheitsverhaltens eine Rolle spielen, näher zu untersuchen. Dazu werden

Theorien der Gesundheitsverhaltensänderung herangezogen, die sowohl absichtliche und bewusste als auch automatische Prozesse der Verhaltensregulation berücksichtigen (d.h. gewohnheitsbezogene; Aarts, Paulussen, & Schaalma, 1997; Lally & Gardner, 2011; Neal, Wood, & Quinn, 2006; Verplanken & Melkevik, 2008). Zur Beschreibung und Förderung von bewussten Prozessen der Gesundheitsverhaltensänderung werden das *sozial-kognitive Prozessmodell gesundheitlichen Handelns* (Schwarzer, 2008; Schwarzer et al., 2011), das *Motivations-Volitions-Prozess Modell* (Fuchs, Göhner, & Seelig, 2011; Göhner, Seelig, & Fuchs, 2009) sowie das *Phasenmodell der Verhaltensaufrechterhaltung* (Rothman et al., 2004) herangezogen.

Des Weiteren wird untersucht, *ob* und *warum* theoriebasierte Bewegungsinterventionen zu Veränderungen im Bewegungs- und Ernährungsverhalten führen. Dabei liegt der Fokus auf psychologischen Variablen (z.B. Konsequenzerfahrungen, Nutzung von Selbstmanagementkompetenzen), die mögliche Interventionseffekte erklären können.

Im einleitenden *Kapitel 1* wird der theoretische Rahmen der Dissertation vorgestellt und es werden Forschungsfragen und Hypothesen aus gesundheitspsychologischen Theorien und bisherigen empirischen Untersuchungen hergeleitet. Die Forschungsfragen konzentrieren sich auf die folgenden drei Bereiche:

Verhaltensaufrechterhaltung

(1) Verhaltenswiederholungen

a. In welchem Ausmaß ist Handlungsplanung für die Aufrechterhaltung von körperlicher Aktivität relevant (*Kapitel 2*)?
b. Welche Rolle spielen Konsequenzerfahrungen mit körperlicher Aktivität in der Verhaltensaufrechterhaltung? Wie hängen Konsequenzerfahrungen, Handlungsplanung und darauffolgendes Verhalten zusammen (*Kapitel 2*)?
c. Wie effektiv ist eine Intervention, die sowohl Konsequenzerfahrungen, als auch selbstregulative Strategien (d.h. Handlungsplanung, Handlungskontrolle) anspricht? Wie können Interventionseffekte im Bezug auf körperliche Aktivität erklärt werden (*Kapitel3, erster Teil*)?

(2) Gewohnheiten

a. Können die Zusammenhänge zwischen Intentionen, Handlungsplanung, Verhalten, und Gewohnheitsstärke bei Studenten (*Kapitel 4, erster Teil*) und Rehabilitationspatienten (*Kapitel 4, zweiter Teil*) so modelliert werden, wie theoretisch angenommen?

b. In welchem Ausmaß können telefonische Auffrischungssitzungen in der Rehabilitations-Nachsorge zur Bildung von Bewegungsgewohnheiten beitragen? Und mit welchen psychologischen Mechanismen können diese Effekte erklärt werden *(Kapitel 5)*?

Multiple Verhaltensänderung

a. Inwieweit führt eine Intervention zur Förderung von körperlicher Aktivität auch zu Veränderungen in anderen, präventiven Gesundheitsverhaltensweisen (*Kapitel 3, zweiter Teil*)?
b. Welche Rolle spielt Gewohnheitsbildung bei der Änderung von mehr als einem Verhalten (*Kapitel 3, zweiter Teil*)?

Diese Forschungsfragen werden in drei korrelativen und zwei quasi-experimentellen Studien in verschiedenen Settings (Universität und medizinische Rehabilitation) und im Bezug auf die zwei präventiven Gesundheitsverhaltensweisen, körperliche Aktivität und gesunde Ernährung, untersucht. Diese empirischen Arbeiten werden in *Kapitel 2* bis *5* vorgestellt. Im Einzelnen umfassen die Kapitel folgende Inhalte:

Im *zweiten Kapitel* werden Ergebnisse einer Längsschnittstudie zu körperlicher Aktivität nach der Rehabilitation vorgestellt, die die Rolle von Konsequenzerfahrungen in der Verhaltensaufrechterhaltung bestätigen: Während der Rehabilitation gemachte, positive Erfahrungen mit körperlicher Aktivität (z.B. Reduktion von Schmerzen) sagen die Aufrechterhaltung eines aktiven Bewegungsalltags vorher. Erklärt werden kann dieser Zusammenhang durch die Nutzung von Handlungsplanung sowie der wahrgenommen Zufriedenheit mit körperlicher Aktivität (*multiple Mediation*). Konsequenzerfahrungen mit körperlicher Aktivität liefern möglicherweise einen Ansatzpunkt zur Optimierung von Rehabilitationsbehandlungen bzw. dafür, Personen bei der Aufrechterhaltung von positiven Verhaltensänderungen zu unterstützen.

Im ersten Teil des *dritten Kapitels* wird die Wirksamkeit einer solchen Intervention in einem quasi-experimentellen Design bei Rehabilitationspatienten untersucht. Neben Konsequenzerfahrungen, werden in der Intervention die selbst-regulativen Kompetenzen, Handlungsplanung und Handlungskontrolle angesprochen. Außerdem wird geprüft, welche psychologischen Mechanismen den Zusammenhang zwischen der computerbasierten Intervention und der anschließenden Ausübung von körperlicher Aktivität erklären, indem Zufriedenheit, Handlungsplanung und Handlungskonrolle als gleichzeitige Mediatoren getestet werden (*multiple Mediation*).

Die Interventionseffekte auf körperliche Aktivität können sowohl auf Veränderungen in der Zufriedenheit als auch auf die Nutzung von Handlungskontrollstrategien zurückgeführt werden. Veränderungen in Handlungsplanung zeigen sich als signifikanter Prädiktor für Veränderungen im Verhalten, können jedoch nicht durch die Intervention beeinflusst werden. Aus den Ergebnissen kann abgeleitet werden, dass erfahrungsbasierte Interventionen, die zusätzlich selbst-regulative Strategien (Handlungskontrolle) ansprechen, erfolgreich zur Verhaltensaufrechterhaltung beitragen und in rehabilitative Standardmaßnahmen integriert werden können.

Kapitel 4 widmet sich der Frage, wie sich Bewegungsgewohnheiten entwickeln, unter Berücksichtigung der in den vorangegangen Kapiteln untersuchten Handlungsplanung. Ergebnisse aus zwei Längsschnittstudien bei Studenten und Rehabilitationspatienten bestätigen die theoretisch angenommenen Zusammenhänge zwischen Intentionen, Handlungsplanung, wiederholter Verhaltensausübung und Gewohnheitsstärke: Sind Personen erst einmal motiviert, körperlich aktiv zu sein, lässt sich die Entwicklung von Bewegungsgewohnheiten in zwei Schritten erklären (*sequentielle Mediation*): Zunächst sind Intentionen mit der Nutzung von Planungsstrategien (*Mediator 1*) assoziiert. Diese wiederum begünstigen eine wiederholte und konsistente Verhaltensausübung (*Mediator 2*). Letztendlich kann dies dazu führen, dass ein Verhalten mit immer weniger Anstrengung ausgeübt wird und sich langfristig zu einer Gewohnheit entwickelt.

In *Kapitel 5* wird geprüft, inwiefern computerbasierte Telefoninterviews diese angenommene Kette von Mechanismen, die für die Gewohnheitsbildung relevant sind, anstoßen können. Es zeigt sich zunächst, dass Patienten in der Interventionsgruppe 12 Monate nach der Rehabilitation ein höheres Ausmaß an Handlungsplanung, Selbstwirksamkeit und körperlicher Aktivität, sowie über eine höhere Gewohnheitsstärke berichten als Patienten in der Kontrollgruppe. Pfadanalysen ergeben des Weiteren, dass Veränderungen in der Gewohnheitsstärke schrittweise durch Veränderungen in der Handlungsplanung sowie Veränderungen der körperlichen Aktivität erklärt werden können (*sequentielle Mediation*). Die Ergebnisse legen insgesamt nahe, dass computerbasierte Telefoninterviews zur „Auffrischung“ von zurückliegenden Behandlungen, Personen darin unterstützen, Bewegungsgewohnheiten zu entwickeln. Die Nutzung von Planungsstrategien sowie das Festhalten an konsistenten Verhaltensroutinen scheinen hierbei eine zentrale Rolle zu spielen.

Im zweiten Teil des *dritten Kapitels* wird untersucht, inwiefern die Ausbildung einer Gewohnheit in einem Verhalten Auswirkungen auf die Ausübung anderer Gesundheitsverhaltensweisen hat. Die Ergebnisse bestätigen die Annahme, dass Interventionen, die ausschließlich körperli-

che Aktivität ansprechen, gleichzeitig Veränderungen im Obst- und Gemüsekonsum bewirken können. Die Analyse der Wirkmechanismen weist darauf hin, dass eine Zunahme der Gewohnheitsstärke, als Folge der Bewegungsintervention, mit positiven Veränderungen im Obst- und Gemüsekonsum einhergeht. Wird körperliche Aktivität zur Gewohnheit, und regelmäßig ohne viel Nachdenken und Anstrengung ausgeübt, stehen möglicherweise mehr Ressourcen für andere Verhaltensweisen zur Verfügung. Erfolgreich angewandte Strategien für körperliche Aktivität (z.B. Handlungsplanung) werden unter Umständen auch dafür genutzt, sich gesund zu ernähren (sog. *Transfer*; Lippke, Nigg, & Maddock, 2012; Nigg, Lee, Hubbard, & Min-Sun, 2009). Wenn das Ziel verfolgt wird, einen gesunden Lebensstil zu fördern (z.B. körperliche Aktivität, gesunde Ernährung), kann die Berücksichtigung solcher verhaltensübergreifenden Effekte hilfreich sein.

Abschließend werden in *Kapitel 6* die Ergebnisse aus den vier empirischen Kapiteln integriert und zusammenfassend diskutiert.

Die korrelativen und experimentellen Befunde dieser Dissertation legen nahe, dass erfahrungsbasierte Kognitionen (Konsequenzerfahrungen, Zufriedenheit, Selbstwirksamkeit) und selbstregulative Kompetenzen (Handlungskontrolle, Handlungsplanung) gleichermaßen zur Verhaltensaufrechterhaltung beitragen. Um Prozesse der Aufrechterhaltung besser zu beschreiben, erscheint es sinnvoll, erfahrungsbasierte Variablen, wie Konsequenzerfahrungen und Zufriedenheit, in bisherige, gesundheitspsychologische Theorien der Verhaltensänderung (z.B. *sozial-kognitives Prozessmodell der Gesundheitsverhaltensänderung*; Schwarzer, 2008; Schwarzer et al., 2011) zu integrieren. Interventionsergebnisse zeigen, dass eine Kombination von Interventionsstrategien (z.B. Erstellen und Anpassen von Handlungsplänen, Bewusstmachen von positiven Erfahrungen) erfolgsversprechend ist, und ressourcensparend mit Hilfe verschiedener, interaktiver Medien (Telefon, Computer) umgesetzt werden kann.

Da Verhaltenshäufigkeit (z.B. 2 mal pro Woche) und Verhaltensintensität (z.B. leichte, moderate Aktivität) an sich keine Auskunft darüber geben, wie schwer bzw. leicht es Personen fällt, ein Gesundheitsverhalten aufrechtzuerhalten, erscheint es vielversprechend, weitere Indikatoren der Nachhaltigkeit von Verhaltensänderungen in Theorie und Praxis zu berücksichtigen. Die Ergebnisse dieser Arbeit legen nahe, dass das Konzept der Gewohnheit (Aarts et al., 1997; Lally & Gardner, 2011; Neal et al., 2006; Verplanken & Melkevik, 2008) hierfür geeignet ist.

Gewohnheiten spielen möglicherweise eine ebenso wichtige Rolle, wenn es darum geht, mehr als ein Gesundheitsverhalten zu ändern. Verhaltensübergreifende Effekte, wie Transfer, kön-

nen durch Gewohnheitsbildung angestoßen werden und in umfassenden Lebensstil-Interventionen genutzt werden.

Ergebnisse dieser Arbeit zeigen, dass die Nachhaltigkeit von medizinischen Rehabilitationsbehandlungen gefördert werden kann, indem psychologisch fundierte Interventionen in die Regelversorgung integriert werden. Diese lassen sich ressourcensparend mit Hilfe interaktiver Medien umsetzen. Außerdem befähigt das Ansprechen *eines* Gesundheitsverhaltens im Rahmen einer gesundheitspsychologischen Intervention die TeilnehmerInnen zu einem allgemein gesünderen Lebensstil.

1

Introduction

Introduction

Health behaviour is central to the prevention and management of chronic diseases (Fisher et al., 2011). The achievement of sustained health benefits, however, is not an effortless task and lies in the way individuals master the self-regulatory challenges involved in health behaviour maintenance. For example, when patients are released from medical rehabilitation treatment, they face the challenge of maintaining exercise with their own initiative, and continuously adhering to healthy, dietary recommendations. Similarly, once individuals complete a weight management program, they have to follow it by engaging in more than one health behaviour to see continued results.

Why do some people repeatedly engage in health behaviours, whereas others disengage from it? And why do some individuals develop seemingly effortless behaviour routines (i.e., habits) whereas others remain locked in a fight with their inner temptations? From a practical perspective, the question arises as to how individuals can be optimally supported to continuously engage in health behaviour, and to ultimately develop healthy lifestyle habits across multiple health behaviours.

Previous research in health psychology has progressed in terms of elucidating resources and self-regulatory skills relevant to initiating health behaviours (e.g., Schwarzer, 2008; Schwarzer, Lippke, & Luszczynska, 2011). Despite these advances, understanding and promoting the long-term maintenance of health behavior changes remains a challenge. Knowledge on those psychological processes that come into play once a behaviour has been initiated is still quite limited (Rothman, 2000; Rothman, Baldwin, & Hertel, 2004; Rothman, Sheeran, & Wood, 2009). In addition, theory-based investigations of predictors and mechanisms of multiple health behaviour change are only in its initial phase (Morabia & Costanza, 2010; Prochaska, Spring, & Nigg, 2008; Spring, Moller, & Coons, 2012).

Therefore, the primary goal of this thesis is to investigate processes of behaviour maintenance by drawing on theories of deliberate (e.g., *health action process approach*, HAPA; Schwarzer, 2008; Schwarzer, et al., 2011; the *motivation volition process model,* MoVo*;* Fuchs, Göhner, & Seelig, 2011; Göhner, Seelig, & Fuchs, 2009; *theory of planned behaviour*, TPB; Ajzen, 1991; *social cognitive theory*, SCT; Bandura, 1997) and habitual behaviour regulation (i.e., *concept of behavioural habits*; Aarts, Paulussen, & Schaalma, 1997; Lally & Gardner, 2011; Neal, Wood, & Quinn, 2006; Verplanken & Melkevik, 2008).

Secondly, this thesis focuses on evaluating the effectiveness of theory-based self-regulation interventions in both maintaining exercise, and promoting healthy nutrition. Finally, factors that may explain these intervention effects are examined, with the intention to further theory progression on single and multiple health behaviour change, and to give recommendations for primary and secondary intervention practice.

This chapter begins with describing the context of this thesis, in order to illustrate the need for studying the antecedents of health behaviour maintenance. Next, the description of the theoretical framework is comprised of a summary and integration of recent literature, and provides the rationale for the assumptions put forth in this thesis. Finally, the research questions that are addressed in the empirical chapters of this thesis (*Chapters 2-5*) are outlined.

Health Behaviour as the Key to the Prevention and Rehabilitation of Chronic Diseases

Non-communicable diseases such as cardiovascular diseases, diabetes, and cancer are one of the major causes of morbidity and mortality worldwide and are responsible for the majority of the disease burden in the European Region (Gaber & Wildner, 2011; World Health Organization, 2002). A closer look at Germany reveals that cardiovascular diseases, diseases of the digestive tract, as well as diseases of the muscular and skeletal system, still account for a tremendous fraction of the countries' health care costs (Robert Koch Institute, 2006). National health authorities (e.g., Deutsche Gesellschaft für Ernährung, Robert Koch Institute), as well as statutory health and pension insurances (e.g., German Pension Insurance) are increasingly recognizing the unique opportunity to prevent and manage chronic diseases by improving individuals' health behaviours. According to national health surveys, however, German adults exercise far below recommended levels (Robert Koch Institute, 2011) and consume too few fruits and vegetables (Rabenberg & Mensink, 2011; Robert Koch Institute, 2011). This highlights the need for large-scale primary prevention efforts, predominantly in places where people spend most of their time, such as universities, and workplaces.

In particular, individuals who already suffer from physical limitations, such as osteoporosis (Conn, Hafdahl, Minor, & Nielsen, 2008; Van Baar, Assendelft, Dekker, Oostendorp, & Bijlsma, 1999), or cardiovascular diseases (Dalal, Zawada, Jolly, Moxham, & Taylor, 2010; Lavie, Milani, & Ventura, 2009) benefit from regular exercise and healthy dietary improvements (Luszczynska & Cieslak, 2009). In 2010, nearly one million German adults participated in medical rehabilitation (Deutsche Rentenversicherung Bund, 2012), mostly due to orthopedic challenges (Deutsche

Rentenversicherung Bund, 2011). Embedding health behaviour interventions in medical rehabilitation centers is, therefore, one of the strategic objectives for secondary prevention in Germany.

Preventive health behaviours must be performed both repeatedly and over a long period of time to facilitate the prevention (Eyre et al., 2004; Hayes & Kriska, 2008) and rehabilitation of chronic diseases beyond treatments (e.g., Hayes & Kriska, 2008; Jolliffe et al., 2003). To support healthy individuals and people already battling with ailments in mastering the self-regulatory challenges of maintaining a healthy lifestyle, it is important to assess the effectiveness and working mechanisms of theory-based approaches that address health behaviours either alone or in concert with other health behaviours (Biddle & Fuchs, 2009; Oldenburg, Absetz, & Chan, 2010). The effects of self-regulation (interventions) on indicators for the sustainability of behavioural changes, however, such as features of habituation, have been understudied so far. The present thesis aims to close this gap by conducting theory-based analyses of processes related to behaviour habituation in primary (i.e., university) and secondary (i.e., cardiac and orthopedic rehabilitation) prevention settings.

Modeling and Promoting Self-regulation of Single Health Behaviours: From Initiation to Habituation

Self-regulation refers to the psychological and behavioural processes related to successful goal pursuit including intention formation, behaviour initiation, and maintenance. Accordingly, models of behaviour regulation propose to distinguish between motivational processes of intention formation and volitional processes of behaviour engagement (Heckhausen, 1991; Kuhl, 1986). However, while theory building and research have progressed on tackling the question of how individuals form an intention (e.g., SCT; Bandura, 1997; HAPA, Schwarzer, 2008; Schwarzer et al., 2011) and how they translate their intentions into behaviour (e.g., HAPA, Schwarzer, 2008; Schwarzer et al., 2011; extended TPB plus action planning, TPB-e; Sniehotta, Gorski, & Araújo-Soares, 2010), less is known about the dynamic processes which unfold once a behaviour has been initiated. Why do people decide to repeatedly engage in a behaviour (i.e., behaviour repetition)? And how do they eventually develop habituated behavioural routines (i.e., habituation)? Research relating directly to the processes of behaviour maintenance, and ultimately the formation of healthy habits in everyday life, has been scarce (Lally & Gardner, 2011) and is therefore the subject to this thesis.

Behaviour Maintenance: Beyond Time-Based Definitions

Until recently, behaviour maintenance has been defined according to specific time thresholds (Seymour et al., 2010). For example, Fjeldsoe, Neuhaus, Winkler, and Eakin (2011) define behaviour maintenance as "sustaining a […] behaviour change achieved by the end of an intervention, for at least 3 months thereafter" (Fjeldsoe et al., 2011, p. 1). Similarly, other authors (Marcus et al., 2000; Laitakari, Vuouri, & Oja, 1996; van Stralen, De Vries, Mudde, Bolman, & Lechner, 2009) refer to maintenance as the phase of continued behavior engagement for at least six months. Although intuitively appealing, this time-based perspective on behaviour maintenance does not provide any insight into the "quality" of a behaviour (Lippke, Ziegelmann, Schwarzer, & Velicer, 2009; Rothman et al., 2009). According to dual process theories (e.g., *reflective impulsive model*, Strack & Deutsch, 2004), a behaviour can have two qualities that may change over the course of time (Rothman et al., 2009): First, if a behaviour is newly adopted (i.e., *behaviour initiation*), it must be regulated very actively (i.e., reflective mode). Second, if a behaviour is performed repeatedly (i.e., *behaviour repetition*, reflective mode), then its execution becomes gradually habituated and conscious self-regulation becomes less important (i.e., *habituation*, automatic mode; Aarts et al., 1997; Lally & Gardner, 2011; Neal et al., 2006; Verplanken & Melkevik, 2008).

In colloquial terms, *habits* are usually referred to as behaviours that have been repeated over and over again. There is more to habits, however, than frequent past performance. Within psychology, habits are understood as behaviours that have acquired a high degree of automaticity (Bargh, 1994). In other words, habits are behaviours which are enacted in response to contextual cues with little conscious deliberation (Verplanken & Melkevik, 2008; Wood & Neal, 2007). Habits are assumed to result from frequent behaviour enactment in stable settings (Aarts et al., 1997; Gardner, de Bruijn, & Lally, 2011; Lally, van Jaarsveld, Potts, & Wardle, 2010). For example, if a person repeatedly goes for a run in the park on Sundays before lunch, his or her behaviour will become closely tied to those contextual cues (i.e., time, location). As a result, behaviour enactment may gradually fall under the control of contextual cues, rather than conscious decision-making and self-regulation (Verplanken & Melkevik, 2008; Wood & Neal, 2007).

To conclude this point, time-based definitions of behaviour maintenance (i.e., duration of repeated behaviour enactment) may need to be combined with psychologically more meaningful attributes of behaviour, such as the degree to which a behaviour is enacted with ease and automaticity (i.e., habit strength; Lippke et al., 2009; Rothman et al., 2009). Essentially then, behaviour

maintenance may be subdivided into two phases: a) *deliberate behaviour repetition* and b) *habituation* (i.e., habituated behaviour repetition; see Figure 1), both of which will be focused upon in this thesis.

A Theoretical Overview: From Behaviour Initiation to Habituation

Processes involved in healthy habit development may be described in four phases: (1) a *decision-making phase (i.e., intention formation)*, (2) a *behaviour initiation phase*, (3) a *behaviour repetition phase*, and (4) a *habituation phase* (Lally & Gardner, 2011; Rothman et al. 2004; see Figure 1). There is accumulating evidence that social-cognitive variables such as attitudes, risk perception, outcome expectancies, and self-efficacy beliefs as modeled by SCT (Bandura, 1997), the theory of planned behaviour (TPB; Ajzen, 1991), or the HAPA (Schwarzer, 2008; Schwarzer et al., 2011) facilitate intention-formation across a variety of health behaviours (Webb & Sheeran, 2006). Analyses of this thesis, however, go beyond investigating predictors of intention formation. The focus of this thesis lies on those processes that come into play once a behaviour has been initiated. Figure 1 summarizes the central concepts and phases of habit formation of this thesis. In the following paragraphs, the constructs of this thesis will be described in more detail and the mechanisms through which they are expected to affect behaviour initiation, repeated exercise engagement and exercise habituation, will be elaborated upon. A significant amount of attention will be placed on predictors and processes of *behaviour repetition* (phase 3) and *behaviour habituation* as these two phases provide the theoretical rationale for this dissertation.

Behaviour Initiation (Phase 2): Translating Intentions into Behaviour

Previous theories of health behaviour, such as the TPB (Ajzen, 1991) assume that once an individual decides to engage in a behaviour, the "Rubicon" is passed and behaviour initiation and maintenance will occur with minimal effort. However, even if people hold strong goal intentions to act, often they do not translate them into behaviour (Sheeran, 2002). This has been referred to as the intention-behaviour gap (Sheeran, 2002). Individuals tend to forget their goal intentions or are distracted by other tasks when they encounter an opportunity to act. Deficits in individual's self-regulation (Baumeister, Heatherton, & Tice, 1994; Carver & Scheier, 1998) and/or insufficient personal resources (e.g., self-efficacy; Bandura, 1997) may further challenge individuals' initial implementation of goals.

Goal implementation becomes more likely when individuals support their goal intentions with self-regulatory strategies. These may be either proactive strategies that are employed prior to

encountering performance-relevant situations (generation of action plans) or strategies that actually control the behaviour during behaviour enactment (action control).

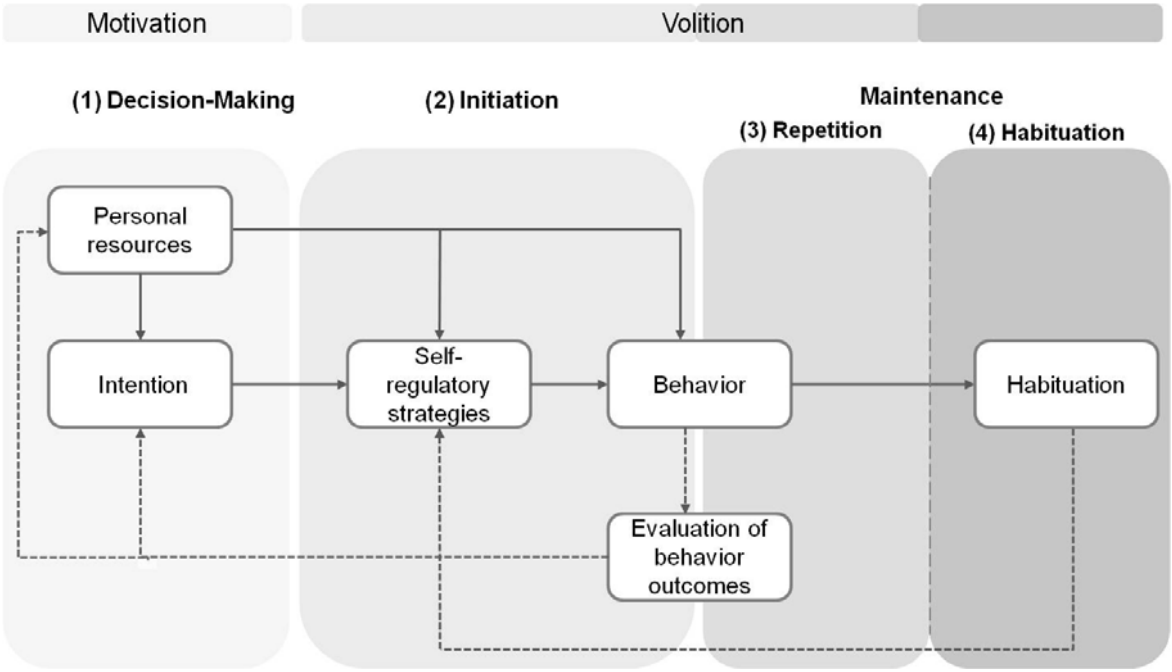

Figure 1. Overview of the concepts of this thesis integrating HAPA, MoVo, Rothman's framework of behaviour maintenance, and the framework of behavioural habits

Note. - - ▶ = Dashed lines indicate how behaviour feedbacks on social-cognitions; ——▶ = Solid lines indicate how cognitions predict other cognitions, and behaviour.

Action plans (i.e., implementation intentions, Gollwitzer & Sheeran, 2006; Leventhal, Singer, & Jones, 1965; Sniehotta, Schwarzer, Scholz, & Schüz, 2005) outline in detail when, where, and how a person intends to act. An action plan supporting the goal intention to do more exercise could be, for example, "when I come home from work, I will go for a walk in the park." *Action control*, on the other hand, refers to an in-situ strategy which includes the investment of self-regulatory effort, awareness of goal standards, and self-monitoring of goal-directed behaviour (Sniehotta, Scholz, & Schwarzer, 2005, 2006). Besides self-regualtory strategies, personal resources, such as *self-efficacy*, play a crucial role in initiating behaviour (Bandura, 1997). Individuals will only pursue their intended actions when they sufficiently believe in their capabilities to master behavioural challenges.

Action planning. Action planning can be investigated from two different perspectives. On the one hand, action planning can be assessed with psychometric scales. In support of assumptions of most health behaviour theories (for overview, see Table 1), observational field studies in university students (Conner, Sandberg, & Norman, 2011; Koring et al., 2011) and rehabilitation patients (Sniehotta, Scholz, & Schwarzer, 2006) provide consistent evidence that self-reported use of action planning bridges the gap between goal intentions and behaviour initiation. On the other hand, action plans can be formulated as part of an intervention. That is, the generation of action plans may be understood as a behaviour change strategy (Michie et al., 2011). The effects of such an experimental manipulation on behaviour change may then be compared to an active or passive control group without an action plan component (e.g., Fleig et al., 2010).

This latter perspective has been applied to a wide range of health behaviours (for a meta-analysis, see Gollwitzer & Sheeran, 2006), particularly to physical exercise (for a meta-analytic review see; Bélanger-Gravel, Godin, & Amireault, 2011) and healthy nutrition (for a meta-analytic review see; Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011).

Previous field studies on the *working mechanisms* of planning trials revealed that generating action plans as part of an intervention may promote the use of action planning in everyday life and thereby support subsequent changes in behaviour (Lippke, Schwarzer, Ziegelmann, Scholz, & Schüz, 2010; Luszczynska, 2006; Wiedemann, Lippke, Reuter, Ziegelmann, & Schwarzer, 2011). Examining planning processes in more detail, experimental research based on the implementation intentions approach (Gollwitzer, 1999) assumes that making action plans may help individuals to become perceptually ready to identify a critical situation (e.g., time of day, specific location). Upon encountering the situational cues specified by the plan, the intended behaviour is assumed to be enacted with substantial ease and little need for conscious effort (Wiedemann, Lippke, & Schwarzer, 2011). Thereby, behaviour initiation should be facilitated.

Action control. Similar to action planning, self-reported use of action control, such as monitoring one's behaviour in relation to goal standards, has been found to bridge the gap between intentions and physical exercise (Pomp, Lippke, Fleig, & Schwarzer, 2010; Sniehotta, Scholz, & Schwarzer, 2005) as well as nutrition (Scholz, Nagy, Göhner, Luszczynska, & Kliegel, 2009). In combination with other strategies, self-monitoring has been identified as one of the key ingredients of successful exercise and dietary change interventions (for a meta regression see; Michie, Abraham, Whittington, McAteer, & Gupta, 2009). In secondary prevention contexts in particular, action

control has been found to account for positive short-term intervention effects on exercise (Sniehotta, Nagy, Scholz, & Schwarzer, 2006). In less complex health behaviours, such as dental flossing, (Schüz, Sniehotta, & Schwarzer, 2007; Sniehotta, Araújo Soares, & Dombrowski, 2007), using action control tools (e.g., dental flossing calendar), has been equally encouraging in promoting behavior initiation.

Self-efficacy. In line with most theories of health behaviour change, behaviour, at least partially, depends on a person's belief in his or her ability to perform a specific action in the face of barriers. Self-efficacy has been consistently identified as one important predictor of exercise initiation (e.g., McAuley & Blissmer, 2000; Williams et al., 2008), particularly among rehabilitation patients (Woodgate & Brawley, 2008). Previous research further suggests that individuals only succeed in making (Gutiérrez Doña, Lippke, Renner, Kwon, & Schwarzer, 2009; Study 2; Schwarzer et al., 2010) and implementing action plans (Gutiérrez Doña et al., 2009; Study 1; Lippke, Wiedemann, Ziegelmann, Reuter, & Schwarzer, 2009; Luszczynska et al., 2010; Richert et al., 2010; Soureti, Hurling, van Mechelen, Cobain, & Chinapaw, 2011) if they feel sufficiently confident about their ability to initiate a behaviour.

Overall then, behaviour initiation appears to be largely determined by self-regulatory strategies and personal resources. As summarized in Table 1, current models of health behaviour change have put emphasis on elucidating the processes of behaviour initiation. Very little attention has been given to examining the ongoing processes of behaviour maintenance including reciprocal relationships between behaviour, self-regulation, and self-efficacy beliefs. These will be described in the following paragraphs.

Deliberate Behaviour Repetition (Phase 3): Behaviour Evaluation, Self-efficacy, and Continued Self-Regulation

Experiences and satisfaction. Central to investigating psychological factors in relation to behaviour maintenance, is acknowledging that people have experiences that come with the consequences of a behaviour (Fuchs et al., 2011; Rothman, 2000; Rothman et al., 2004). For example, a favorable exercise outcome elicited by going for a walk may be an enhanced feeling of well-being. If experiences match or even exceed expectations, perceptions of satisfaction should emerge (Rothman, 2000; Rothman, et al., 2004). Satisfaction with experienced behaviour outcomes works as a reward (Aarts et al., 1997) and is therefore another important determinant of whether or not a person repeatedly engages in a behaviour (Fuchs et al., 2011; Rothman, 2000; Rothman et al.,

2004). Satisfaction has been shown to promote behaviour maintenance and prevent relapse across a number of health behaviours, including exercise (Williams et al, 2008), smoking (Baldwin et al., 2006; Hertel et al., 2008), and weight management (Finch et al., 2005). Research, however, that directly relates satisfaction to the domain of physical exercise, has been rare, particularly in individuals with established disease. As illustrated in Figure 1, experiences may feedback on social-cognitions (Fuchs et al., 2011; Rothman, 2000; Rothman et al., 2004) and thereby guide subsequent, repeated behaviour engagement. So far, little empirical consideration has been given to elucidate the mechanisms of how experiences direct exercise maintenance and are therefore studied in this thesis.

Mastery experiences and self-efficacy. According to SCT (Bandura, 1997), experiences affect subsequent behaviour indirectly by increasing *self-efficacy* beliefs (Parschau et al., under review). Bandura (1997) assumes that self-efficacy beliefs are mainly established by previous mastery experiences. Behaviour-specific mastery experiences can be understood as one specific kind of behaviour outcome experiences. Whereas exercise experiences relate to any kind of experienced behaviour outcome (Rothman, 2000; Rothman et al., 2004), mastery experiences relate to past behavioural achievements that are attributed to one's own efforts (Bandura, 1997). Research suggests that exercise engagement per se (McAuley & Blissmer, 2000), as well as specific, exercise-related mastery experiences, foster self-efficacy beliefs (Warner, Schüz, Knittle, Ziegelmann, & Wurm, 2011). In line with SCT and other health behaviour theories (see Table 1), Scholz, Sniehotta, Schüz, and Oeberst (2007) further revealed that mastery of action plans after cardiac rehabilitation treatment (i.e., mastery experience) enhances self-efficacy beliefs, which in turn, promotes continued behaviour engagement.

In sum, self-efficacy has been consistently found to predict behaviour maintenance in different populations ranging from healthy (e.g., Williams et al., 2008) to symptomatic (McAuley & Blissmer, 2000; Renner, Hankonen, Ghisletta, & Absetz, 2011; Sniehotta, Scholz, & Schwarzer, 2005) individuals. Implementation and evaluation of according experience-based behaviour change strategies, however, have been rare. Only few experimental studies have explicitly tested whether intervention effects on long-term exercise (Brassington, Atienza, Perczek, DiLorenzo, & King, 2002) or dietary changes (Luszczynska, Tryburcy, & Schwarzer, 2007) were explained by changes in self-efficacy. In the present thesis, it was therefore tested whether an experience-based intervention component (i.e., prompt recall of positive exercise experiences/achievements) is successful in

enhancing perceptions of satisfaction, as well as self-efficacy. In addition, it was tested whether changes in self-efficacy and satisfaction as a result of an intervention are associated with behaviour maintenance.

Action planning and action control. As outlined above action planning and action control help to initiate behaviour. Both self-regulatory strategies may be equally useful to promote sustained repetition of behaviour as required for habituation (Lally & Gardner, 2011). Action plans specify the context cues (e.g., time, location) in response to which a goal-directed behaviour is performed. As a result of making plans, behaviour execution is theorized to become progressively cued by context rather than by deliberate decision-making (Gollwitzer & Sheeran, 2006; Webb & Sheeran, 2007). In other words, continued commitment to action plans should therefore ensure behaviour consistency in terms of frequency (i.e., repetition) but also in terms of context stability (i.e., behaviour is elicited in response to the same contextual cues). Eventually, intended behaviour should be performed more often (i.e., repetition phase) and thereby gradually acquires the features of a habit (i.e., habituation phase; see Figure 1; Aarts et al., 1997; Gardner, de Bruijn, & Lally, 2011; Lally et al. , 2010).

In line with HAPA, previous observational studies support this notion by revealing that planning predicts long-term post-rehabilitation exercise (Reuter, Ziegelmann, Lippke, & Schwarzer, 2009; Sniehotta, Scholz, & Schwarzer, 2005; Ziegelmann, Luszczynska, Lippke, & Schwarzer, 2007). There is also initial evidence that planning interventions aimed at long-term dietary (Chapman & Armitage, 2010; Luszczynska, Scholz, & Sutton, 2007; Stadler, Oettingen, & Gollwitzer, 2010) and exercise changes (Fuchs et al., 2011; Luszczynska, 2006; Ziegelmann, Lippke, & Schwarzer, 2006) are successful.

The evidence on the usefulness of action control in facilitating repeated behaviour engagement is less consistent. Self-monitoring, one facet of action control, has been associated with long-term maintenance of weight loss (Wing & Phelan, 2005) and exercise behaviour (Sniehotta, Scholz, & Schwarzer, 2005). Intervention-induced changes in action control have also been found to account for changes in exercise up to four (Sniehotta, Scholz, Schwarzer, Fuhrmann, et al., 2005) and 12 months (Scholz & Sniehotta, 2006) after cardiac rehabilitation treatment. Contrarily, a recent systematic review on the maintenance of behaviour changes following a physical exercise or dietary intervention concluded that successful maintenance was unrelated to the inclusion of self-monitoring strategies (for a review see; Fjeldsoe et al., 2011).

Follow-up intervention boosters. Besides teaching individuals skills (action planning, action control) to regulate their health behaviour, the duration of a health promotion program (i.e., number of intervention units) can diminish or boost sustained effects on behaviour. Repeated behaviour performance beyond initial treatments may be supported by follow-up booster sessions that remind individuals of previous intervention content. Follow-up boosters refer to "brief contacts beyond the main part of the intervention to reinforce previous intervention content" (Fjeldsoe et al., 2011, p. 601). A systematic review on the maintenance of behaviour changes following a physical exercise or dietary intervention revealed that physical exercise trials using follow-up prompts were most successful in achieving sustained behaviour outcomes (Fjeldsoe et al., 2011). In the clinical context, telephone-delivered boosters have been successfully implemented to promote abstinence rates among smokers with somatic diseases (Metz et al., 2007; Rigotti, Munafo, & Stead, 2008), and exercise outcomes among pulmonary (Ries, Kaplan, Myers, & Prewitt, 2003) and orthopedic rehabilitation patients (Fuchs et al., 2011; Mangels, Schwarz, Worringen, Holme, & Rief, 2009).

In conclusion, previous research delivered encouraging results regarding the usefulness of action plans in promoting behaviour maintenance: Action plans may create and strengthen context-behavior associations that, if sufficiently reinforced through repetition, may become habitual (Lally & Gardner, 2011). Findings on action control, however, are not as consistent and need further study. Therefore, this dissertation further studies the benefits of both self-regulatory strategies in promoting continued behaviour engagement (i.e., *repetition*) as well as the effectiveness and working mechanisms of booster sessions.

Habituation (Phase 4): Effortless Behaviour Regulation

As illustrated in Figure 1, habituation may be considered as the final phase of the behaviour change process that follows a phase of behaviour repetition. Previous research (Gardner et al., 2011; Lally & Gardner, 2011; Lally et al., 2010) supports the notion that frequent behaviour enactment facilitates habituation. For example, Orbell and Verplanken (2010) successfully enhanced habit strength of dental flossing and respective flossing behaviour by means of an action planning intervention. However, the authors did not analyze any underlying sequential mechanisms (e.g., changes in action planning -- changes in behavior -- changes in habit) that may explain why the planning intervention affected habit strength.

Concluding, once behaviour transforms into a habit, demands placed on deliberate self-regulation and personal resources are reduced to a minimum. Behaviour enactment takes place with

substantial amount of ease and is governed by relatively automatic processes rather than conscious deliberation (Aarts et al., 1997; Gardner, de Bruijn, & Lally, 2011; Lally, van Jaarsveld, Potts, & Wardle, 2010). In other words, habituation goes along with the release of self-regulatory and personal resources (see Figure 1). This may have implications for self-regulatory efforts directed towards other health behaviour domains (see next section). Overall, a phase of behaviour repetition and habituation may capture most readily the transition that rehabilitation patients undergo when they are discharged from rehabilitation treatment: Patients are faced with the challenge to maintain exercise beyond treatment, and ultimately develop exercise habits that fit into their home-based activities (D'Angelo & Reid, 2007; *Chapter 2, 3, 4 part two, 5*). Table 1 provides a summary and description of the defining processes and variables of each of the presented phases, from behaviour initiation to habituation.

From Single to Multiple Health Behaviour Change: Theoretical Approaches and Interventions

Mechanisms of change in single health behaviours have been studied extensively, however, there has been very little theory-guided research on how individuals manage to engage in more than one health behaviour (Morabia & Costanza, 2010; Prochaska et al., 2008; Spring et al., 2012). Orchestrating the performance of multiple health behaviours, such as adhering to a healthy diet while exercising regularly, requires much effort and is a complex self-regulatory task.

According to the *strength and energy model* (Baumeister, Muraven, & Tice, 2000) self-regulation is a limited resource (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Hence, too high demands in one domain of action may put a limit to the resources available to another. For example, regulating one's exercise behaviour can deplete resources for adhering to a healthy diet (Hagger, et al., 2010). Effects of depletion may be attenuated, however, if behaviour execution in one domain becomes habituated. If self-regulatory resources related to one behaviour become "vacant" because of habituation, the very same resources may be then available for another health behaviour. Following the concept of *transfer* (Barnett & Ceci, 2002), it is most likely that those strategies (e.g., action planning) that have been successfully applied in one behavioural domain are

Table 1. Theoretical Overview: Phases of Health Behaviour Change from Behaviour Initiation to Habituation (adapted from Lally & Gardner, 2011; Rothman et al., 2004; Schwarzer, 2008; Schwarzer et al., 2011)

Phase		Variables/ Processes	Theory/Framework						Description
			SCT	HAPA	TPB-e	MoVo	Rothman	Lally	
Behaviour initiation		Intention	+	+	+	+	-	+	Translation of *intentions* in the first-time engagement of behaviour is supported by self-regulation (i.e., *action planning, action control*) and *self-efficacy*.
		Self-efficacy	+	+	+	+	+	-	
		Action Planning	-	+	+	+	-	+	
		Action Control	-	+	-	+	-	-	
Behaviour maintenance	*Deliberate* behaviour repetition	Self-efficacy	+	+	-	-	+		Behavioural efforts are continuously supported by deliberate self-regulation (i.e., *action planning, action control*) and *self-efficacy*. *Experiences* individuals have had as a result of engaging in the new behaviour are considered. People's assessment of the experiences - their *satisfaction* - determines whether behaviour is continued or not. Behaviour evaluations, in turn, enhance or inhibit further self-regulation and resources, thereby determining future direction of behaviour. All factors add to behaviour *consistency* that is behaviour is enacted consistently in terms of *frequency* and *context*.
		Action Planning	-	+	-	-	-	+	
		Action Control	-	+	-	-	-	-	
		Outcome Experiences	+	-	-	+	+	+	
		Satisfaction	-	-	-	+	+	+	
	Habituated behaviour enactment	Decrease in need for self-regulation, self-efficacy, and outcome evaluation	-	-	-	-	+	+	Demands placed on self-regulation and personal resources are reduced to a minimum. Behaviour enactment takes place with much ease and is rather governed by automatic processes than conscious deliberation. Self-regulatory resources that become unoccupied may be invested in the pursuit of other health behaviour goals.

Note. + = indicators that have facilitating effect on behaviour change according to that theory; Habituated behaviour (in the last phase) is assumed to persist as long as the behaviour is repeated in a stable context; Grey shaded phases are the focus of this thesis.

then also used for another behaviour (Lippke, Nigg, & Maddock, 2012; Nigg, Lee, Hubbard, & Min-Sun, 2009). Evaluating the effects of an exercise self-regulation intervention on healthy nutrition behaviour, and studying potential underlying working mechanisms (e.g., changes in exercise habit), may be a first step in studying such processes of regulating more than one halth behaviour (i.e., cross-behaviour regulation).

Research Aims of the Present Thesis

The present thesis aims to add to the description and promotion of single and multiple health behaviour changes relevant to the prevention and management of chronic diseases. In particular, processes of exercise maintenance will be examined by integrating research on deliberate and habitual behaviour regulation. Moreover, explanatory factors for the effects of an exercise-based self-regulation intervention on exercise and fruit and vegetable consumption will be investigated in a clinical field setting. In more detail, this thesis focused on three major research areas, addressing the following research questions.

Processes behaviour maintenance

1) Deliberate behaviour repetition

a. How relevant is action planning in predicting exercise maintenance (*Chapter 2*)?
b. What role do behaviour outcome evaluations play in exercise maintenance? How do behaviour outcome evaluations interrelate with action planning and subsequent behaviour (*Chapter 2*)?
c. How effective are combined, experience-based and self-regulation interventions in promoting repeated behaviour engagement? And how can intervention effects be explained (*Chapter 3, part one*)?

2) Habituation

a. How do intentions guide exercise habit formation (*Chapter 4*)?
   Can the interrelations between intentions, action planning, behaviour, and habit be modelled in university students *(Chapter 4, part one)* and rehabilitation patients (*Chapter 4, part two*) as theoretically predicted?
b. How effective are follow-up, experience-based and self-regulation booster sessions in promoting habituation? And which mechanisms account for these effects (*Chapter 5*)?

Processes of multiple health behaviour change

a. Is an exercise intervention effective in promoting other health behaviours (*Chapter 3, part two*)?
b. What role does habituation play in changing more than one health behaviour (*Chapter 3, part two*)?

In Figure 2, the focus of the empirical chapters is summarized within the previously introduced framework (Figure 1).

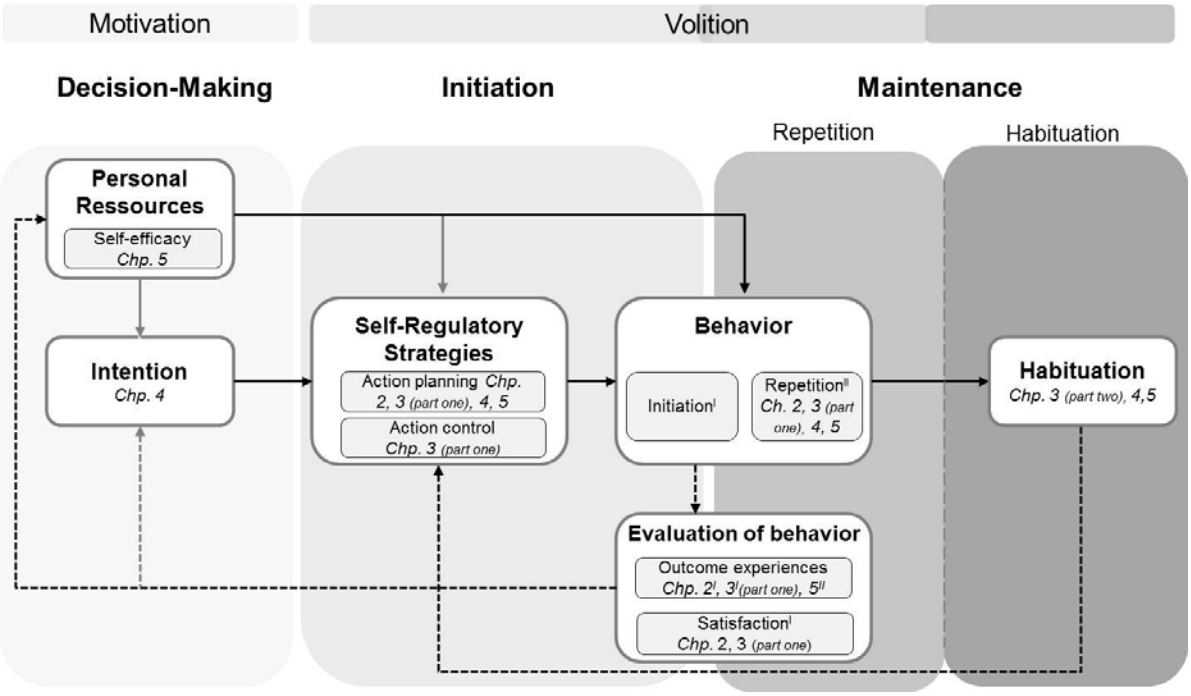

Figure 2. Summary of the chapters' content

Note. ⇢ = Dashed lines indicate how behaviour feedbacks on social-cognitions; → = Solid lines indicate how cognitions predict each other and behaviour; *Chp*. = *Chapter*(*s*); Black lines were investigated within this thesis; [I]rehabilitation context (supervised exercise); [II]home-based context (self-directed exercise).

Studies in this Thesis

To examine the volitional processes of behaviour maintenance, this thesis includes five studies with different designs, health behaviours and samples. The structure of the prospective observational (*Chapter 2, 4*) and experimental studies (*Chapter 3, 5*) is outlined in Table 2. All participants were recruited in field settings.

Table 2. Longitudinal Design of the Studies

					Weeks after baseline		Months after baseline	
Behaviour	Design	Setting	Baseline	2	3[2]	9[3]	6	12
Physical exercise (C*hp. 2*)	Observational	Secondary Prevention (Rehabilitation)	**M**		**M**	**M**		
Physical exercise (C*hp. 3, part one*)[1]	Experimental	Secondary Prevention (Rehabilitation)	**M&I**		**I**	**M**		
Fruit and vegetable intake (C*hp. 3 , part two*)[1]	Experimental	Secondary Prevention (Rehabilitation)	**M&I**		**I**	**M**		
Physical exercise (*Chp. 4 ,part one*)	Observational	Primary Prevention (University)	**M**	**M**				
Physical exercise (*Chp. 4, part two*)	Observational	Secondary Prevention (Rehabilitation)	**M**		**M**	**M**		**M**
Physical exercise (*Chp. 5*)	Experimental	Secondary Prevention (Rehabilitation)	**M**&I[4]		**M**&I[4]	**M&I**	**I**	**M**

Note. Bold letters are indicative for measurement points ('M') and interventions ('I'). *Chp.* = *Chapter;* [1]Research questions of *Chapter 3* were analysed within the same experimental study; [2]End of rehabilitation treatment; [3]Six weeks after rehabilitation treatment; [4]Short-term intervention effects were evaluated in part one of *Chapter 3*.

Baseline assessments were taken either in a primary prevention setting at a university (*Chapter 4, part one*) or in a secondary prevention setting during and after medical rehabilitation treatment (*Chapter 1* to *3, part two, Chapter 4, part two,* and *Chapter 5*). The follow-up measures were employed up to 12 months after baseline, in order to capture short-term (*Chapter 2, 3, 4, part one*) and long-term changes (*Chapter 4, part two,* and *Chapter 5*) in personal resources, self-regulation, and

behavioural outcomes (see Table 2). Besides paper-pencil questionnaires (*Chapter 4, part one,* and *Chapter 5*), interactive communication technologies (i.e., computer, telephone) were used to deliver the questionnaires (*Chapter 2, 3, 4, part two*), the interventions (*Chapter 3*) and the follow-up booster sessions (*Chapter 5*). Physical exercise was the behavioural target in all studies, with *Chapter 3 (part two)* additionally focusing on changes in fruit and vegetable intake. Further information about study design, recruitment and procedures is provided in the empirical chapters.

References

Aarts, H., Paulussen, T., & Schaalma, H. (1997). Physical exercise habit: On the conceptualization and formation of habitual health behaviours. Health Education Research, 12(3), 363-374.

Adriaanse, M. A., Vinkers, C. D. W., De Ridder, D. T., Hox, J. J., & De Wit, J. B. F. (2011). Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. *Appetite, 56*(1), 183-193.

Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behaviour and Human Decision Processes, 50*(2), 179-211.

Baldwin, A. S., Rothman, A. J., Hertel, A. W., Linde, J. A., Jeffery, R. W., Finch, E. A., et al. (2006). Specifying the determinants of the initiation and maintenance of behaviour change: An examination of self-efficacy, satisfaction, and smoking cessation. *Health Psychology, 25*(5), 626.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bargh, J. A. (1994). The four horsemen of automaticity: Awareness, intention, efficiency, and control in social cognition. In R. S. Wyer Jr. & T. K. Srull (Eds.), *Handbook of social cognition* (2nd ed., pp. 1-40). Hillsdale, NJ: Erlbaum.

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn?: A taxonomy for far transfer. *Psychological Bulletin, 128*(4), 612-637.

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation*. San Diego, CA: Academic Press.

Baumeister, R. F., Muraven, M., & Tice, D. M. (2000). Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Psychological Bulletin, 18*(2), 130-150.

Bélanger-Gravel, A., Godin, G., & Amireault, S. (2011). A meta-analytic review of the effect of implementation intentions on physical activity. *Health Psychology Review*, 1-32.

Biddle, S. J. H., & Fuchs, R. (2009). Exercise psychology: A view from Europe. *Psychology of Sport and Exercise, 10*(4), 410-419.

Brassington, G. S., Atienza, A. A., Perczek, R. E., DiLorenzo, T. M., & King, A. C. (2002). Intervention-related cognitive versus social mediators of exercise adherence in the elderly. *American Journal of Preventive Medicine, 23*(2), 80-86.

Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behaviour*. New York: Cambridge University Press.

Chapman, J., & Armitage, C. J. (2010). Evidence that boosters augment the long-term impact of implementation intentions on fruit and vegetable intake. *Psychology & Health, 25*(3), 365-381.

Conn, V. S., Hafdahl, A. R., Minor, M. A., & Nielsen, P. J. (2008). Physical activity interventions among adults with arthritis: Meta-analysis of outcomes. *Seminars in Arthritis and Rheumatism, 37*, 307-316.

Conner, M., Sandberg, T., & Norman, P. (2011). Using action planning to promote exercise behaviour. *Annals of Behavioural Medicine, 40*(1), 65-76.

D'Angelo, M. S., & Reid, R. D. (2007). A model for exercise behaviour change regulation in patients with heart disease. *Journal of Sport & Exercise Psychology, 29*(2), 208-224.

Dalal, H. M., Zawada, A., Jolly, K., Moxham, T., & Taylor, R. S. (2010). Home based versus centre based cardiac rehabilitation: Cochrane systematic review and meta-analysis. *British Medical Journal 340*, 1-15. doi: 10.1136/bmj.b5631

Deutsche Rentenversicherung Bund (2011). *Reha-Bericht Update 2011: Die medizinische und berufliche Rehabilitation der Rentenversicherung im Licht der Statistik*. [Rehabilitation report update 2011: Medical and occupational rehabilitation of the pension insurance in the light of statistics]. Retrieved from http://www.suchthilfe.de/themen/drv_%20reha_bericht_update_110318.pdf

Deutsche Rentenversicherung Bund (2012). *Statistik der Deutschen Rentenversicherung: Aktuelle Daten 2012*. [Statistics of the German Pension Insurance: Current data 2012]. Retrieved fromhttp://www.deutsche-rentenversicherung.de/cae/servlet/contentblob/30000/publicationFile/19085/aktuelle_daten_2011.pdf

Eyre, H., Kahn, R., Robertson, R. M., Clark, N. G., Doyle, C., Gansler, T., et al. (2004). Preventing cancer, cardiovascular disease, and diabetes: A common agenda for the American Cancer Society, the American Diabetes Association, and the American Heart Association. *A Cancer Journal for Clinicians, 54*(4), 190-207.

Fisher, E. B., Fitzgibbon, M. L., Glasgow, R. E., Haire-Joshu, D., Hayman, L. L., Kaplan, R. M., et al. (2011). Behaviour matters. *American Journal of Preventive Medicine, 40*(5), 15-30.

Finch, E. A., Linde, J. A., Jeffery, R. W., Rothman, A. J., King, C. M., & Levy, R. L. (2005). The effects of outcome expectations and satisfaction on weight loss and maintenance: Correlational and experimental analyses-a randomized trial. *Health Psychology, 24*(6), 608-616.

Fjeldsoe, B., Neuhaus, M., Winkler, E., & Eakin, E. (2011). Systematic review of maintenance of behaviour change following physical activity and dietary interventions. *Health Psychology, 30*(1), 99-109.

Fleig, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T., & Gravert, C. (2010). Förderung von körperlicher Aktivität im betrieblichen Kontext: Ein randomisiertes Kontrollgruppen-Design zur Untersuchung von stadienspezifischen Interventionseffekten [Promoting physical activity in a workplace setting: A randomized control trial investigating stage-specific intervention effects]. *Zeitschrift für Gesundheitspsychologie, 18*(2), 69-78.

Fuchs, R., Göhner, W., & Seelig, H. (2011). Long-term effects of a psychological group intervention on physical exercise and health: The MoVo concept. *Journal of Physical Activity & Health, 8*(6), 794-803.

Gaber, E., & Wildner, M. (2011). Sterblichkeit, Todesursachen und regionale Unterschiede. [Mortality, causes of death, and regional differences]. In Robert Koch Institute (Ed.), *Gesundheitsberichterstattung des Bundes*. Berlin: Robert Koch Institute.

Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A systematic review and meta-analysis of applications of the self-report habit index to nutrition and physical activity behaviours. *Annals of Behavioural Medicine*, 1-14.

Göhner, W., Seelig, H., & Fuchs, R. (2009). Intervention effects on cognitive antecedents of physical exercise: A 1-year follow-up study. *Applied Psychology: Health and Well-Being, 1*(2), 233-256.

Gollwitzer, P. M. (1999). Implementation intentions: strong effects of simple plans. *American Psychologist, 54*(7), 493-503.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology, 38*, 69-119.

Gutiérrez Doña, B., Lippke, S., Renner, B., Kwon, S., & Schwarzer, R. (2009). Self-efficacy and planning predict dietary behaviors in Costa Rican and South Korean women: two moderated mediation analyses. *Applied Psychology: Health and Well-Being, 1*(1), 91-104.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological Bulletin, 136*(4), 495-525.

Hayes, C., & Kriska, A. (2008). Role of physical activity in diabetes management and prevention. *Journal of the American Dietetic Association, 108*(4), 19-23.

Heckhausen, H. (1991). *Motivation and action*. New York: Springer-Verlag.

Hertel, A. W., Finch, E. A., Kelly, K. M., King, C., Lando, H., Linde, J. A., et al. (2008). The impact of expectations and satisfaction on the initiation and maintenance of smoking cessation: an experimental test. *Health Psychology, 27*(3), 197-206.

Jolliffe, J. A., Rees, K., Taylor, R. S., Thompson, D., Oldridge, N., & Ebrahim, S. (2003). Exercise-based rehabilitation for coronary heart disease (Cochrane Methodology Review). In T. C. Library (Ed.), (Vol. 4). Chichester, UK: John Wiley & Sons, Ltd.

Koring, M., Richert, J., Lippke, S., Parschau, L., Reuter, T., & Schwarzer, R. (2011). Synergistic effects of planning and self-efficacy on physical activity. *Health Education & Behaviour*. doi: 10.1177/1090198111417621

Kuhl, J. (1986). Motivation and information processing: A new look at decision making,dynamic change, and action control. In R. M. Sorrentino & E. T. Higgins (Eds.), *Handbook of motivation and cognition: Foundation of social behavior* (pp. 404-434). New York: The Guildford Press.

Laitakari, J., Vuori, I., & Oja, P. (1996). Is long-term maintenance of health-related physical activity possible? An analysis of concepts and evidence. *Health Education Research, 11*(4), 463-477.

Lally, P., & Gardner, B. (2011). Promoting habit formation. *Health Psychology Review*, 1-22. doi: 10.1080/17437199.2011.603640

Lally, P., van Jaarsveld, C. H. M., Potts, H. W. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *European Journal of Social Psychology, 40*(6), 998-1009.

Lavie, C. J., Milani, R. V., & Ventura, H. O. (2009). Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. *Journal of the American College of Cardiology, 53*(21), 1925-1932.

Leventhal, H., Singer, R., & Jones, S. (1965). Effects of fear and specificity of recommendation upon attitudes and behaviour. *Journal of Personality and Social Psychology, 2*(1), 20-29.

Lippke, S., Nigg, C. R., & Maddock, J. E. (2012). Health-promoting and health-risk behaviours: Theory-driven analyses of multiple health behaviour change in three international samples. *International Journal of Behavioural Medicine*, 1-13.

Lippke, S., Schwarzer, R., Ziegelmann, J. P., Scholz, U., & Schüz, B. (2010). Testing stage-specific effects of a stage-matched intervention: a randomized controlled trial targeting physical exercise and its predictors. *Health Education & Behaviour, 37*(4), 533-546.

Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T., & Schwarzer, R. (2009). Self-efficacy moderates the mediation of intentions into behavior via plans. *American Journal of Health Behavior, 33*(5), 521-529.

Lippke, S., Ziegelmann, J. P., Schwarzer, R., & Velicer, W. F. (2009). Validity of stage assessment in the adoption and maintenance of physical activity and fruit and vegetable consumption. *Health Psychology, 28*(2), 183-193.

Luszczynska, A. (2006). An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. *Social Science & Medicine, 62*(4), 900-908.

Luszczynska, A., Cao, D. S., Mallach, N., Pietron, K., Mazurkiewicz, M., & Schwarzer, R. (2010). Intentions, planning, and self-efficacy predict physical activity in Chinese and Polish adolescents: Two moderated mediation analyses. *International Journal of Clinical and Health Psychology, 10*(2), 265-278.

Luszczynska, A., & Cieslak, R. (2009). Mediated Effects of Social Support for Healthy Nutrition: Fruit and Vegetable Intake Across 8 Months After Myocardial Infarction. *Behavioural Medicine, 35*(1), 30-38.

Luszczynska, A., Scholz, U., & Sutton, S. (2007). Planning to change diet: A controlled trial of an implementation intentions training intervention to reduce saturated fat intake among patients after myocardial infarction. *Journal of Psychosomatic Research, 63*(5), 491-497.

Luszczynska, A., Tryburcy, M., & Schwarzer, R. (2007). Improving fruit and vegetable consumption: a self-efficacy intervention compared with a combined self-efficacy and planning intervention. *Health Education Research, 22*(5), 630-638.

Mangels, M., Schwarz, S., Worringen, U., Holme, M., & Rief, W. (2009). Evaluation of a behavioural-medical inpatient rehabilitation treatment including booster sessions: A randomized controlled study. *The Clinical Journal of Pain, 25*(5), 356-364.

Marcus, B. H., Forsyth, L. A. H., Stone, E. J., Dubbert, P. M., McKenzie, T. L., Dunn, A. L., et al. (2000). Physical activity behaviour change: Issues in adoption and maintenance. *Health Psychology, 19*(1), 32-41.

McAuley, E., & Blissmer, B. (2000). Self-efficacy determinants and consequences of physical activity. *Exercise and Sport Sciences Reviews, 28*(2), 85-88.

Metz, K., Flöter, S., Kröger, C., Donath, C., Piontek, D., & Gradl, S. (2007). Telephone booster sessions for optimizing smoking cessation for patients in rehabilitation centers. *Nicotine & Tobacco Research, 9*(8), 853-863.

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*(6), 690-701.

Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. *Psychology & Health, 26*(11), 1479-1498.

Morabia, A., & Costanza, M. C. (2010). Multiple health behaviour change interventions: Tell us what you see. *Preventive medicine, 50*(1-2), 1-2.

Neal, D. T., Wood, W., & Quinn, J. M. (2006). Habits - A repeat performance. *Current Directions in Psychological Science, 15*(4), 198-202.

Nigg, C. R., Lee, H., Hubbard, A. E., & Min-Sun, K. (2009). Gateway health behaviours in college students: Investigating transfer and compensation effects. *Journal of American College Health, 58*(1), 39-44.

Oldenburg, B., Absetz, P., & Chan, C. (2010). Behavioural interventions for prevention and management of chronic disease. In A. Steptoe, K. Freedland, J. R. Jenning, M. Liabre, S. Manuck & E. Susman (Eds.), *Handbook of behavioural medicine: methods and applications* (pp. 969-988). New York: Springer.

Orbell, S., & Verplanken, B. (2010). The automatic component of habit in health behaviour: Habit as cue-contingent automaticity. *Health Psychology, 29*(4), 374-383.

Parschau, L., Fleig, L., Koring, M., Lange, D., Lippke, S., & Schwarzer, R. (under review). Positive experience, self-efficacy, and action control predict physical activity.

Pomp, S., Lippke, S., Fleig, L., & Schwarzer, R. (2010). Synergistic Effects of Intention and Depression on Action Control: Longitudinal Predictors of Exercise after Rehabilitation. *Mental Health and Physical Activity, 2*, 78-84.

Prochaska, J. J., Spring, B., & Nigg, C. R. (2008). Multiple health behaviour change research: An introduction and overview. *Preventive Medicine, 46*(3), 181-188.

Rabenberg, M., & Mensink, G. B. M. (2011). Fruit and vegetable consumption today. In Robert Koch Institute (Ed.), *GBE kompakt* (Vol. 2, pp. 1-9). Berlin: Robert Koch Institute.

Renner, B., Hankonen, N., Ghisletta, P., & Absetz, P. (2011). Dynamic psychological and behavioural changes in the adoption and maintenance of exercise. *Health Psychology*. doi: 10.1037/a0025302

Reuter, T., Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2009). Long-term relations between intentions, planning, and exercise: A 3-year longitudinal study after orthopedic rehabilitation. *Rehabilitation Psychology, 54*(4), 363-371.

Richert, J., Reuter, T., Wiedemann, A. U., Lippke, S., Ziegelmann, J., & Schwarzer, R. (2010). Differential effects of planning and self-efficacy on fruit and vegetable consumption. *Appetite, 54*(3), 611-614.

Ries, A. L., Kaplan, R. M., Myers, R., & Prewitt, L. M. (2003). Maintenance after pulmonary rehabilitation in chronic lung disease: A randomized trial. *American Journal of Respiratory and Critical Care Medicine, 167*, 880-888.

Rigotti, N. A., Munafo, M. R., & Stead, L. F. (2008). Smoking cessation interventions for hospitalized smokers: a systematic review. *Archives of Internal Medicine, 168*(18), 1950-2002.

Robert Koch Institute. (2011). *Daten und Fakten: Ergebnisse der Studie "Gesundheit in Deutschland aktuell 2009"*. Retrieved from http://www.rki.de/cln_116/nn_197444/DE/Content/GBE/Gesundheitsberichterstattung/GBEDownloadsB/GEDA09, templateId=raw, property=publicationFile.pdf/GEDA09.pdf

Robert Koch Institute. (2006). *Health in Germany: Summary*. Retrieved from http://www.rki.de/cln_116/nn216468/EN/Content/Health_ _Reporting/HealthInGermany/GesInDtldSummary,templateId=raw, property=publication File.pdf/GesInDtldSummary.pdf

Rothman, A. J. (2000). Toward a theory-based analysis of behavioural maintenance. *Health Psychology, 19*, 64-69.

Rothman, A. J., Baldwin, A. S., & Hertel, A. W. (2004). Self-regulation and behaviour change: Disentangling behavioural initiation and behavioural maintenance. In K. Vohs & R. Baumeister (Eds.), *The handbook of self-regulation* (pp. 130-148). New York: Guilford Press.

Rothman, A. J., Sheeran, P., & Wood, W. (2009). Reflective and automatic processes in the initiation and maintenance of dietary change. *Annals of Behavioural Medicine, 38*, 4-17.

Scholz, U., Nagy, G., Göhner, W., Luszczynska, A., & Kliegel, M. (2009). Changes in self-regulatory cognitions as predictors of changes in smoking and nutrition behaviour. *Psychology & Health, 24*(5), 545-561.

Scholz, U., & Sniehotta, F. F. (2006). Langzeiteffekte einer Planungs- und Handlungskontrollintervention auf die körperliche Aktivität von Herzpatienten nach der Rehabilitation. [Long-term effects of a planning and action control intervention on physical activity of cardiac patients after rehabilitation]. *Zeitschrift für Gesundheitspsychologie, 14*(2), 73-81.

Scholz, U., Sniehotta, F. F., Schüz, B., & Oeberst, A. (2007). Dynamics in self-regulation: Plan execution self-efficacy and mastery of action plans. *Journal of Applied Social Psychology, 37*(11), 2706-2725.

Schüz, B., Sniehotta, F. F., & Schwarzer, R. (2007). Stage-specific effects of an action control intervention on dental flossing. *Health Education Research, 22*(3), 332-341.

Schwarzer, R. (2008). Modeling health behaviour change: How to predict and modify the adoption and maintenance of health behaviours. *Applied Psychology: An International Review, 57*, 1-29.

Schwarzer, R., Lippke, S., & Luszczynska, A. (2011). Mechanisms of health behaviour change in persons with chronic illness or disability: The Health Action Process Approach (HAPA). *Rehabilitation Psychology, 56*(3), 161-170.

Schwarzer, R., Richert, J., Kreausukon, P., Remme, L., Wiedemann, A. U., & Reuter, T. (2010). Translating intentions into nutrition behaviors via planning requires self-efficacy: Evidence from Thailand and Germany. *International Journal of Psychology, 45*(4), 260-268.

Seymour, R. B., Hughes, S. L., Ory, M. G., Elliot, D. L., Kirby, K. C., Migneault, J., et al. (2010). A lexicon for measuring maintenance of behavior change. *American Journal of Health Behavior, 34*(6), 660-668.

Sheeran, P. (2002). Intention-behaviour relations: A conceptual and empirical review. *European Review of Social Psychology, 12*(1), 1-36.

Sniehotta, F. F., Araújo-Soares, V., & Dombrowski, S. U. (2007). Randomized controlled trial of a one-minute intervention changing oral self-care behaviour. *Journal of Dental Research, 86*(7), 641-645.

Sniehotta, F. F., Gorski, C., & Araújo-Soares, V. (2010). Adoption of community-based cardiac rehabilitation programs and physical activity following phase III cardiac rehabilitation in Scotland: A prospective and predictive study. *Psychology & Health, 25*(7), 839-854.

Sniehotta, F. F., Nagy, G., Scholz, U., & Schwarzer, R. (2006). The role of action control in implementing intentions during the first weeks of behaviour change. *British Journal of Health Psychology, 45*(1), 87-106.

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health, 20*(2), 143-160.

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2006). Action plans and coping plans for physical exercise: A longitudinal intervention study in cardiac rehabilitation. *British Journal of Health Psychology, 11*(1), 23-37.

Sniehotta, F. F., Scholz, U., Schwarzer, R., Fuhrmann, B., Kiwus, U., & Völler, H. (2005). Long-term effects of two psychological interventions on physical exercise and self-regulation following coronary rehabilitation. *International Journal of Behavioural Medicine, 12*(4), 244-255.

Sniehotta, F. F., Schwarzer, R., Scholz, U., & Schüz, B. (2005). Action planning and coping planning for long-term lifestyle change: theory and assessment. *European Journal of Social Psychology, 35*(4), 565-576.

Soureti, A., Hurling, R., van Mechelen, W., Cobain, M., & Chinapaw, M. (2011). Moderators of the mediated effect of intentions, planning, and saturated-fat intake in obese individuals. *Health Psychology*. doi: 10.1037/a002649

Spring, B., Moller, C. M., & Coons, M. J. (2012). Multiple health behaviours: Overview and implications. *Journal of Public Health, 34*(1), 3-10.

Stadler, G., Oettingen, G., & Gollwitzer, P. M. (2010). Intervention effects of information and self-regulation on eating fruits and vegetables over two years. *Health Psychology, 29*(3), 274-283.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behaviour. *Personality and Social Psychology Review, 8*(3), 220-247.

Van Baar, M. E., Assendelft, W. J. J., Dekker, J., Oostendorp, R. A. B., & Bijlsma, J. W. J. (1999). Effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: a systematic review of randomized clinical trials. *Arthritis & Rheumatism, 42*(7), 1361-1369.

van Stralen, M. M., De Vries, H., Mudde, A. N., Bolman, C., & Lechner, L. (2009). Determinants of initiation and maintenance of physical activity among older adults: A literature review. *Health Psychology Review, 3*(2), 147-207.

Verplanken, B., & Melkevik, O. (2008). Predicting habit: The case of physical exercise. *Psychology of Sport and Exercise 9*(1), 15-26.

Warner, L. M., Schüz, B., Knittle, K., Ziegelmann, J. P., & Wurm, S. (2011). Sources of perceived self-efficacy as predictors of physical activity in older adults. *Applied Psychology: Health and Well-Being, 3*, 172–192.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioural intentions engender behaviour change? A meta-analysis of the experimental evidence. *Psychological Bulletin, 132*(2), 249-268.

Webb, T. L., & Sheeran, P. (2007). How do implementation intentions promote goal attainment? A test of component processes. *Journal of Experimental Social Psychology, 43*(2), 295-302.

Wiedemann, A. U., Lippke, S., Reuter, T., Ziegelmann, J. P., & Schwarzer, R. (2011). How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. *European Journal of Social Psychology, 41*(1), 42-51.

Wiedemann, A. U., Lippke, S., & Schwarzer, R. (2011). Multiple plans and memory performance: Results of a randomized controlled trial on fruit and vegetable intake. *Journal of Behavioural Medicine*. doi: 10.1007/s10865-011-9364-2

Williams, D. M., Lewis, B. A., Dunsiger, S., Whiteley, J. A., Papandonatos, G. D., Napolitano, M. A., et al. (2008). Comparing psychosocial predictors of physical activity adoption and maintenance. *Annals of Behavioural Medicine, 36*(2), 186-194.

Wing, R. R., & Phelan, S. (2005). Long-term weight loss maintenance. *The American Journal of Clinical Nutrition, 82*(1), 222-225.

Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. *Psychological Review, 114*(4), 843-863.

Woodgate, J., & Brawley, L. R. (2008). Self-efficacy for exercise in cardiac rehabilitation. *Journal of Health Psychology, 13*(3), 366-387.

World Health Organisation. (2002). *The World Health Report 2002: Reducing risk, promoting health life*. Retrieved from http://www.who.int/entity/whr/2002/en/whr02_en.pdf

Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2006). Adoption and maintenance of physical activity: Planning interventions in young, middle-aged, and older adults. *Psychology & Health, 21*(2), 145-163.

Ziegelmann, J. P., Luszczynska, A., Lippke, S., & Schwarzer, R. (2007). Are goal intentions or implementation intentions better predictors of health behaviour? A longitudinal study in orthopedic rehabilitation. *Rehabilitation Psychology, 52*(1), 97-102.

2

Exercise Maintenance after Rehabilitation: How Experience Can Make a Difference

---

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2011). Exercise maintenance after rehabilitation: How experience can make a difference. *Psychology of Sport & Exercise, 12,* 293-299.

Abstract

Objectives. Rehabilitation treatment includes physical exercise to enable patients to decrease limitations and facilitate post-treatment exercise performance. However, many patients fail to maintain an active lifestyle after their discharge from rehabilitation. It is assumed that their experience with exercise during rehabilitation treatment, their satisfaction with it, and their self-regulatory goal pursuit may be sufficient for long-term exercise maintenance. Therefore, the present study aims to examine the psychological mechanisms that might contribute to exercise maintenance after rehabilitation.

Design. At the beginning and at the end of cardiac and orthopedic rehabilitation, 248 patients filled in a computer-based questionnaire assessing exercise experiences, satisfaction, planning, and behaviour. Physical exercise was reassessed 6 weeks after discharge.

Method. Multiple mediation analysis was conducted to unveil working mechanisms of exercise experiences. It was tested whether the impact of exercise experiences during rehabilitation had an effect on behaviour after discharge and whether satisfaction and planning would mediate this process, controlling for past behaviour and patient group (cardiac vs. orthopedic).

Results. Analyses revealed that experiences exert its influence on subsequent behaviour via two independent social-cognitive pathways: satisfaction and planning (full mediation).

Conclusions. Findings suggest that focusing on individuals' experiences during rehabilitation may promote exercise maintenance indirectly by increasing satisfaction levels and planning skills. Standard rehabilitation care may be complemented by psychological interventions that promote positive experiences, improve satisfaction, and teach self-regulatory skills such as planning.

Keywords: physical exercise, experiences, satisfaction, planning, health action process approach, multiple mediation

Introduction

Engaging in regular physical exercise is related to numerous psychological and physical health benefits (Hardman & Stensel, 2003). In particular, individuals who already suffer from physical limitations, such as arthritis and osteoporosis (Conn, Hafdahl, Minor, & Nielsen, 2008; Van Baar, Assendelft, Dekker, Oostendorp, & Bijlsma, 1999), or cardiovascular diseases (Dalal, Zawada, Jolly, Moxham, & Taylor, 2010; Lavie, Milani, & Ventura, 2009) gain from regular exercise. Thus, it is imperative to understand mechanisms that increase the likelihood of successful exercise adoption and maintenance (Biddle & Fuchs, 2009), especially in chronically ill individuals. The current study addresses this question and investigates the role of exercise experiences in the process of exercise maintenance among cardiac and orthopedic rehabilitation patients.

Exercise-Based Rehabilitation: Gateway to an Active Lifestyle

Rehabilitation treatment includes exercise to enable patients to decrease limitations and facilitate post-treatment exercise performance. Participation in exercise-based rehabilitation is, therefore, an important step for cardiac and orthopedic patients towards improved health and a physically active lifestyle. However, the success of sustaining health benefits obtained during rehabilitation lies in the way patients implement health-promoting activities into their life after discharge (D'Angelo & Reid, 2007; Göhner & Schlicht, 2006; Minor & Brown, 1993). Transferring exercise behaviour from a supervised clinical setting to a self-directed leisure-time context poses a major challenge for rehabilitation patients. Not surprisingly, a high percentage of orthopedic (Sluijs, Kok, & van der Zee, 1993) and cardiac patients (Burke, Dunbar-Jacob, & Hill, 1997; Dorn, Naughton, Imamura, & Trevisan, 2001) fail to maintain an active lifestyle after rehabilitation. Widespread acknowledgement of the exercise maintenance problem after rehabilitation has prompted theory-based investigation of exercise determinants in this population. As proposed by the Health Action Process Approach (HAPA; Schwarzer, 2008) and Rothman's framework of health behaviour change (Rothman, 2000; Rothman, Baldwin, & Hertel, 2004) the initiation and maintenance of exercise is governed by distinct psychological factors. Both models assume that the initial decision to exercise is guided by pre-motivational factors, such as outcome expectancies, self-efficacy (Schwarzer, 2008; Rothman, 2000; Rothman et al., 2004; Schwarzer, 2008), and risk perception (Schwarzer, 2008). Decisions regarding behaviour maintenance are predicted to rely on self-regulatory strategies, such as *planning* (Schwarzer, 2008), *behavioural experiences,* and *perceived satisfaction* with experienced behaviour outcomes (Rothman, 2000; Rothman et al., 2004). These

post-motivational factors become particularly important for rehabilitation patients. From a theoretical perspective, rehabilitation patients are about to progress from *behaviour initiation* in a supervised clinical setting to *behaviour maintenance* in a self-managed post rehabilitation context (D'Angelo & Reid, 2007). Figure 1 illustrates the theoretical backdrop of the study.

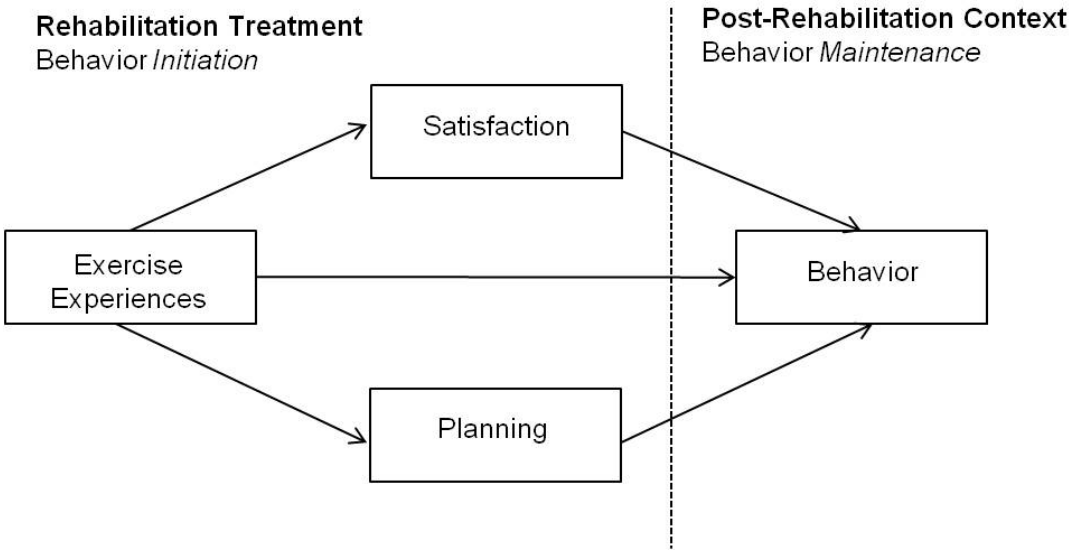

Figure 1. Theoretical mediation model: Experience during rehabilitation predicts exercise behaviour after rehabilitation, mediated by satisfaction and planning

Maintaining Exercise after Rehabilitation: The Role of Exercise Experiences

Central to investigating psychological factors in relation to behaviour maintenance is to acknowledge that people have experiences with the consequences of a behaviour (e.g., losing weight as a result of exercising). These may modify previously formed cognitions and thereby guide future behaviour engagement (Fuchs et al., in press). *Behaviourial experiences* can be understood as specific behaviour-related outcome experiences Fuchs et al., in press). For instance, patients may choose to train on a stationary bike (behaviour). By doing so frequently they might feel more flexible (experience), and eventually realize that they lose weight (experience). Or, they may participate in a daily muscle strengthening training and learn that the training alleviates their back pain (experience). Thus, whether or not patients transfer exercise from the rehabilitation into their post-rehabilitation routine may depend on their exercise experiences during rehabilitation. If patients experience a variety of benefits attainable from recommended activities during exercise

treatment they might be more likely to adopt therapeutic exercise recommendations as their personal goals. Exercise experiences may therefore be understood as a catalyst of social-cognitive mechanisms that promote post-rehabilitation exercise maintenance.

So far, little research has examined the effect of exercise experiences on subsequent behaviour. Fuchs et al. (in press) found that orthopedic patients who participated in a psychological exercise-based intervention during rehabilitation reported less pain and more exercise after discharge. However, the direct link of exercise experiences (i.e., reduction in pain) on behaviour was not explicitly tested in that study. In a sample of healthy older adults, perceived changes in exercise experiences predicted adherence to home-based exercise recommendations (Brassington, Atienza, Perczek, DiLorenzo, & King, 2002). To sum up, there is some initial empirical support that exercise experiences may be associated with subsequent performance. However, the question remains *how* exercise experiences exert their influence on subsequent behaviour. The post-intentional processes that can explain a link between exercise experiences and exercise behaviour have not been well characterized. In the present study the rehabilitation context was used to investigate on this relationship. While previous studies have examined planning and satisfaction as predictors of exercise behaviour, the present study investigates a broader representation of post-intentional processes by including exercise experiences in a theoretically integrated model based on the HAPA (Schwarzer, 2008) and Rothman's (2000) framework of health behaviour change (see Figure 1). This study investigates the mechanisms via which experiences may influence subsequent exercise behaviour. In detail, we propose a multiple mediator model in which the impact of exercise experiences on post rehabilitation exercise is mediated by perceptions of satisfaction and planning.

Satisfaction: Subjective Evaluation of Experiences

Perceived satisfaction can be understood as the subjective evaluation of experienced health behaviour outcomes (Rothman, 2000; Rothman et al., 2004). Rothman (2000) has integrated behaviour experiences and behaviour evaluations (i.e., satisfaction) in a framework of health behaviour change. In detail, the authors (Rothman, 2000; Rothman et al., 2004) postulate that people evaluate a previously performed behaviour by comparing their experiences with their outcome expectations. If experiences match or exceed expectations, *perceptions of satisfaction* should emerge. Thus, individuals with high levels of satisfaction should be more likely to maintain a behaviour. According to Rothman's framework, perceptions of satisfaction should mediate the effects of experiences on subsequent behaviour.

A study that explicitly analyzed the associations between behaviour-related experiences and satisfaction was conducted by Baldwin, Rothman, Hertel, Keenan and Jeffrey (2009). Among a sample of ex-smokers, the authors found that a variety of cessation-related experiences covering health-related (e.g., impact of smoking cessation on cravings) and social experiences (e.g., impact of smoking cessation on social interactions), were positively associated with perceptions of satisfaction (Baldwin et al., 2009).

The direct effect of satisfaction on behaviour maintenance has been investigated in several studies. In the smoking domain, research has provided support for the second part of Rothman's thesis by demonstrating that people's satisfaction with smoking cessation is a critical determinant of whether those who have been successful at quitting smoking maintain their abstinence over time (Baldwin, et al., 2006). In the domain of weight loss management, satisfaction with weight loss has been identified as determinant of sustained behaviour (Finch et al., 2005). To sum up, previous research has provided support for parts of Rothman's assumptions. However, the interplay of experiences, satisfaction, and behaviour has not been investigated in one integrative model. One aim of the present study is, therefore, to test whether experiences exert their influence on behaviour via perceptions of satisfaction. Applying Rothman's assumptions to the rehabilitation context, patients who have a variety of positive exercise experiences during rehabilitation should also have higher levels of satisfaction. Consequently, they should be more likely to continue their efforts in sustaining behaviour beyond rehabilitation.

Planning

Besides satisfaction, planning might be another potential pathway via which experiences influence exercise maintenance. Planning (Implementation Intentions; Gollwitzer, 1999) refers to a prospective self-regulatory strategy, in which people link behavioural responses to specific situations to achieve certain goals (Sheeran & Orbell, 1999; Sniehotta, et al., 2005). For example, patients may plan to continue their muscle strength training (i.e., behavioural response) on Mondays at 7 p.m. in the local fitness club (i.e., situational cue in home-based environment). On encountering specified cues, intended behaviour can be initiated almost without the need of conscious acts (Gollwitzer & Sheeran, 2006; Webb & Sheeran, 2007).

Thus, for rehabilitation patients, planning is an important self-regulatory tool as it can help to integrate a new or modified pattern of behaviour into one's usual routines. Supporting theoretical assumptions of the HAPA (Schwarzer, 2008), observational studies among cardiac (Sniehotta,

Scholz, & Schwarzer, 2006) and orthopedic patients (Lippke, Ziegelmann, & Schwarzer, 2004a; Ziegelmann, Luszczynska, Lippke, & Schwarzer, 2007) provide consistent support that planning increases the likelihood of the initiation and maintenance of intended physical exercise behaviour. However, theoretical considerations and analyses of the association of exercise experiences and planning are rather less explicated in the past. One might argue that once a behaviour has been initiated, concrete experiences with physical exercise may directly feedback on planning and thereby guide future behaviour.

Aims of the Present Study and Hypotheses

Although theories have acknowledged the role of experiences in health behaviour change, previous research has mainly focused on testing *whether* experiences affect subsequent behaviour. To our knowledge, potential working mechanisms of experiences have not been investigated before. Unveiling those psychological processes that translate experiences into future behaviour has important implications for interventions aimed at the promotion of exercise maintenance.

The aim of the present study is, therefore, to test for possible mediators that explain *how* exercise experiences have an impact on subsequent behaviour. In line with theorizing by the HAPA (Schwarzer, 2008) and Rothman's (2000) framework of health behaviour change, we propose a multiple mediator model in which exercise-related experiences during rehabilitation exert their influence on leisure-time exercise via perceptions of satisfaction and planning (see Figure 1).

Methods

Participants and Procedure

Patients with a medical indication to engage in regular physical exercise after rehabilitation were recruited for Time 1 (T1) assessments during their first week of stay in two orthopedic rehabilitation centers (one stationary and one out-patient) and one stationary cardiac rehabilitation clinic. After giving informed consent, 415 patients (n = 95 cardiac and n = 320 orthopedic patients) filled in a computer-based questionnaire assessing physical exercise, social-cognitive and sociodemographic variables.

All patients participated in the regular clinic program (standard care) that comprised a complex regime of medical, physiotherapeutic, and psychological therapies. Exercise therapy constituted the major part of rehabilitation treatment (Jäckel, Bengel, & Herdt, 2006; Pfeifer, Sudeck, Brüggemann, & Huber, 2010). For the duration of rehabilitation treatment, patients received an individualized exercise training program that was adjusted to their diagnosis. Individuals were rec-

ommended to engage in regular physical exercise after discharge by the clinic staff either in a self-directed manner or in a group setting.

The computer-based follow-up assessment (T2) took place during the final week of rehabilitation measuring social-cognitive variables (i.e., self-efficacy, experiences, satisfaction, and planning). Patients stayed in the rehabilitation clinics for 14 to 38 days (M = 23.40, SD = 3.68). Baseline assessments took place between 0 and 8 days after admission (M = 3.16, SD = 2.14). On average, Time 2 assessments were carried out 17.42 (SD = 8.26, range 13-35) days after T1. Six weeks after discharge (T3) physical exercise was reassessed via Computer-Assisted Telephone Interviews (CATI).

Of the initial sample (N = 415), 78.1% (n = 324) patients participated in the T2-assessment. The longitudinal sample (i.e., those individuals who completed the six week post-discharge follow-up) comprised 248 participants (60.0% of baseline). Mean age of the longitudinal sample was 49.2 years (SD = 10.0; range 22–76 years), and the sample consisted of slightly more women (54.1%) than men. Of all participants, 75.7% were living with a partner, 72.8% had at least one child. 89.9% reported German as mother tongue. Two thirds of the longitudinal sample (64.6%) reported to have a high school degree or more, and 76.1% were employed.

Drop-out analyses indicated that patients who continued study participation were slightly older (M = 49.2) than those who did not (M = 46.6; $F(1,413) = 2.21$; $p < .05$). Besides that, no other differences were found with regard to physical exercise, social-cognitive variables (i.e., planning, experience, maintenance self-efficacy), and socio-demographic variables (all $ps > .05$).

Ethical approval was granted from the Ethics Commission of the German Association of Psychology (Deutsche Gesellschaft für Psychologie, DGPs).

Measures

Unless mentioned otherwise, all scales were used in several prior studies and were tested regarding their psychometric properties (Lippke, Ziegelmann, & Schwarzer, 2004a, 2004b; Lippke, Ziegelmann, Schwarzer, & Velicer, 2009; Reuter, Ziegelmann, Lippke, & Schwarzer, 2009; Schwarzer, 2008; Ziegelmann, Luszczynska, Lippke, & Schwarzer, 2007). Item examples given below are translated from German.

Physical exercise considering the *effort* of exercise was measured at T1 and T3 with a modified version of the Godin Leisure-Time Exercise Questionnaire (GLTEQ; Godin & Shephard, 1985; Plotnikoff, et al., 2007).This self-report measure has been validated with physiological and

anthropometrical measures (i.e., VO_2 max and body fat; Godin & Shephard, 1985; Jacobs, Ainsworth, Hartman, & Leon, 1993). Participants were asked to report the average number of sessions per week and the average duration of a session regarding Strenuous (heart beats rapidly, sweating), Moderate (not exhausting, light perspiration) and Mild (minimal effort, no perspiration) physical exercise in the past month. Only activities outside of work duties (at work or at home) and voluntary activities were addressed. Answers (product of frequency and duration) for each of these three activity categories were then converted to MET (metabolic equivalent) minutes by multiplying the weekly minutes of Mild activity by 2.5 METs (Ainsworth et al., 2000), Moderate activity by 4.0 METs (Brown & Bauman, 2000), and Strenuous activity by 7.5 METs (Brown & Bauman, 2000). Furthermore, an overall activity index score was computed: Strenuous, Moderate, and Mild activities MET minutes.

Planning was assessed at T2 with four items addressing when, where, and how of the activity, taken from Lippke et al. (2004a). The items were worded: "For the month after the rehabilitation, I have already planned…" (1) "…which physical exercise I will perform (e.g., walking)", (2) "…where I will be physically active (e.g., in the park)," (3) "…on which days of the week I will be physically active" and (4) "…for how long I will be physically active" (Cronbach's $\alpha = .90$).

Satisfaction was assessed at T2 with one item that asked participants, "As of today, how satisfied are you with what you have experienced as a result of exercising?". Participants were asked to think about exercise experiences they had during rehabilitation. This measure has been used by Baldwin et al. (2009) and was adapted to the domain of physical exercise in this study.

Experiences were measured at T2 with 5 items adapted from Fuchs (2003). The applied *Exercise Experiences Scale* (EES) assesses experiences individuals may have as a consequence of exercising. The stem "When I was physically active I experienced that…" was followed by five positive exercise experiences, for example,"… it had a positive impact on my health." The item wordings of the scale are reported in Table 1.

The five items of the EES were subjected to a principal component analysis (PCA) for the longitudinal sample of 248 patients to explore the instrument's factorial structure. Two components had eigenvalues over Kaiser's criterion of 1, and explained 68.6% of the variance. An oblique rotation (Oblimin) was then performed on these two factors to increase their interpretability. Table 1 shows the factor loadings after rotation.

Table 1. Item Wordings and Summary of Exploratory Factor Analyses Results for the Exercise Experiences Scale (EES, $N = 248$)

Factor and Item	*1*	*2*
Factor I: Health-related experiences (α = .75)		
When I was physically active, I experienced that…		
1. … I felt better afterwards	**.78**	.09
2. … it had a positive impact on my health (e.g., less pain)	**.88**	-.05
3. … I felt more flexible afterwards	**.87**	-.96
Factor II: Social experiences ($r = .32$)		
When I was physically active, I experienced that…		
4. … it had a positive impact on my appearance	.34	**.49**
5. … I got to know other people	-.10	**.96**

Note. Factor loadings > .40 are in boldface.

Items loading on the first factor (3 items) are mainly concerned with health-related experiences. Items loading on the second factor (2 items) represent social experiences. Despite its heterogeneous nature, the 5-item experiences scale demonstrated sufficient internal consistency (Cronbach's α = .74). The highest inter-item correlation was $r = .49$ (see Table 1, item 2 and 3), and the great majority of the inter-item correlations clustered around $r = .25$–$.30$, indicating that the items are sufficiently differentiating and not redundant with one another. The internal consistency values of the health-related experiences subscale was higher (Cronbach's α = .75) than the social experiences subscale ($r = .34$) which covered two very different types of experiences (see Table 1).

Analytical Procedure

For estimating direct and indirect effects of multiple mediators in one model, we used the *non-parametric bootstrapping procedure* using the INDIRECT macro (Version 4) by Preacher and Hayes (2008). Point estimates and confidence intervals were estimated for the indirect effects. All variables were standardized (Aiken, West, & Reno, 1991). To account for baseline behaviour and differences between the two groups of patients (orthopedic vs. cardiac), Time 1 exercise behaviour and patient group were included as covariates. Missing data (< 10% on all variables) were imputed using the Expectation Maximization (EM) algorithm. All analyses were run with SPSS 17.

Results

Correlations

Means, standard deviations and intercorrelations of all model variables are displayed in Table 2.

Table 2. Means (*M*), Standard Deviations (*SD*), and Intercorrelations for Exercise Experiences, Satisfaction, Planning, and Physical Exercise in $N = 248$ Rehabilitation Patients

	1	*2*	*3*	*4*	*M*	*SD*	*Range*
1. Exercise Experiences T2					4.15	0.92	1-6
2. Satisfaction T2	.52***				4.93	1.12	1-6
3. Planning T2	.46***	.28**			4.21	1.33	1-6
4. Physical Exercise T1 index score MET minutes	.04	.03	.12*		613.07	839.89	0-3,615.00
5. Physical Exercise T3 index score MET minutes	.13*	.17*	.21*	.06	1,201. 75	1,079.01	0-4,501.00

Note. *p <.05; **p <.01; ***p <.001.

Satisfaction, exercise experiences, and planning at the end of rehabilitation were significantly associated with physical exercise six weeks after discharge. Satisfaction, experiences, and planning showed moderate to high correlations. The highest correlation was found between satisfaction and experience which may indicate an overlap between the two constructs. However, as they show differential patterns with the other variables and share only 27% of variance, it was decided to analyze the two constructs separately. Physical exercise prior to rehabilitation was not related to physical exercise behaviour 6 weeks after rehabilitation. In the current study, we did not find a high correlation between exercise at baseline (pre-rehabilitation) and T3 (post-rehabilitation), which stands in contrast to the typically high correlations between any baseline behaviour and its corresponding subsequent behaviour. This may be due to treatment-based changes in exercise behaviour of patients in the rehabilitation setting.

Multiple Mediation Analysis

It was tested whether the impact of exercise experiences during rehabilitation on exercise behaviour after discharge would be mediated by satisfaction and planning. To account for baseline behaviour and differences between the two groups of patients (orthopedic vs. cardiac), Time 1 exercise behaviour and patient group were included as covariates. As depicted in Figure 2, experiences (independent variable) were significantly associated with satisfaction and planning (multiple mediators). Both mediators were also significantly related to physical exercise at T3. Physical exercise at baseline (T1) and patient group (cardiac vs. orthopedic) were not significantly associated with physical exercise at T3 (all *ps* < .05). The total effect of exercise-related experiences on physical exercise became non-significant when the mediators were entered, indicating full mediation. Satisfaction and planning had significant indirect effects ($\beta_{satisfaction}$ = .07, SE =.04, LL BCA = .02, UL BCA = .16; $\beta_{planning}$ = .08, SE =.02, LL BCA = .02, UL BCA = .15). The contrast testing both mediators against each other was not significant, indicating comparable indirect effects.

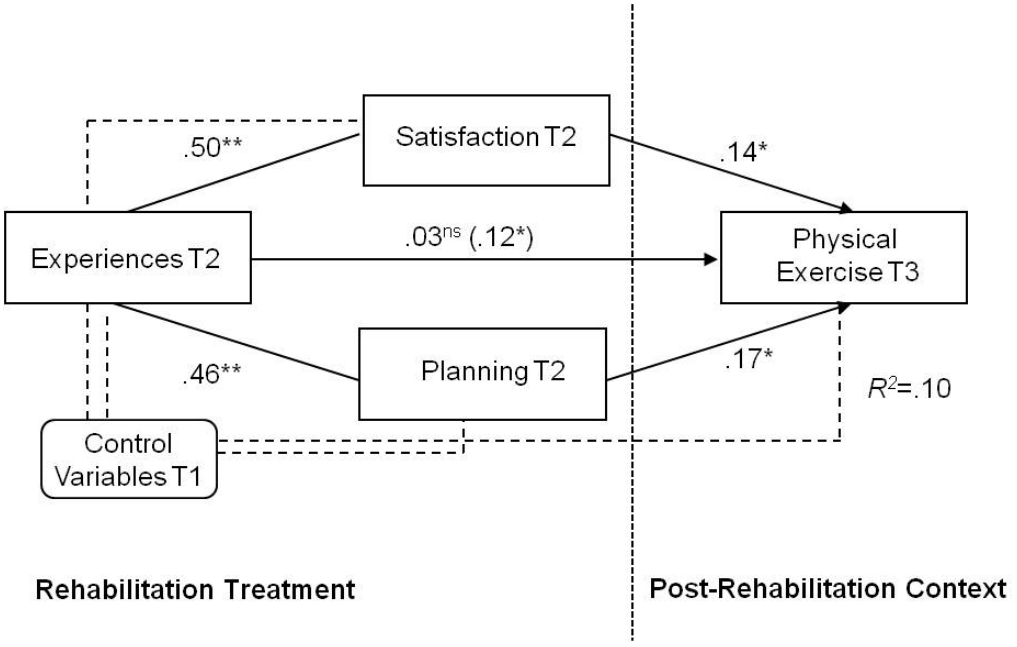

Figure 2. Planning and satisfaction mediate between experiences and physical exercise (*N* = 248)

Note. **p* <.05; ***p* <.01; Control variables were patient group (cardiac vs. orthopedic) and prior physical exercise.

Discussion

The aim of this study was to investigate psychological mechanisms by which rehabilitation patients regulate behaviour in order to gain a better understanding of how people might be encouraged to maintain regular exercise. A sample of 248 individuals participating in orthopedic and cardiac rehabilitation was studied at three points in time in terms of experiences, satisfaction, planning, and exercise. The uniqueness of the current study is the investigation of the working mechanisms by which patients' exercise experiences during rehabilitation impact exercise maintenance in a post-rehabilitation context. Post-motivational variables from Rothman's (2000) framework of health behaviour change and HAPA (Schwarzer, 2008) were tested in a theoretically integrated mediation model.

Two Social-cognitive Pathways Lead from Experiences to Exercise

Supporting the hypotheses, satisfaction and planning mediated the effect of experiences on behaviour. Thus, the present study delivers initial empirical support for the proposed theoretical model in which experiences exert their influence on behaviour via two separate social-cognitive pathways.

First, the results imply that satisfaction with exercise-related outcomes is a central cognition when translating experiences into behaviour. In other words, patients who have many positive experiences as a result of exercising during rehabilitation are more likely to be satisfied. Consequently, they are more likely to sustain their efforts to maintain exercise beyond rehabilitation. This adds to studies reporting prospective effects of perceived satisfaction on subsequent behaviour in smoking cessation (Baldwin et al., 2006) and weight management (Finch et al., 2005). Our findings provide evidence that Rothman's (2000) theoretical assumptions on the interplay of experiences, satisfaction, and behaviour hold true for physical exercise in a clinical sample of rehabilitation patients.

Second, besides cognitions of satisfaction, present results suggest that the use of self-regulatory strategies (i.e., planning) may be an additional mechanism via which experiences influence future behaviour. As found by Ziegelmann et al. (2007) levels of physical exercise may still rely on planning even after the behaviour has been initiated. It is possible that, at the phase when behaviour becomes part of one's daily routines, planning still predicts exercise. In particular, planning may help patients to master the transfer of behaviour from one context to another (Foxon, 2009).

Whereas previous studies have mainly focused on planning as a proximal predictor of behaviour (Lippke, et al., 2004a; Sniehotta, et al., 2006; Ziegelmann, et al., 2007), the present study reveals significant associations between planning and behaviour-related experiences. The positive association between planning and exercise experiences may imply that positive experiences are instrumental in strengthening planning strategies. To sum up, our study sheds further light on the social-cognitive processes beyond behaviour motivation in rehabilitation patients. From a theoretical and practical perspective, it is important to acknowledge that behavioural experiences with a behaviour feedback on cognitions. These in turn may promote or inhibit further behaviour enactment (Fuchs et al., in press).

Practical Implications for Psychological Interventions in Rehabilitation

Given the critical role that exercise experiences, satisfaction, and planning play in directing people's ability to maintain exercise levels, the present findings also have important implications for designing interventions. The proposed theoretical mediator model identifies several potential target variables through which interventions could facilitate exercise maintenance.

Firstly, it is important that individuals actually have positive experiences with a behaviour and acknowledge them. To augment positive experiences, individuals should be encouraged to choose a type of exercise that leads to immediate positive experiences and can be executed within the boundaries of their personal capabilities. An intervention in which clinic staff are directed to provide periodic encouragement to reflect on exercise-related experiences and to give positive feedback on attained outcomes might increase patients' satisfaction with physical exercise (Fuchs, et al., in press). For example, at the end of a walking session, patients may be regularly encouraged to review their most positive exercise-related experience or sensation. In a self-administered manner, patients may be additionally invited to run an exercise-experience diary where they can state which kind of exercise they did, where they did it, for how long they did it and what they experienced as a result of exercising. Such a self-management tool provided during rehabilitation might raise awareness of positive experiences and thereby increase perceptions of satisfaction (Fuchs, et al., in press). It may also initiate behaviour evaluations that result in enhanced levels of self-efficacy. Social Cognitive Theory (Bandura, 1997) assumes that if positive behaviour experiences or accomplishments are attributed to one's own efforts (i.e., mastery experiences), perceptions of self-efficacy may emerge.

Second, an additional and established avenue to designing interventions involves planning. Application of self-administered planning interventions in patient's self-management practice has yielded significant benefits for a diversity of patient samples (Arbour-Nicitopoulos, Ginis, & Latimer, 2009; Lippke, Ziegelmann, & Schwarzer, 2004b; Luszcynska, 2006; Osman, et al., 2002; Ziegelmann, Lippke, & Schwarzer, 2006). Against the background of this study, planning interventions may profit from activating previous experiences with a target behaviour. In detail, recalling positive experiences and situational cues (e.g., location, time, duration) linked to a formerly enacted behaviour may help individuals to make more realistic, specific, and instrumental plans. To sum up, psychological interventions targeting planning and satisfaction may complement standard rehabilitation care and contribute to improved treatment outcomes (Göhner, Seelig, & Fuchs, 2009). Although results were limited to the domain of physical exercise, we think that the implications drawn from these findings may be transferred to other health behaviours, such as healthy nutrition.

The present study has several limitations. First, we relied on a single-item measure of satisfaction. Although the applied measure of satisfaction was able to predict behaviour, it will be important to develop and validate multi-item measures (Baldwin et al., 2006), particularly in the domain of physical exercise. Second, we did not consider the role that patient's outcome expectancies play in their evaluation of attained behavioural outcomes (i.e., satisfaction). Behavioural experiences are an integral part of satisfaction which is also reflected by the high intercorrelations between the two constructs. However, as assumed by Rothman (2000) positive exercise experiences per se may not necessarily lead to high levels of perceived satisfaction. Whether or not individuals are satisfied with their experiences may not only be determined by the type of experience but also, at least to some degree, by their initial behavioural outcome expectancies (Baldwin et al., 2009; Rothman, 2000). Third, the employed Exercise Experiences Scale mainly captured cognitive aspects of exercise experiences that patients may have during rehabilitation. An extended version of the scale may incorporate more emotional outcomes (e.g., "When I was physically active, I felt happier afterwards." or "When I was physically active, I felt less lonely afterwards.") to cover a wider range of behavioural experiences. Fourth, our analyses covered only a short time frame of post-rehabilitation exercise (i.e., 6 weeks). To gain a broader understanding of patients' behaviour regulation, additional follow-up measurement points should be included. Fourth, although our findings generalize over two patient groups, further research is needed to replicate findings in other patient groups (e.g., psychosomatic patients) and nonclinical samples. Finally, causal conclusions

require experimental tests, but the longitudinal design with the predictor, mediators, and outcome variables measured at two points in time (separated with an at least 6-week gap) strengthened our conclusions. Although causal relations cannot be determined from the analyses reported here, the findings suggest that focusing on exercise-related experiences may promote the maintenance of behaviour by increasing satisfaction and self-regulation.

Conclusions

As health behaviours are beneficial only to the extent that they are maintained, it is not only important to investigate processes that help people initiate changes in behaviour, but also to look at those processes that promote a self-sustaining pattern of behaviour (Nigg, Borrelli, Maddock, & Dishman, 2008; Rothman, 2000; Rothman, et al., 2004). The findings from this study, namely the identification of satisfaction and planning as mediators between experiences and exercise maintenance, unveil potential, post-motivational mechanisms of how exercise can be maintained. In the rehabilitation context, a useful next step might be conducting a randomized controlled trial in which an intervention is designed to maximally enhance positive exercise experiences, satisfaction, and self-regulatory strategies such as planning.

Acknowledgements

This work has been funded by the Deutsche Rentenversicherung Bund (DRV; German Pension Insurance) within the project FABA (Project ID 8011 - 106 - 31/31.91). The authors would like to thank the rehabilitation clinics and its patients for participating in this study. We especially appreciate the support of Mrs. Pimmer, Dr. Kiwus, Dr. Glatz, Dr. Milse, and Dr. Johnigk.

References

Aiken, L. S., West, S. G., & Reno, R. R. (1991). Multiple regression: Testing and interpreting interactions: Sage Publications, Inc.

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A., Strath, S. J., O'Brien, W. L., Bassett, D. R., Schmitz, K. H., & Emplaincourt, P. O. (2000). Compendium of physical activities: an update of activity codes and MET intensities. Medicine & Science in Sports & Exercise, 32, S498.

Arbour-Nicitopoulos, K. P., Ginis, K. A. M., & Latimer, A. E. (2009). Planning, leisure-time physical activity, and coping self-efficacy in persons with spinal cord injury: a randomized controlled trial. Archives of Physical Medicine and Rehabilitation, 90, 2003-2011.

Baldwin, A., Rothman, A., Hertel, A., Keenan, N., & Jeffery, R. (2009). Longitudinal associations between people's cessation-related experiences and their satisfaction with cessation. Psychology & Health, 24, 187-201.

Baldwin, A. S., Rothman, A. J., Hertel, A. W., Linde, J. A., Jeffery, R. W., Finch, E. A., & Lando, H. A. (2006). Specifying the determinants of the initiation and maintenance of behaviour change: An examination of self-efficacy, satisfaction, and smoking cessation. Health Psychology, 25, 626.

Bandura, A. (1997). Self-efficacy: The exercise of control: New York: Freeman.

Biddle, S. J. H., & Fuchs, R. (2009). Exercise psychology: A view from Europe. Psychology of Sport and Exercise, 10, 410-419.

Brassington, G. S., Atienza, A. A., Perczek, R. E., DiLorenzo, T. M., & King, A. C. (2002). Intervention-related cognitive versus social mediators of exercise adherence in the elderly. American Journal of Preventive Medicine, 23, 80-86.

Brown, W. J., & Bauman, A. E. (2000). Comparison of estimates of population levels of physical

activity using two measures. Australia and New Zealand Journal of Public Health, 24, 520-525.

Burke, L. E., Dunbar-Jacob, J. M., & Hill, M. N. (1997). Compliance with cardiovascular disease prevention strategies: A review of the research. Annals of Behavioural Medicine, 19, 239-263.

Conn, V. S., Hafdahl, A. R., Minor, M. A., & Nielsen, P. J. (2008). Physical activity interventions among adults with arthritis: Meta-analysis of outcomes. Seminars in Arthritis and Rheumatism, 37, 307-316.

D'Angelo, M. S., & Reid, R. D. (2007). A model for exercise behaviour change regulation in patients with heart disease. Journal of Sport & Exercise Psychology, 29, 208-224.

Dalal, H. M., Zawada, A., Jolly, K., Moxham, T., & Taylor, R. S. (2010). Home based versus centre based cardiac rehabilitation: Cochrane systematic review and meta-analysis. British Medical Journal, 340, 1-15.

Dorn, J., Naughton, J., Imamura, D. A. I., & Trevisan, M. (2001). Correlates of compliance in a randomized exercise trial in myocardial infarction patients. Medicine & Science in Sports & Exercise, 33, 1081.

Finch, E. A., Linde, J. A., Jeffery, R. W., Rothman, A. J., King, C. M., & Levy, R. L. (2005). The effects of outcome expectations and satisfaction on weight loss and maintenance: Correlational and experimental analyses-a randomized trial. Health Psychology, 24, 608-616.

Foxon, M. (2009). Process approach to the transfer of training: Using action planning to facilitate the transfer of training. Australian Journal of Educational Technology, 10, 1-18.

Fuchs, R. (2003). Sport, Gesundheit und Public Health [Sports, health, and public health]. Hogrefe.

Fuchs, R., Göhner, W., & Seelig, H. (in press). Long-term effects of a psychological group intervention on physical exercise and health: The MoVo concept. Journal of Physical Activity and Health.

Godin, G., & Shephard, R. J. (1985). A simple method to assess exercise behaviour in the community. Canadian Journal of Applied Sport Sciences, 10, 141-146.

Göhner, W., & Schlicht, W. (2006). Preventing chronic back pain: evaluation of a theory-based cognitive-behavioural training programme for patients with subacute back pain. Patient Education and Counseling, 64, 87-95.

Göhner, W., Seelig, H., & Fuchs, R. (2009). Intervention effects on cognitive antecedents of physical exercise: A 1-year follow-up study. Applied Psychology: Health and Well-Being, 1, 233-256.

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. American Psychologist, 54, 493-503.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. Advances in Experimental Social Psychology, 38, 69-119.

Hardman, A. E., & Stensel, D. J. (2003). Physical activity and health: The evidence explained. Routledge:London.

Jacobs, D. R., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. Medicine & Science in Sports & Exercise, 25, 81-91.

Jaeckel W, Bengel J, Herdt, J. Research in rehabilitation. Stuttgart: Schattauer; 2006.Jacobs, D. R., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. Medicine & Science in Sports & Exercise, 25, 81-91.

Lavie, C. J., Milani, R. V., & Ventura, H. O. (2009). Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. Journal of the American College of Cardiology, 53, 1925.

Lippke, S., Ziegelmann, J. P., & Schwarzer, R. (2004a). Behavioural intentions and action plans promote physical exercise: A longitudinal study with orthopedic rehabilitation patients. Journal of Sport and Exercise Psychology, 26, 470-483.

Lippke, S., Ziegelmann, J. P., & Schwarzer, R. (2004b). Initiation and maintenance of physical exercise: Stage-specific effects of a planning intervention. Research in Sports Medicine, 12, 221-240.

Lippke, S., Ziegelmann, J. P., Schwarzer, R., & Velicer, W. F. (2009). Validity of stage assessment in the adoption and maintenance of physical activity and fruit and vegetable consumption. Health Psychology, 28, 183-193.

Luszczynska, A. (2006). An implementation intentions intervention, the use of planning strategy, and physical activity after myocardial infarction. Social Science and Medicine, 62, 900-908.

Minor, M. A., & Brown, J. D. (1993). Exercise maintenance of persons with arthritis after participation in a class experience. Health Education & Behaviour, 20, 83-95.

Nigg, C. R., Borrelli, B., Maddock, J., & Dishman, R. K. (2008). A theory of physical activity maintenance. Applied Psychology, 57, 544-560.

Osman, L. M., Calder, C., Godden, D. J., Friend, J. A. R., McKenzie, L., Legge, J. S., & Douglas, J. G. (2002). A randomised trial of self-management planning for adult patients admitted to hospital with acute asthma. Thorax, 57, 869-874.

Pfeifer, K., Sudeck, G., Brüggemann, S., & Huber, G. (2010). DGRW-Update: Bewegungstherapie in der medizinischen Rehabilitation-Wirkungen, Qualität, Perspektiven [DGRW-Update: Exercise Therapy in Medical Rehabilitation-Effects, Quality, Perspectives]. Rehabilitation, 49, 224-236.

Plotnikoff, R. C., Lippke, S., Reinbold-Matthews, M., Courneya, K. S., Karunamuni, N., Sigal, R. J., & Birkett, N. (2007). Assessing the validity of a stage measure on physical activity in a population-based sample of individuals with type 1 or type 2 diabetes. Measurement in Physical Education and Exercise Science, 11, 73-91.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behaviour Research Methods, 40, 879-891.

Reuter, T., Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2009). Long-term relations between intentions, planning, and exercise: A 3-year longitudinal study after orthopedic rehabilitation. Rehabilitation Psychology, 54, 363-371.

Rothman, A. J. (2000). Toward a theory-based analysis of behavioural maintenance. Health Psychology, 19, 64-69.

Rothman, A.J., Baldwin, A., & Hertel, A. (2004). Self-regulation and behaviour change: Disentangling behavioural initiation and behavioural maintenance. In K. Vohs and R. Baumeister (Eds.), The handbook of self-regulation (pp. 130-148). Guilford Press: New York, NY.

Schwarzer, R. (2008). Modeling health behaviour change: How to predict and modify the adoption and maintenance of health behaviours. Applied Psychology: An International Review, 57, 1-29.

Sheeran, P., & Orbell, S. (1999). Implementation intentions and repeated behaviour: Augmenting the predictive validity of the theory of planned behaviour. European Journal of Social Psychology, 29, 349-369.

Sluijs, E. M., Kok, G. J., & van der Zee, J. (1993). Correlates of exercise compliance in physical therapy. Physical Therapy, 73, 771-786.

Sniehotta, F., Scholz, U., Schwarzer, R., Fuhrmann, B., Kiwus, U., & Völler, H. (2005). Long-term effects of two psychological interventions on physical exercise and self-regulation following coronary rehabilitation. International Journal of Behavioural Medicine, 12, 244-255.

Sniehotta, F., Scholz, U., & Schwarzer, R. (2006). Action plans and coping plans for physical exercise: A longitudinal intervention study in cardiac rehabilitation. British Journal of Health Psychology, 11, 23-37.

Van Baar, M. E., Assendelft, W. J. J., Dekker, J., Oostendorp, R. A. B., & Bijlsma, J. W. J. (1999). Effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: A systematic review of randomized clinical trials. Arthritis & Rheumatism, 42, 1361-1369.

Webb, T. L., & Sheeran, P. (2007). How do implementation intentions promote goal attainment? A test of component processes. Journal of Experimental Social Psychology, 43, 295-302.

Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2006). Adoption and maintenance of physical activity: Planning interventions in young, middle-aged, and older adults. Psychology & Health, 21, 145-163.

Ziegelmann, J. P., Luszczynska, A., Lippke, S., & Schwarzer, R. (2007). Are goal intentions or implementation intentions better predictors of health behaviour? A longitudinal study in orthopedic rehabilitation. Rehabilitation Psychology, 52, 97-102.

.

3

Intervention Effects of Exercise Self-regulation on Physical Exercise and Eating Fruits and Vegetables: A Longitudinal Study in Orthopedic and Cardiac Rehabilitation

---

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2011). Intervention effects of exercise self-regulation on physical exercise and eating fruits and vegetables: A longitudinal study in orthopedic and cardiac rehabilitation, *Preventive Medicine, 53*(3), 182-187.

Abstract

Objective. The primary objective of this study was to unveil the mechanisms by which an exercise self-regulation intervention affects physical exercise in a rehabilitation context. The second aim was to investigate whether the intervention led to changes in fruit and vegetable intake that was not targeted in the intervention. Finally, it was tested whether changes in exercise habit strength may explain such a transfer effect.

Method. A quasi-experimental design was conducted in Germany between 2009 and 2011 with 725 rehabilitation patients. Patients received either a self-regulation intervention or an online questionnaire. Six weeks after discharge, self-reported changes in exercise and dietary behaviours, exercise habit strength, and cognitions were measured.

Quantitative Results. The exercise self-regulation intervention led to a higher increment in exercise behaviour, exercise habit strength, and fruit and vegetable intake than the control condition. Changes in physical exercise were mediated by changes in action control (*slope*=0.04;CI_{BCA}=0.01 to 0.06) and satisfaction (*slope*=0.05;CI_{BCA} =0.02 to 0.08), but not in action planning. Changes in fruit and vegetable intake were mediated by changes in exercise habit strength (*slope*=0.05;CI_{BCA} =0.01 to 0.08).

Conclusion. Interventions could be optimized if they aim at fostering exercise habits. This in turn may also facilitate transfer effects from one health behaviour to the other.

Keywords: physical exercise, fruit and vegetable consumption, habit, multiple behaviour change, self-regulation intervention

Introduction

Individuals can prevent and manage existing diseases, such as cardiovascular diseases and orthopedic disorders, by adopting a healthy diet (Brunner et al., 2008; Chahoud, Aude, & Mehta, 2004) and regular exercise (Conn, Hafdahl, Minor, & Nielsen, 2008; Dalal, Zawada, Jolly, Moxham, & Taylor, 2010; Resnick et al., 2007). Adhering to multiple health behaviour recommendations, however, is a difficult self-regulatory task for many patients in medical rehabilitation. Despite good intentions, many patients fail to initiate and maintain a healthy diet (e.g., Luszczynska & Cieslak, 2009) and regular exercise (e.g., Reuter, Ziegelmann, Lippke, & Schwarzer, 2009) after discharge from the rehabilitation program. Thus, there is a need to develop theory-based interventions for clinical practice and identify those psychological processes that initiate and maintain multiple health behaviours.

Predictors and Mechanisms of Single Health Behaviour Change in Rehabilitation

As proposed by the *Health Action Process Approach* (HAPA; Schwarzer, 2008) and *Rothman's Framework of Health Behaviour Change* (Rothman, 2000; Rothman, Baldwin, & Hertel, 2004), decisions regarding exercise changes and maintenance are predicted to rely on self-regulatory variables, such as *action planning* (Lippke, Ziegelmann, & Schwarzer, 2004; Reuter et al., 2009; Wiedemann et al., 2011; Ziegelmann, Luszczynska, Lippke, & Schwarzer, 2007), *action control* (Pomp, Lippke, Fleig, & Schwarzer, 2010; Sniehotta, Nagy, Scholz, & Schwarzer, 2006; Sniehotta, Scholz, & Schwarzer, 2005a), as well as *perceived satisfaction* with experienced behaviour outcomes (Fleig, Lippke, Pomp, & Schwarzer, 2011). Action planning refers to a *prospective* self-regulatory strategy, by which people mentally link behavioural responses to specific situations to achieve certain goals (Sheeran & Orbell, 1999; Sniehotta et al., 2005b). Action control refers to an *in situ* strategy including the investment of self-regulatory effort, awareness of one's own standards, as well as self-monitoring behaviour (Sniehotta et al., 2006; Sniehotta et al., 2005b).

There is convincing evidence that psychological interventions in rehabilitation are effective in improving patients' post-rehab exercise behaviour by increased action planning (Luszczynska, 2006; Ziegelmann, Lippke, & Schwarzer, 2006) and action control (Sniehotta et al, 2005b).

Whereas mechanisms of changes in single health behaviours have been extensively studied, there has been only little theory-guided research on the processes of multiple health behaviour change (Prochaska, Spring, & Nigg, 2008). The present study investigates the mechanisms by

which an exercise self-regulation intervention affects (a) exercise behaviour and (b) fruit and vegetable intake in a sample of rehabilitation patients.

When Exercise Interventions Affect Other Health Behaviours: Transfer Effects in Multiple Health Behaviour Change

Psychological interventions in secondary prevention often focus on the promotion of selected health behaviours (e.g., physical exercise only; Fuchs, Göhner,& Seelig, in press). From a multiple health behaviour perspective, the question emerges, whether interventions targeted to change one health behaviour may also initiate changes in other behaviours (Lippke, Nigg, & Maddock, 2012; Prochaska & Sallis, 2004; Wilcox, King, Castro, & Bortz, 2000). For example, an intervention targeted at physical exercise may also have a positive effect on healthy nutrition. Such an effect may be referred to as a "*transfer effect*", as positive intervention effects on one behaviour are also observed in another behaviour (Lippke et al., 2011). Transfer effects may take two different forms depending on the time sequence of behaviour changes. First, changes in the target behaviour of an intervention and the non-target behaviour can occur simultaneously (i.e., *transfer as co-occurrence*). Second, changes in the target behaviour and non-target behaviour may also occur sequentially. In other words, changes in the target behaviour initiate subsequent changes in the non-target behaviour (i.e., *transfer as carry-over*).

Empirical support for the occurrence of transfer effects in intervention studies has been inconsistent. An intervention study by Mata et al. (2009) revealed that a psychological intervention primarily targeted at physical exercise not only increased exercise behaviour but was also associated with improved eating regulation. Similarly, Dutton, Napolitano, Whiteley, and Marcus (2008) revealed that changes in physical exercise due to an exercise self-regulation intervention covaried with reductions in fat intake. On the contrary, concurrent effects of the intervention on fruit and vegetable intake as well as subsequent effects of the intervention on changes in fat intake and fruit and vegetable intake could not be found (Dutton et al., 2008). Other studies also failed to show that exercise-only interventions facilitate changes in fruit and vegetable intake (Prochaska & Sallis, 2004; Wilcox et al., 2000) and other indicators of healthy eating (Prochaska & Sallis, 2004).

According to the *Strength and Energy Model* (Baumeister et al., 2000), self-regulation is a limited resource which may be utilized across different domains of actions or health behaviours (Hagger et al., 2010). Theoretically, mechanisms of transfer effects have been attributed to a transfer of self-regulatory resources from one behaviour to the other (Lippke et al., in press; Nigg, Lee,

Hubbard, & Min-Sun, 2009). For example, changes in physical exercise may also promote self-monitoring of one's nutrition behaviour or the generation of nutrition-specific action plans.

Habit strength and its role in multiple health behaviour change: Facilitator of transfer effects

As a health behaviour becomes more routinized, less self-regulatory effort is required for its execution (Aarts, Paulussen, & Schaalma, 1997; Baumeister et al., 2000; Orbell & Verplanken, 2010; Verplanken & Melkevik, 2008). In orthopedic rehabilitation patients, Ziegelmann et al. (2007) revealed that exercise engagement becomes less dependent on self-regulation after an individual had integrated exercise into his or her lifestyle. Thus, if an intervention promotes habituation in one health behaviour, more self-regulatory resources may be available for another behaviour. In other words, as individuals move further along the behaviour change process in a single behaviour, transfer of resources to another health behaviour may become more likely. Analyzing the co-variation of changes in exercise habit and changes in healthy nutrition behaviour may be a first step to investigate this "facilitation hypotheses".

Aims of the Present Study

The present study investigates the psychological mechanisms through which an exercise self-regulation intervention promotes (a) physical exercise and (b) fruit and vegetable consumption. First, the following hypotheses on primary intervention outcomes and working mechanisms were tested: (a) The intervention leads to an increase in physical exercise compared to a control condition, (b) the intervention increases action planning, action control, and satisfaction, and (c) changes in action planning, action control, and satisfaction mediate between the exposure to the experimental conditions and changes in physical exercise. Next, hypotheses on transfer effects and working mechanisms were tested: (d) the intervention leads to an increase in fruit and vegetable intake (i.e., transfer effect), (e) the intervention increases exercise habit strength, and (f) changes in exercise habit strength explain the increase in fruit and vegetable intake.

Method

Participants and Procedure

Patients with a medical indication to engage in regular exercise after rehabilitation were invited to participate in an exercise program during their first week of stay in two orthopedic rehabilitation centers (one in-patient and one out-patient) and one in-patient cardiac center. The exercise self-regulation intervention and the questionnaire were delivered via computers. In Germany, a stay

in rehabilitation is usually covered by a compulsory insurance (i.e., German Pension Insurance). All individuals participated in the regular clinic program that comprised a complex regimen of medical, physiotherapeutic, and psychological therapies with an average duration of 21.7 days (*SD* = 6.4).

Eligible individuals were randomly assigned to the exercise self-regulation intervention or the control group condition by a computer algorithm. Participants were blinded to their allocation for the duration of the study. After giving informed consent, patients filled in a computer-based questionnaire. Subsequently, the computer randomly assigned participants to the exercise self-regulation intervention or the control group (see Figure 1). The uneven allocation ratio is due to a two-step recruitment of the control group. Prior to the launch of the randomized controlled trial, a pilot patient sample (PPS) was recruited. Participants filled in a questionnaire at the onset of rehabilitation and six weeks after discharge. The participants in the PPS were compared to those participants who were randomized to the control group during the main trial by using analyses of variance (ANOVAs) for continuous measures, and χ^2-tests for categorical measures. No significant differences were identified regarding behavioural, social-cognitive, and socio-demographic variables (all $p > 0.05$). To increase power, the PPS and the randomized control group were merged into one control group in the present study. Thereby, a quasi-experimental design was applied.

The follow-up assessment (T2) took place six weeks (M = 42.1, SD = 12.4) after discharge via Computer-Assisted Telephone Interviews. Data at follow-up were available from n = 504 participants (69.5% of the initial sample). The participant flow throughout the stages of the study is illustrated in Figure 1. Mean age of the longitudinal sample was 48.6 years (SD = 10.3; range 22–76 years), and the sample consisted of slightly more women (56.7%) than men. Of all participants, 74.9% were living with a partner. Two thirds of the longitudinal sample (66.6%) reported to have at least a high school degree. Ethical approval was granted from the Ethics Commission of the German Association of Psychology (Deutsche Gesellschaft für Psychologie, DGPs).

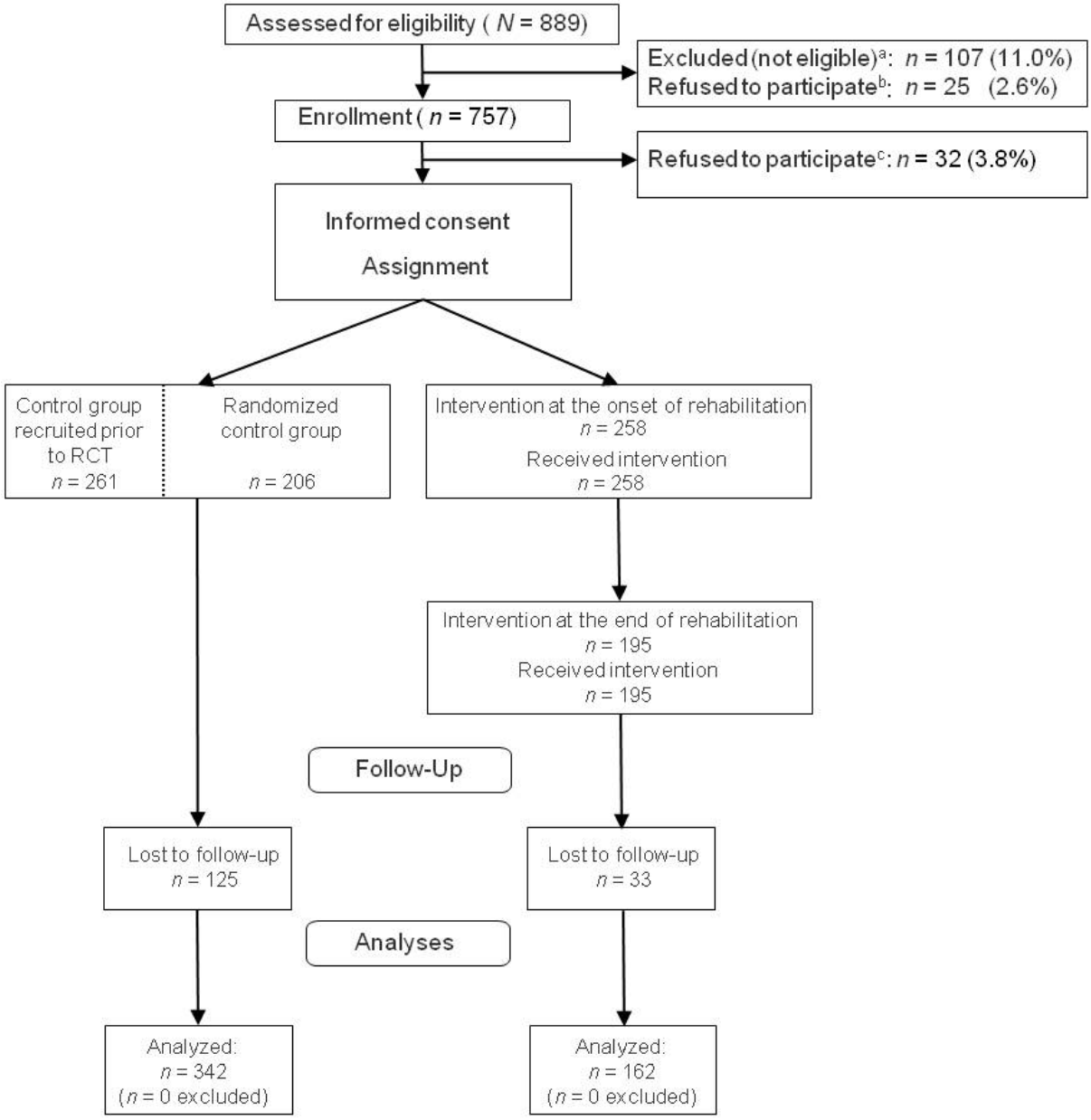

Figure 1. Flowchart of participant progress through the study phases

Note. [a]Excluded as inclusion criteria were not met (i.e., being capable of exercising on their own, able to fill out a computer-based questionnaire, being not too handicapped to write and having sufficient literacy); [b]Refused to participate and did not show up at the appointment; [c]Refused to participate due to time constraints, concerns regarding protection of data privacy, and other reasons not communicated to study assistant. The study was conducted in Germany between 2009 – 2011.

Experimental Conditions

At baseline, participants in both conditions received the same online questionnaire. In addition, participants in the intervention received instructions embedded in the online questionnaires.

Exercise self-regulation intervention. The intervention consisted of two units at the onset and at the end of rehabilitation to prepare orthopedic and cardiac rehabilitation patients to perform physical exercise on a regular basis after discharge. On average, 17.7 (*SD* = 5.6) days elapsed between intervention participation at the beginning and the end of rehabilitation. At rehabilitation onset the intervention comprised four volitional components: (a) post rehabilitation exercise goal setting, (b) checking the self-concordance of these goals (Göhner, Seelig, & Fuchs, 2009), (c) the formation of action plans (e.g., Prestwich, Lawton, & Connor, 2003), and (d) the recall of positive exercise experiences (Fleig et al., 2011; Fuchs et al, in press). On average, participants spent 36.1 minutes (*SD* = 10.1) on the questionnaire and the intervention at T1.

At the end of rehabilitation, the intervention focused on the following volitional approaches: (a) the formation of action plans, (b) the reflection of positive exercise experiences (Fleig et al., 2011; Fuchs et al., in press), and (c) an action control diary to self-monitor one's home-based behaviour (Aittasalo, Miilunpalo, Kukkonen-Harjula, & Pasanen, 2006; Sniehotta et al., 2005b). On average, participants spent 25.4 minutes (*SD* = 15.1) on the intervention.

Control group. Participants in the control group only completed the online questionnaire at T1 and T2 in addition to their standard rehabilitation care.

Measures

Unless otherwise stated, response formats were six-point Likert scales, ranging from totally disagree (1) to totally agree (6). Scale scores were obtained by averaging item responses. Item examples given below are translated from German.

Physical exercise considering the *effort* of exercise was measured at T1 and T2 with a modified version of the Godin Leisure-Time Exercise Questionnaire (GLTEQ; Godin & Shephard, 1985; Plotnikoff et al., 2007). This self-report measure has been validated with physiological and anthropometric measures (i.e., VO_2 max and body fat; Godin & Shephard, 1985; Jacobs et al., 1993). Participants indicated how often per week and how long per session they performed strenuous physical exercise (fast heart rate, sweating) and moderate physical exercise (hardly exhausting, light sweating). Only activities outside of work duties and voluntary activities were addressed.

Total physical exercise was the total number of sessions per week multiplied by minutes per session.

Action planning was assessed at T1 and T2 with two items adapted from Schwarzer et al. (2007). The first item was worded: "For the next month, I have already planned where, when, and how I will be physically active." The second item was worded "Usually, I make specific plans for my physical activities (e.g., When I come home from work on Wednesday, I go to the gym)" (r_{T1} = 0.65, r_{T2} = 0.71).

Action control was assessed with a 3-item scale comprising three facets of the action control process (Sniehotta et al., 2005a): Self-monitoring (item a), awareness of standards (item b), and self-regulatory effort (item c). The items were introduced by the stem "Think about the last four weeks when answering the following questions." Statements read: (a) "I consistently monitored when, where, and how long I exercised," (b) "I often had my exercise intention on my mind," and (c) "I really tried hard to exercise regularly." (Cronbach's α_{T1} = 0.78, α_{T2} = 0.79).

Satisfaction with exercise experience was assessed at T1 and T2 with one item that asked participants "As of today, how satisfied are you with what you have experienced as a result of exercising?" Participants were asked to think about exercise experiences they had during rehabilitation. This measure has been used by Baldwin, Rothman, Hertel, Keenan, and Jeffery (2009) and was adapted to the domain of physical exercise in this study (Fleig et al., 2011). Answers could be given on a 6-point Likert scale with the anchors "not at all satisfied" (1) to "totally satisfied" (6).

Exercise habit strength was assessed at T1 and T2 with two items adapted from Verplanken and Orbell (2003). Participants were asked to think about the past four weeks and their previous level of physical exercise. The items were worded: "Being as physically active as I have been during the last month is something" (a) "…I do without thinking about it," (b) "...that has become a confirmed habit for me." Answers could be given on a 6-point Likert scale with the anchors "not at all" (1) to "very much" (6) (r_{T1} = 0.65, r_{T2} = 0.62).

Fruit and vegetable intake (FVI) was assessed at T1 and T2 with two items. Study participants were asked (a) "Please think about the last four weeks: Did you eat at least five servings of fruit and/ or vegetables per day?" The item followed the definition of a serving, i.e., "one handful of fruit or vegetables." Study participants were required to answer either with "no" or "yes" in a way that the computer system did not allow to skip the item. The item was followed by an open-ended question (b) "How many servings of fruit and/or vegetables did you eat on an average day?"

Statistical Methods

All analyses were run with SPSS 17. Dropout analyses compared retained participants and those lost after T1 using ANOVAs for continuous measures and χ^2-tests for categorical measures. Randomization checks tested baseline differences between participants in the two experimental conditions by means of ANOVAs for continuous and χ^2-tests for categorical measures.

Intervention effects on physical exercise and putative social-cognitive mediators at follow-up were evaluated using ANCOVAs with the corresponding T2 variable as dependent variable, condition (control, intervention) as between-persons factor, and the corresponding baseline variable and patient group as covariates. A multiple mediator analysis (Preacher & Hayes, 2008) was run to test whether the effects of the self-regulation intervention on behaviour change may be explained by changes in action planning, action control, and satisfaction.

Differential intervention effects on exercise habit strength and fruit and vegetable intake at follow-up were analyzed by ANCOVAs with baseline values (i.e., habit strength and behaviour) and patient group as covariates. A mediator analysis (Preacher & Hayes, 2008) was run to test whether the effects of the intervention on changes in fruit and vegetable intake may be explained by changes in exercise habit strength.

For both mediation models, changes in behaviour and social-cognitive variables were operationalized as residualized change scores by regressing T2 scores on T1 scores. Confidence intervals were estimated applying the bootstrap approach (5.000 bootstrap resamples). Patient group, body mass index and gender were entered as covariates. Missing data (< 10% on all variables) were imputed using the Expectation Maximization (EM) algorithm.

Results

Preliminary Results

Dropout analyses. Results indicated that patients who continued study participation were more likely to have a partner than those who did not ($p = 0.04$). Besides that, no other differences were found with regard to treatment condition, physical exercise, exercise habit, fruit and vegetable intake, social-cognitive variables (i.e., action planning, action control, satisfaction), and socio-demographic variables (all $p > 0.05$).

Randomization check. Results revealed no baseline differences across the two conditions regarding physical exercise, exercise habit, fruit and vegetable intake, social-cognitive variables

(i.e., action planning, action control, satisfaction), and socio-demographic variables (all $p > 0.05$) indicating that the randomization procedure succeeded.

Intervention Effects on Exercise Variables

Intervention effects on physical exercise. ANCOVAs identified intervention effects on physical exercise as a function of intervention condition, $p < 0.001$, partial $\eta^2 = 0.06$ (see Table 1). T2 physical exercise was additionally influenced by baseline behaviour, $p < .001$, but not by patient group, $p = 0.49$.

Intervention effects on mediators. Differences between the conditions were found regarding both action control ($p < 0.001$, partial $\eta^2 = 0.03$), and satisfaction ($p < 0.001$, partial $\eta 2 = 0.04$), but not for action planning ($p = 0.25$), (see Table 1). T2 action control was additionally influenced by the corresponding baseline variable, $p < 0.001$, but not by patient group, $p = 0.69$. T2 satisfaction was influenced by the corresponding baseline variable, $p = 0.02$, but not by patient group, $p = 0.63$. As one precondition for mediation, namely significant intervention effects on the mediator, was not met for action planning, mediation analyses were conducted with satisfaction and action control only.

Working Mechanism (Multiple Mediation Analysis)

Group assignment significantly predicted changes in action control and in satisfaction (Table 2). Both mediators also were significantly associated with changes in physical exercise. The total effect of the intervention on physical exercise was lowered when the mediators were entered, indicating partial mediation. Satisfaction and action control had significant indirect effects. The multiple mediator model accounted for 18% of the variance in behaviour. Gender ($p = 0.41$) and patient group (cardiac vs. orthopedic; $p = 0.77$) were not significantly associated with changes in exercise. However, body mass index at baseline was significantly associated with behaviour change (*slope* = 0.09, *SE* = 0.04; $p = 0.03$).

Table 1. Pre- and Posttest Mean (*SD*; range) of Primary Outcome Measures and Mediators

	Intervention condition (n = 162)		Control condition (n = 342)	
Outcomes	t1	t2	t1	t2
Physical exercise in minutes/week	157.98 (194.85; 0-930)	223.58 (197.77; 0-950)	134.74 (194.15; 0-710)	162.47 (139.80; 0-690)
Exercise habit	4.01 (1.34; 1-6)	5.23 (1.36; 1-6)	4.10 (1.51; 1-6)	4.33 (1.55; 1-6)
Action planning	3.53 (1.55; 1-6)	3.89 (1.46; 1-6)	3.41 (1.67; 1-6)	4.10 (1.45; 1-6)
Action control	3.42 (1.76; 1-6)	4.92 (1.41; 1-6)	3.28 (1.45; 1-6)	4.31 (1.52; 1-6)
Satisfaction	4.28 (1.52; 1-6)	5.34 (0.94; 1-6)	4.40 (1.48; 1-6)	4.60 (1.21; 1-6)
Fruit and vegetable intake in servings/day	3.21 (1.72; 0-6.5)	3.81 (1.83; 0-10)	3.32 (1.61; 0-6)	3.39 (1.18; 0- 9)

Note. T1 took place during the first week of rehabilitation; t2 took place six weeks after discharge from rehabilitation; The study was conducted in Germany between 2009 and 2011.

Table 2. Summary of Results for Multiple Mediation Model

Independent variable (IV)	Dependent variable (DV)	Mediating variables (M)	Effect of IV on M	Effect of M on DV	Total effect	Direct effect	Indirect effects	Lower BC 99% CI for	Higher BC 99% CI for	Contrast of mediators	Lower BC 99% CI for contrast	Higher BC 99% CI for contrast
Intervention group	Physical exercise	Action control	0.17**	0.21**	0.25**	0.16*	0.04	0.01	0.06	0.01	-0.02	0.04
		Satisfaction	0.22**	0.21**			0.05	0.02	0.08			

Note. Reported are standardized regression coefficients; n = 504; *p = 0.02; **p < 0.001; BC = bias corrected, CI = bootstrapping confidence interval. Changes in physical exercise, action control, and satisfaction were operationalized as residualized change scores T2/T1 The study was conducted in Germany between 2009 and 2011.

Intervention Effects on Fruit and Vegetable Intake and Exercise Habit Strength

At follow-up, the intervention group reported a higher fruit and vegetable intake ($p < 0.001$, partial $\eta^2 = 0.02$), and higher levels of exercise habit strength ($p < 0.001$, partial $\eta^2 = 0.04$), as compared to individuals in the control group (see Table 1). T2 fruit and vegetable consumption was additionally influenced by baseline behaviour, $p < 0.001$, but not by patient group, $p = 0.69$. T2 exercise habit was influenced by the corresponding baseline variable, $p< 0.001$, but not by patient group, p=0.89.

Working Mechanism of Transfer Effect

Group assignment predicted changes in fruit and vegetable intake (*slope* = 0.14, *SE* = 0.05; $p = 0.03$) as well as changes in exercise habit (*slope* = 0.18, *SE* = 0.04; $p = 0.02$). Behaviour change was associated with changes in exercise habit (*slope* = 0.25, *SE* = 0.10; $p < 0.001$). After controlling for changes in exercise habit, the relation between group assignment and behaviour change was lowered to *slope* = 0.09 (*SE* = 0.04; $p = 0.04$), indicating partial mediation.

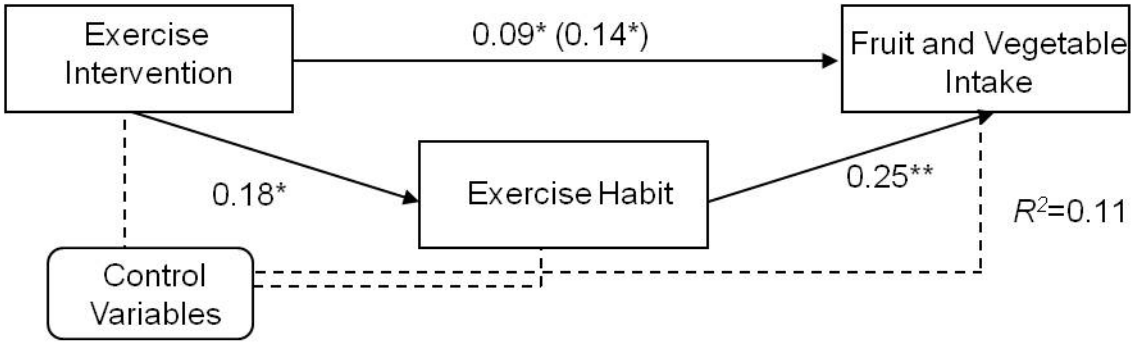

Figure 2. Mediator model (control group vs. intervention group) with fruit and vegetable intake as outcome

Note. *$p < 0.05$; **$p < 0.001$. Control variables were patient group (cardiac vs. orthopedic), gender, and body mass index; Changes in exercise habit and fruit and vegetable consumption were operationalized as residualized change scores T2/T1; The study was conducted in Germany between 2009 and 2011.

The indirect effect equaled *slope* = 0.05 (CI_{BCA} = 0.01 to 0.08). The mediator model accounted for 11% of the variance in fruit and vegetable intake (see Figure 2). Body mass index ($p = 0.12$) and patient group ($p = 0.37$) were not associated with changes in fruit and vegetable intake. However, gender was associated with behaviour change favoring women (*slope* = 0.13, *SE* = 0.04; $p <$ 0.001).

Discussion

The first purpose of the study was to examine the effects of an exercise self-regulation intervention addressing action planning, action control, and satisfaction on changes in physical exercise in rehabilitation patients. These analyses are novel in terms of considering satisfaction with exercise experiences as a mediator of intervention effects. The second aim of the study was to investigate whether and how an exercise self-regulation intervention promotes fruit and vegetable consumption. By combining two lines of research, the framework of behavioural habits (Aarts, Paulussen, & Schaalma, 1997; Orbell & Verplanken, 2010; Verplanken & Melkevik, 2008) and the Strength and Energy Model (Baumeister et al., 2000), the present paper has an innovative theoretical approach towards multiple health behaviour change.

Changes in Action Control and Satisfaction Explain Intervention Effects on Physical Exercise

The results provide evidence that the intervention is a useful mean to enhance physical exercise after rehabilitation. As hypothesized it was found that one mechanism underlying the intervention consisted of an increase in the volitional process of action control. This corroborates previous findings in rehabilitation (Sniehotta et al., 2005a). Supporting assumptions by Rothman (2000), changes in cognitions of satisfaction additionally explained the effect of the intervention on exercise behaviour. This adds to previous studies reporting prospective effects of perceived satisfaction on subsequent behaviour in smoking cessation (Baldwin et al., 2006), weight management (Finch et al., 2005), and exercise behaviour (Fleig et al, 2011). In previous studies in the rehabilitation context, action planning was found to add to the prediction of physical exercise (e.g., Reuter et al., 2009). Unexpectedly, patients in the intervention group did not outperform patients in the control group with regard to changes in action planning. Similarly to Sniehotta et al. (2005b), both groups reported moderately high levels of action planning six weeks after discharge. A more detailed investigation of the therapy program revealed that some aspects of action planning had already been incorporated in the standard treatment of the rehabilitation clinics. Due to a possible ceiling effect, the intervention may not have led to a further increase in the use of action planning in comparison to the control group (Sniehotta et al., 2005a). To sum up, psychological interventions targeting action control and satisfaction may complement standard rehabilitation care and contribute to improved and sustainable treatment outcomes.

Changes in Exercise Habit Strength Facilitate Transfer Effects

This study has investigated the occurrence of a transfer effect and acknowledged the role of habit strength in multiple health behaviour change. As expected, changes in fruit and vegetable intake due to the intervention were mediated by changes in exercise habit. In line with the Strength and Energy Model (Baumeister et al., 2000), the exposure to an exercise intervention may challenge the engagement in another health behaviour as resources become limited.

The present study, however, provides initial evidence that habituation in physical exercise may facilitate engagement in fruit and vegetable consumption. By developing behavioural routines, individuals may invest previously utilized resources in other intended health behaviours. Future studies should extend present findings by analyzing whether changes in exercise habit do not only co-occur with changes in fruit and vegetable intake, but also predict long-term changes in healthy nutrition. Thereby, a time sequence of a transfer effect could be tested.

In the present study it was investigated whether intervention-induced changes in one health behaviour "naturally" transfer to another behaviour. Ideally, future intervention studies would include an experimental manipulation that may initiate a transfer of resources across health behaviours. To sum up, interventions could be optimized if they aim at fostering exercise habits which in turn may facilitate transfer effects to healthy nutrition.

Limitations

Some limitations need to be addressed. Firstly, the use of self-report questionnaires could have led to over- or underreporting. Secondly, we relied on a two-item measure of exercise habit strength. Future studies may include an extended measure of habit strength such as the *Self-Report Habit Index* (SRHI; Verplanken & Orbell, 2003) which may be also applied for healthy nutrition. Thirdly, for a better understanding of the role of self-regulatory processes in the adoption and maintenance of exercise behaviour and fruit and vegetable intake, a longer follow-up period is desirable. Fourthly, patients' baseline levels of exercise were rather high, corroborating previous findings in orthopedic rehabilitation patients (Ziegelmann, Lippke, & Schwarzer, 2006). This may be explained by the fact that our study has mainly attracted those patients to participate who had already been quite active prior to rehabilitation. Thus, further research is needed to replicate findings in other patient groups and non-clinical samples.

Conclusions

This study adds to our understanding of self-regulatory mechanisms in exercise behaviour after rehabilitation. The addition of psychological interventions targeted at action control and satisfaction may increase the effectiveness of standard rehabilitation treatment. For the promotion of a healthy lifestyle, (a) psychological interventions should address behaviour-specific self-regulatory variables, (b) take into account measures of habit strength, and (c) utilize transfer effects from one behaviour to the other.

Acknowledgements

This work has been funded by the Deutsche Rentenversicherung Bund (DRV; German Pension Insurance) within the project FABA (Project ID 8011 - 106 - 31/31.91). The authors would like to thank the rehabilitation clinics and their patients for participating in this study. We especially appreciate the support of Mrs. Pimmer, Dr. Kiwus, Dr. Glatz, Dr. Milse, and Dr. Johnigk. None of the authors have any conflicting interests.

References

Aarts, H., Paulussen, T., Schaalma, H., 1997. Physical exercise habit: on the conceptualization and formation of habitual health behaviours. Health Educ. Res. 12, 363.

Aittasalo, M., Miilunpalo, S., Kukkonen-Harjula, K., Pasanen, M., 2006. A randomized intervention of physical activity promotion and patient self-monitoring in primary health care. Prev. Med. 42, 40-46.

Baldwin, A., Rothman, A., Hertel, A., Keenan, N., Jeffery, R., 2009. Longitudinal associations between people's cessation-related experiences and their satisfaction with cessation. Psychol. Health 24, 187-201.

Baldwin, A.S., Rothman, A.J., Hertel, A.W., Linde, J.A., Jeffery, R.W., Finch, E.A., Lando, H.A., 2006. Specifying the determinants of the initiation and maintenance of behaviour change: An examination of self-efficacy, satisfaction, and smoking cessation. Health Psychol. 25, 626 - 634.

Baumeister, R.F., Muraven, M., Tice, D.M., 2000. Ego depletion: A resource model of volition, self-regulation, and controlled processing. Psychol. Bull. 18, 130-150.

Brunner, E.J., Mosdøl, A., Witte, D.R., Martikainen, P., Stafford, M., Shipley, M.J., Marmot, M.G., 2008. Dietary patterns and 15-y risks of major coronary events, diabetes, and mortality. Am. J. Clin. Nutr. 87, 1414-1421.

Chahoud, G., Aude, Y.W., Mehta, J.L., 2004. Dietary recommendations in the prevention and treatment of coronary heart disease: Do we have the ideal diet yet? Am. J. Cardiol. 94, 1260-1267.

Conn, V.S., Hafdahl, A.R., Minor, M.A., Nielsen, P.J., 2008. Physical activity interventions among adults with arthritis: Meta-analysis of outcomes. Semin. Arthritis Rheu. 37, 307-316.

Dalal, H.M., Zawada, A., Jolly, K., Moxham, T., Taylor, R.S., 2010. Home based versus centre based cardiac rehabilitation: Cochrane systematic review and meta-analysis. Brit. Med. J. 340, 1-15.

Dutton, G.R., Napolitano, M.A., Whiteley, J.A., Marcus, B.H., 2008. Is physical activity a gateway behaviour for diet? Findings from a physical activity trial. Prev. Med. 46, 216-221.

Finch, E.A., Linde, J.A., Jeffery, R.W., Rothman, A.J., King, C.M., Levy, R.L., 2005. The effects of outcome expectations and satisfaction on weight loss and maintenance: Correlational and experimental analyses-a randomized trial. Health Psychol. 24, 608-616.

Fleig, L., Lippke, S., Pomp, S., Schwarzer, R., 2011. Exercise maintenance after rehabilitation: How exercise can make a difference. Psychol. Sport Exerc. 12, 293-299.

Fuchs, R., Göhner, W., Seelig, H., in press. Long-term effects of a psychological group intervention on physical exercise and health: The MoVo concept. J. Phys. Act. Health.

Godin, G., Shephard, R.J., 1985. A simple method to assess exercise behaviour in the community. Can. J. appl. sport sci. 10, 141-146.

Göhner, W., Seelig, H., Fuchs, R., 2009. Intervention Effects on Cognitive Antecedents of Physical Exercise: A 1-Year Follow-Up Study. Appl. Psychol. Health Wellbeing 1, 233-256.

Hagger, M., Wood, C., Stiff, C., Chatzisarantis, N.L.D., 2010. Self-regulation and self-control in exercise: the strength-energy model. Int. Rev. Sport Exerc. Psychol. 3, 208-238.

Jacobs, D.R., Ainsworth, B.E., Hartman, T.J., Leon, A.S., 1993. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med. Sci. Sports Exerc. 25, 81-91.

Lippke, S., Nigg, C.R., Maddock, J.E., in press. Health-Promoting and Health-Risk Behaviours: Theory-Driven Analyses of Multiple Health Behaviour Change in Three International Samples. Int. J. Behav. Med. 1-13.

Lippke, S., Ziegelmann, J.P., Schwarzer, R., 2004. Initiation and maintenance of physical exercise: Stage-specific effects of a planning intervention. Res. Sports Med. 12, 221-240.

Luszczynska, A., 2006. An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. Soc. Sci. Med. 62, 900-908.

Luszczynska, A., Cieslak, R., 2009. Mediated Effects of Social Support for Healthy Nutrition: Fruit and Vegetable Intake Across 8 Months After Myocardial Infarction. Behav. Med. 35, 30-38.

Mata, J., Silva, M.N., Vieira, P.N., Carraça, E.V., Andrade, A.M., Coutinho, S.R., Sardinha, L.B., Teixeira, P.J., 2009. Motivational" Spill-Over" During Weight Control: Increased Self-Determination and Exercise Intrinsic Motivation Predict Eating Self-Regulation. Health Psychol. 28, 709-716.

Nigg, C.R., Lee, H., Hubbard, A.E., Min-Sun, K., 2009. Gateway Health Behaviours in College Students: Investigating Transfer and Compensation Effects. J. Am. Coll. Health 58, 39-44.

Orbell, S., Verplanken, B., 2010. The automatic component of habit in health behaviour: Habit as cue-contingent automaticity. Health Psychol. 29, 374-383.

Plotnikoff, R.C., Lippke, S., Reinbold-Matthews, M., Courneya, K.S., Karunamuni, N., Sigal, R.J., Birkett, N., 2007. Assessing the validity of a stage measure on physical activity in a population-based sample of individuals with type 1 or type 2 diabetes. Meas. Phys. Educ. Exerc. Sci. 11, 73-91.

Pomp, S., Lippke, S., Fleig, L., Schwarzer, R., 2010. Synergistic effects of intention and depression on action control: Longitudinal predictors of exercise after rehabilitation. Ment. Health Phys. Act. 2, 78-84.

Preacher, K.J., Hayes, A.F., 2008. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Beh. Res. Meth. 40, 879.

Prestwich, A., Lawton, R., Conner, M., 2003. The use of implementation intentions and decisional balance sheet in promoting exercise behaviour. Psychol. Health 18, 707-721.

Prochaska, J.J., Sallis, J.F., 2004. A randomized controlled trial of single versus multiple health behaviour change: promoting physical activity and nutrition among adolescents. Health Psychology: Official Journal of The Division of Health Psychology, Am. Psychol. Assoc. 23, 314-318.

Prochaska, J.J., Spring, B., Nigg, C.R., 2008. Multiple health behaviour change research: An introduction and overview. Prev. Med. 46, 181-188.

Resnick, B., Orwig, D., Yu-Yahiro, J., Hawkes, W., Shardell, M., Hebel, J.R., Zimmerman, S., Golden, J., Werner, M., Magaziner, J., 2007. Testing the effectiveness of the exercise plus program in older women post-hip fracture. Ann. Behav. Med. 34, 67-76.

Reuter, T., Ziegelmann, J.P., Lippke, S., Schwarzer, R., 2009. Long-term relations between intentions, planning, and exercise: A 3-Year Longitudinal Study After Orthopedic Rehabilitation. Rehabil. Psychol. 54, 363-371.

Rothman, A.J., 2000. Toward a theory-based analysis of behavioural maintenance. Health Psychol. 19, 64-69.

Rothman, A.J., Baldwin, A.S., Hertel, A.W., 2004. Self-regulation and behaviour change: Disentangling behavioural initiation and behavioural maintenance, The handbook of self-regulation, pp. 130–148.

Schwarzer, R., 2008. Modeling health behaviour change: How to predict and modify the adoption and maintenance of health behaviours. Appl. Psychol.-Int. Rev. 57, 1-29.

Schwarzer, R., Schüz, B., Ziegelmann, J.P., Lippke, S., Luszczynska, A., Scholz, U., 2007. Adoption and maintenance of four health behaviours: Theory guided longitudinal studies on dental flossing, seat belt use, dietary behaviour, and physical activity. Ann. Behav. Med. 33, 156-166.

Sheeran, P., & Orbell, S., 1999. Implementation intentions and repeated behaviour: Augmenting the predictive validity of the theory of planned behaviour. Europ. J. Social Psychol., 29, 349-369.

Sniehotta, F. F., Scholz, U., Schwarzer, R., Fuhrmann, B., Kiwus, U., Völler, H., 2005a. Long-term effects of two psychological interventions on physical exercise and self-regulation following coronary rehabilitation. Int. J. Behav. Med. 12, 244-255.

Sniehotta, F.F., Nagy, G., Scholz, U., Schwarzer, R., 2006. The role of action control in implementing intentions during the first weeks of behaviour change. Brit. J. Health Psychol. 45, 87-106.

Sniehotta, F.F., Scholz, U., Schwarzer, R., 2005b. Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. Brit. J. Soc. Psychol. 20, 143-160.

Verplanken, B., Melkevik, O., 2008. Predicting habit: The case of physical exercise. Psychol. Sport Exerc. 9, 15-26.

Verplanken, B., Orbell, S., 2003. Reflections on past behaviour: A self-report index of habit strength. J. Appl. Soc. Psychol. 33, 1313-1330.

Wiedemann, A. U., Lippke, S., Reuter, T., Ziegelmann, J. P., & Schwarzer, R. (2011). How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. Europ. J. Social Psychol., 41, 42-51.

Wilcox, S., King, A.C., Castro, C., Bortz, I., 2000. Do changes in physical activity lead to dietary changes in middle and old age? Am. J. Prev. Med. 18, 276-283.

Ziegelmann, J.P., Lippke, S., Schwarzer, R., 2006. Adoption and maintenance of physical activity: Planning interventions in young, middle-aged, and older adults. Psychol. Health 21, 145-163.

Ziegelmann, J.P., Luszczynska, A., Lippke, S., Schwarzer, R., 2007. Are goal intentions or implementation intentions better predictors of health behaviour? A longitudinal study in orthopedic rehabilitation. Rehabil. Psychol. 52, 97-102.

4

Beyond Goal Intentions: Processes of Habit Formation in the Exercise Domain

---

Fleig, L., Lippke, S., Pomp, S., Parschau, L., Koring, M., Lange, D., & Schwarzer, R. (under review). Beyond goal intentions: Processes of habit formation in the exercise domain.

Abstract

Objectives. Habits are behavioural responses to environmental cues that are executed with minimal conscious control. Habit formation requires both behaviour initiation and maintenance. We examined whether exercise intentions direct habit formation by increasing the use of action planning, a self-regulatory strategy which promotes behaviour repetition.

Design and Methods. Two field studies investigated the effect of goal intentions on habit strength through a sequential path from action planning to exercise. Exercise intentions, action planning, habit strength, and exercise were assessed at two measurement points in time in 329 university students (Study 1), and at four points in time in 205 rehabilitation patients (Study 2).

Results. In a multiple step mediation model, the indirect effect of intentions on habit strength through action planning and behaviour was significant in both samples.

Conclusions. Action planning and behaviour operated as sequential mediators to bridge the gap between goal intentions and habit strength. Exercise habits may develop as a result of action planning and frequent behaviour enactment. Including these constructs jointly into behaviour change models improves the understanding of the mechanisms involved in habit formation.

Keywords: habit strength, goal intentions, action planning, multiple step mediation, physical exercise, habit formation

Introduction

For most individuals, many daily behaviours such as brushing one's teeth, using a seat-belt, or washing one's hands, have become routinized to the point that they can be performed with little conscious effort (Ajzen, 2002). There is evidence that even complex health behaviours, such as physical exercise, can become habituated, even though they are initially guided by goal intentions and deliberate self-regulation (Lally, van Jaarsveld, Potts, & Wardle, 2010; Rhodes, de Bruijn & Matheson, 2010). Healthy habit formation is a desired goal for many health behaviour change interventions (Lally & Gardner, 2011), because once a behaviour has become habitual, risk of relapse might be reduced, and maintenance of the behaviour ensured (Rothman, Sheeran, & Wood, 2009; Verplanken & Wood, 2006). To contribute to the design of theory- and evidence-based health behaviour interventions, we investigated the processes involved in exercise habit formation in a primary and a secondary prevention context.

Translating Goal Intentions into Habits

Habits are understood as behaviours that have acquired a high degree of automaticity (Bargh, 1994). In other words, habits are enacted in response to contextual cues with little conscious deliberation (Verplanken & Melkevik, 2008; Wood & Neal, 2007). While developing healthy habits, individuals face subsequent self-regulatory challenges (Lally & Gardner, 2011) from intention formation, via intention implementation towards behaviour maintenance.

Action planning: Self-regulatory strategy to implement goal intentions.

Initially, individuals need to build goal intentions to engage in a desired behaviour. Even if people hold strong goal intentions to act, however, they do not always translate them into behaviour (Sheeran, 2002). They forget their goal intentions or may be distracted by other tasks when they encounter an opportunity to enact the desired behaviour. Behaviour initiation becomes more likely when individuals support their goal intentions with action plans (i.e., implementation intentions, Gollwitzer & Sheeran, 2006; Leventhal, Singer & Jones, 1965; Sniehotta, Schwarzer, Scholz, & Schüz, 2005). Action planning refers to a deliberate, prospective self-regulatory strategy, in which people mentally link behavioural responses with specific situations (Sheeran & Orbell, 1999). An example of an action plan supporting the goal intention of more frequent exercise would be: "when I come home from work on Monday, I will go for a walk in the park." Upon encountering the situational cues specified by the plan (i.e., time, location), the intended behaviour is assumed to become more likely, as a smaller amount of conscious effort is required for the initiation

of the behaviour (Gollwitzer & Sheeran, 2006; Webb & Sheeran, 2007). Consequently, the intended behaviour should be performed more often. There is ample empirical support that action planning promotes exercise, particularly among patients engaged in rehabilitation programs (Bélanger-Gravel, Godin, & Amireault, 2011; Fleig, Lippke, Pomp, & Schwarzer, 2011). In line with prominent models of health behaviour, such as the health action process approach (HAPA; Schwarzer, 2008; Schwarzer, Lippke, & Luszczynska, 2011), or the extended theory of planned behaviour (TPB; Sniehotta, Gorski, Araújo-Soares, 2010), observational field studies in primary (Koring, et al., 2011) and secondary prevention settings (Lippke, Ziegelmann & Schwarzer, 2004; Reuter, Ziegelmann, Lippke & Schwarzer, 2009; Sniehotta, Scholz, & Schwarzer, 2005) provide consistent support that the use of action planning not only predicts exercise, but also bridges the gap between goal intentions and exercise. In terms of interventions, previous field studies on the working mechanisms of planning trials have revealed that generating action plans promotes the use of action planning in everyday life, and thereby supports subsequent repeated exercise engagement (Lippke, Schwarzer, Ziegelmann, Scholz, & Schüz, 2010; Luszczynska, 2006; Wiedemann, Lippke, Reuter, Ziegelmann, & Schwarzer, 2011).

Behaviour repetition as a prerequisite for habit formation.

Essentially then, frequent behaviour enactment in stable settings is a prerequisite for habit formation (Aarts, Paulussen, & Schalma, 1997; Gardner, de Bruijn, & Lally, 2011; Lally et al., 2010). For example, if a person – as a result of his or her action plans - repeatedly goes for a run in the gym on Sundays after lunch, his or her behaviour will become closely tied to those contextual cues (i.e., time, location). As a result, behaviour enactment may gradually fall under the control of contextual cues rather than conscious decision-making and self-regulation (Verplanken & Melkevik, 2008; Wood & Neal, 2007). Thus, goal intentions may be best transformed into exercise habits by increasing the use of action planning, which promotes the repetition of behaviour (see Figure 1).

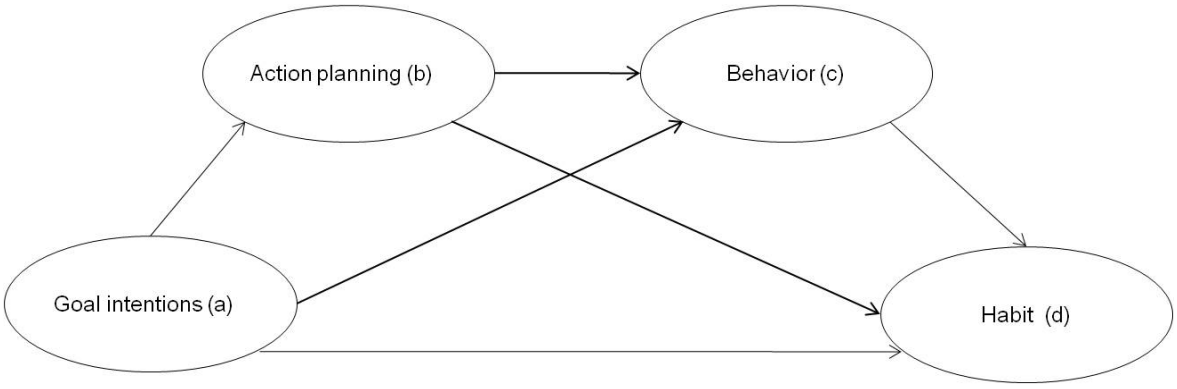

Figure 1. Theoretical framework of habit formation: goal intentions (a, independent variable) are translated into habits (d, dependent variable) via a sequential path from (b, mediator 1) action planning to (c, mediator 2) behaviour

As far as we are aware, however, previous studies have mainly focused on the link between frequent behaviour execution and habituation (Lally & Gardner, 2011; Lally, et al., 2010), or the link between intentions, behaviour and habits (Wood & Neal, 2007; Aarts, et al., 1997), without explicitly considering the role of self-regulatory strategies.

Aims of the Two Studies in University Students and Rehabilitation Patients

Based on the HAPA (Schwarzer, 2008; Schwarzer, et al., 2011), TPB (Sniehotta, et al., 2010) and the habit formation framework suggested by Lally and Gardner (2011), in this study we therefore examined whether habit formation relies on two processes that may operate in a sequential manner. In particular, we hypothesized that (a) goal intentions promote the use of action planning, which (b) in turn, was assumed to (c) increase the frequency of exercise. As a result, (d) behaviour should progressively develop into a habit (see Figure 1). In two observational studies, we aimed to test the effects of goal intentions on exercise habit strength through action planning and exercise, via multiple step mediation analyses. In a university student sample (Study 1), we examined whether goal intentions are translated into exercise habits via a sequential path from action planning to frequent behaviour enactment. Among medical rehabilitation patients (Study 2), we investigated whether the effect of initial exercise intentions on long-term changes in exercise habit strength, may be explained by a sequence from changes in action planning to changes in behaviour.

Study 1

How goal intentions direct exercise habits: A field study in university students

Method

Participants and Procedure

German university students were approached during courses, and were invited to take part in a combined paper-pencil and online survey. At baseline (T1), 529 students first provided informed consent, and then filled in the questionnaire assessing exercise, social-cognitive and socio-demographic variables.

The follow-up assessment (T2) took place two weeks later in the same courses with 329 participants (62.2%). The mean age of the longitudinal sample was 24.9 years (*SD*=6.6; range 17–46 years), and the sample consisted of mainly women (79.4%). Of all participants, 36.3% were living with a partner. The majority of the longitudinal sample (92.7%) reported having at least a high school degree. Participants were rewarded with credit points for their course upon completion of all three assessments. Attrition analyses indicated that with regard to physical exercise, social-cognitive and socio-demographic variables (all *ps*>.05), participants who continued study participation did not differ from those who dropped out.

Measures

Unless otherwise stated, response formats were on six-point Likert scales, ranging from "totally disagree" (1) to "totally agree" (6). Item examples provided below are translated from German.

Self-reported *physical exercise* was measured at T1, with a part of the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003): participants indicated how often per week they had performed leisure time physical exercise.

Goal intentions to perform physical exercise in the next two weeks were measured at T1 with an assessment analogous to that of exercise behaviour: participants indicated how often per week they intended to perform leisure physical exercise (Koring, et al, 2011).

Action Planning (Lippke, et al., 2004) was assessed at T1 with four items addressing when, where, and how to be active. The items were worded: "for the next two weeks, I have already planned…" (1) "…which physical exercise I will perform", (2) "…where I will be physically active," (3) "…on which days of the week I will be physically active", and (4) "…for how long I will be physically active" (Cronbach's α=.93).

Exercise habit strength was assessed at T1 and T2 with four items adapted from Verplanken and Orbell (2003). Participants were asked to think about the past two weeks and their previous levels of physical exercise. The items were worded: "being as physically active as I have been during the last two weeks is something" (a) "…I do without thinking about," (b) "… I do automatically," (c) "...that belongs to my daily routines," (d) "… I would miss if I did not do it." Answers were given on a six-point Likert scale with the anchors "not at all" (1) to "very much" (6) (Cronbach's α=.85).

Statistical Analyses

All analyses were run with SPSS 20. Action planning and exercise were specified as sequential mediators of the effect of intentions on habit strength in a multiple step mediation model (Hayes, Preacher, & Myers, 2010). Within a three-step mediation model, a dependent variable is regressed on an independent variable via a chain of two sequential mediators. For all calculations, variables were *z*-standardized (Aiken & West, 1991). Estimates of path coefficients were calculated by using Ordinary Least Squares regressions. Confidence intervals were estimated applying the bootstrap approach. Gender, marital status and baseline habit strength were included as covariates. Missing data (<5% on all variables) were imputed using the Expectation Maximization (EM) algorithm.

Results

Descriptive Statistics

Means, standard deviations and intercorrelations of all model variables are displayed in Table 1. Goal intentions, action planning, and exercise were significantly associated with habit strength at T2.

Table 1. Means (*M*), Standard Deviations (*SD*), and Intercorrelations for Goal Intentions, Action Planning, Exercise Habit Strength, and Physical Exercise in *N*=329 Students (Study 1).

	1	*2*	*3*	*4*	*M*	*SD*	*Range*
1. Goal intentions T1[1]					1.86	1.45	0-7
2. Action planning T1	. 35**				3.96	1.41	1-6
3. Physical exercise T1[2]	.64**	.36**			1.30	1.43	0-7
4. Exercise habit strength T2	.11*	.22**	.26**		4.14	1.18	1-6
5. Exercise habit strength T1	.20**	.20**	.32**	.56**	4.16	1.20	1-6

Note. *p<.05; **p<.01; [1]Weekly intended frequency of leisure time physical exercise; [2]weekly frequencyof physical exercise.

Multiple Step Mediation Analyses

Goal intentions T1 were associated with action planning T1 and exercise T1 (see Figure 2). Habit strength T2 was predicted by action planning T1 and behaviour T1, but not by goal intentions T1 (see Figure 2). After controlling for action planning and exercise, the relation between goal intentions and exercise habit strength remained non-significant.

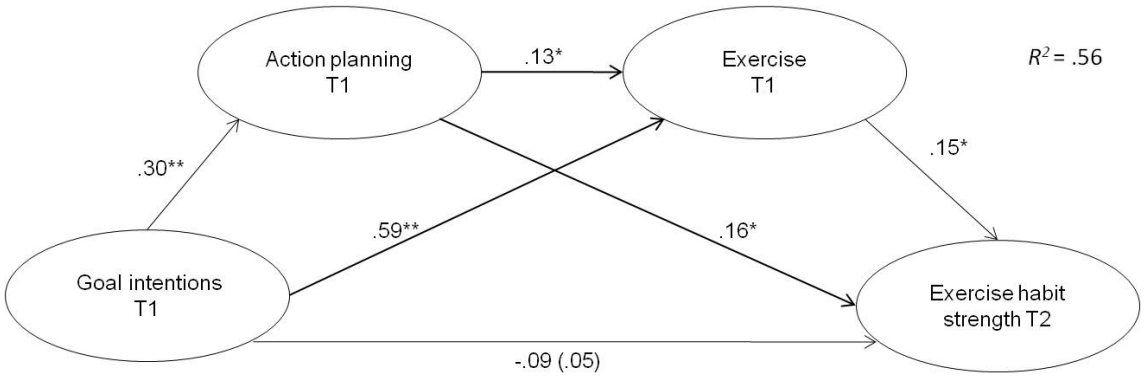

Figure 2. Multiple step mediation model in *N*=329 university students

Note. *p<.05; **p<.01; Control variables were baseline habit strength, gender, and marital status.

The specific indirect effect of goal intentions through action planning, and exercise on habit strength equalled β=.014 (CI_{BCA}=.001 to .030). The specific indirect effect of goal intentions through action planning on habit strength was β=.048 (CI_{BCA}=.017 to .078). The specific indirect

effect of goal intentions through exercise on habit strength revealed β=.088 (CI_{BCA}=.022 to .179). The multiple mediator model accounted for 56% of the variance in T2 exercise habit strength. Among all covariates, only T1 habit strength (p=.001) was associated with T2 habit strength. Marital status (p=.07) and gender (p=.94) were not associated with T2 habit strength.

Discussion of Study 1

This study tested the underlying theory of the mediation process between goal intentions and exercise habit strength in a university field setting. We investigated whether the translation of goal intentions into exercise habits could be facilitated by action planning and frequent behaviour enactment. By applying a multiple-step mediation model, we tested whether both variables operate in a stepwise manner (see Figure 2). Results supported the hypothesized relationships. Evidence is provided that action planning (mediator 1) is associated with the frequency of leisure time physical exercise (mediator 2; e.g., Koring, et al., 2011). In addition, results indicated that both variables operate in a presumably sequential manner for translating goal intentions into exercise habits.

To allow for the temporally correct specification of goal intentions, action planning, exercise, and habit strength, however, all model variables should be measured at different points in time. Thus, a further study was necessary to apply a longitudinal study design with four measurement points in time, using change scores. As in previous research investigating the underlying processes of habit formation (Aarts & Dijksterhuis, 2000; Lally, et al., 2010; Orbell & Verplanken, 2010), Study 1 was conducted in a university setting with rather young participants. To further generalize findings beyond student samples, Study 2 aimed at replicating the findings in a secondary prevention context among medical rehabilitation patients.

Study 2

Developing exercise habits after rehabilitation treatment

The approach of Study 2 was similar to that of Study 1, aiming at replicating the findings with four instead of two measurement points in time, and in a diverse sample. The main difference from Study 1 lies in the research context, because participants were much older, and they were recovering from serious illness or injury after medical rehabilitation treatment. Whereas Study 1 investigated static relationships, Study 2 employed a path model with change scores.

Method

Participants and Procedure

Participants were recruited at two orthopedic rehabilitation centers (one inpatient and one outpatient), and one inpatient cardiac rehabilitation clinic. Rehabilitation included exercise therapy as well as exercise counseling. At the onset (T1) and at the end of rehabilitation (T2), patients were asked to fill out a computer-based questionnaire. A total of 419 patients agreed to participate and provided informed consent (n=121 cardiac and n=298 orthopedic patients), of which 352 completed the second questionnaire at the end of rehabilitation. The second follow-up assessment (T3) took place six weeks after discharge via Computer-Assisted Telephone Interviews with n=326 patients. Twelve months after discharge (T4), n=205 patients filled in paper-pencil questionnaires in.

The mean age of the longitudinal sample was 48.9 years (SD=10.4; range 19–77 years), and the sample consisted of slightly more women (52.9%) than men. Of all participants, 72.9% were living with a partner. Two thirds of the entire sample (64.2%) reported having a high school degree, and 73.3% were employed. Drop-out analyses indicated that patients who continued study participation were more likely to be employed than those who did not (p=.03). Aside from that, no other differences were found with regard to exercise, social-cognitive and socio-demographic variables (all p>.05).

Measures

Item examples given below are translated from German. Self-reported *physical exercise* was measured at T1 and T3, with a modified version of the Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1985; Plotnikoff, et al., 2007). Participants indicated how often per week and how long per session they performed strenuous physical exercise (fast heart rate, sweating) and moderate physical exercise (hardly exhausting, light sweating). Only activities outside of work duties and voluntary activities were addressed. Total physical exercise was the total number of sessions per week, multiplied by minutes per session.

Goal intentions to perform physical exercise were assessed at T1 by two items, as suggested by Nigg (2005): “after rehabilitation, I intend to perform the following activities at least three [two] days per week for 40 [20] minutes…” (1) “…strenuous (heart beats rapidly, sweating) physical exercises” and (2) “…moderate (not exhausting, light perspiration) physical exercises.” Answers were given on a six-point scale from “not at all true” (1) to “absolutely true” (6). Both answers

were aggregated to a sum score (correlation of the two items r=.13). Thus, items with discriminant validity were combined to obtain an index that reflects a broad construct.

Action planning (Lippke, et al., 2004) was assessed at T1 and T2 with four items addressing the when, where, and how of the activity. The items were worded: "for the month after the rehabilitation, I have already planned…" (1) "…which physical exercise I will perform (e.g., walking)," (2) "…where I will be physically active (e.g., in the park)," (3) "…on which days of the week I will be physically active" and (4) "…for how long I will be physically active" (Cronbach's α=.93). Responses were given on a six-point Likert scale, ranging from totally disagree (1) to totally agree (6).

Exercise habit strength was assessed at T1 and T4 with two items adapted from Verplanken and Orbell (2003). Participants were asked to think about the past four weeks and their previous level of exercise. The items were worded: "being as physically active as I have been during the last month is something" (a) "…I do without thinking about," (b) "...that has become a confirmed habit for me." Answers were given on a six-point Likert scale, with the anchors "not at all" (1) to "very much" (6) (intercorrelation of the two items r=.65).

Statistical Analyses

All analyses were performed in the same manner as in Study 1. In addition, change scores were used to specify the multiple mediation model. Changes in action planning and exercise were operationalized as residualized change scores by regressing T2 and T3 scores, respectively, on the corresponding baseline variables. In the mediation model, standardized change scores were used.

Results

Descriptive Statistics

Means, standard deviations and intercorrelations of all model variables are displayed in Table 2. T1 goal intentions, T2 action planning, and T3 exercise were significantly associated with exercise habit strength at T4.

Multiple Step Mediation Analyses

Goal intentions T1 predicted exercise habit strength at T4, as well as action planning T2 and exercise T3. Exercise habit strength T4 was predicted by action planning T2 and exercise T3 (see Figure 3).

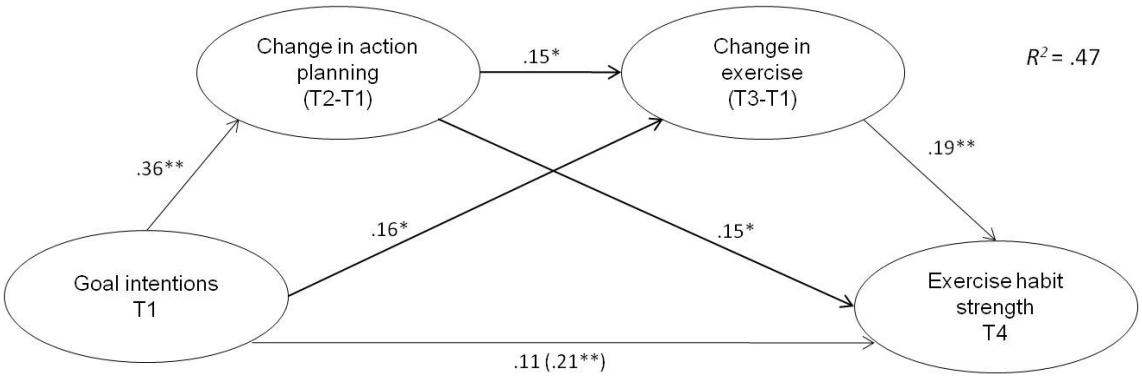

Fig 2. Multiple step mediation model in *N*=329 university students

Note. **p*<.05; ***p*<.01; Control variables were baseline habit strength, gender, and marital status.

After controlling for action planning and exercise, the relation between goal intentions and exercise, habit strength was lowered to β=.11 (*SE*=.08; *p*=.16), indicating full mediation. The specific indirect effect of goal intentions through action planning and exercise on habit strength revealed β = .014 (CI_{BCA}=.001 to .034). The specific indirect effect of goal intentions through action planning on habit strength was β = .054 (CI_{BCA}=.009 to .122). The specific indirect effect of goal intentions through exercise on habit strength equalled β=.030 (CI_{BCA}=.012 to .070). The multiple mediator model accounted for 47% of the variance in habit strength at T4. Baseline habit strength was associated with habit strength at T4 (*p*=.02). In contrast, gender (*p*=.18) and marital status (*p*=.45) were not associated with exercise habit strength at T4.

Discussion of Study 2

Study 2 replicated the major findings of Study 1, although the setting and sample characteristics were very different. Moreover, Study 2 involved four measurement points in time, allowing for the temporally correct specification of the mediators as assumed in our theoretical framework of habit formation (see Figure 1). Thus, although causality cannot be proven in such longitudinal research (Weinstein, 2007), the path model does reflect the hypothesized temporal order.

Table 2. Means (*M*), Standard Deviations (*SD*), and Intercorrelations for Goal Intentions, Action Planning, Exercise Habit Strength, and Physical Exercise in *N*=205 Rehabilitation Patients (Study 2)

	1	*2*	*3*	*4*	*5*	*6*	*M*	*SD*	*Range*
1. Goal intentions T1							3.48	1.29	1-6
2. Action planning T2	.41**						4.27	1.30	1-6
3. Action planning T1	.47**	.50**					3.41	1.65	1-6
4. Physical exercise T3[1]	.26**	.19*	.12*				157.51	186.83	0-900
5. Physical exercise T1[1]	.41**	.20*	.27**	.27**			85.03	121.77	0-840
6. Exercise habit strength T4	.29**	.33**	.27**	.30**	.20*		4.24	1.67	0-6
7. Exercise habit strength T1	.43**	.16*	.33**	.24**	.39**	.31**	3.49	1.73	0-6

Note. [1]Physical exercise in minutes per week; *p<.05; **p<.01.

General Discussion of Both Studies

These two longitudinal studies tested the effects of goal intentions on action planning, exercise, and habit strength, and the underlying theory of the mediation process in a university and a rehabilitation field setting. To analyze the mechanisms of habit formation based on the framework by Lally and Gardner (2011), a path analysis was performed with action planning and exercise specified as sequential mediators between goal intentions and exercise habit strength. The main contribution of this paper lies in the extension of the simple intention-planning-behaviour mediator model into a multiple-step mediation model, with exercise habit strength as the most distal outcome. Results were in line with hypotheses.

Goal Intentions are Translated into Exercise Habits in Two Steps

In line with previous research, we found that habit strength increased as a result of action planning (Orbell & Verplanken, 2010) and frequent behaviour enactment (Lally, et al., 2010; Orbell & Verplanken, 2010). Our findings are novel in that they provide evidence that both variables help to realize goal intentions in a stepwise manner.

Goal intentions direct habit formation by promoting action planning and exercise repetition.

First, our results showed that goal intentions stimulated the use of action planning. In a next step, action planning was found to enhance exercise, adding to previous findings from observational studies (Bélanger-Gravel, et al., 2011; Fleig, et al., 2011) and action planning trials (Lippke, et al., 2010; Luszczynska, 2006; Wiedemann, et al., 2011). By increasing behaviour, action planning may create a "cognitive framework for the development of future habits" (Verplanken, 2005, p. 107).

Behaviour repetition as a prerequisite for habit formation.

Finally, our results suggest that the more individuals engaged in exercise, the more their behaviour acquired features of a habit. Our data can be well integrated with results from a previous longitudinal field study analyzing intra-individual changes in habit strength (Lally, et al., 2010). The authors found the following consistent intra-individual pattern: the more frequently a behaviour was performed in response to stable context cues, the more it acquired features of a habit (i.e., automaticity; Lally, et al., 2010). As far as we are aware, only one previous trial on dental hygiene was evaluated in terms of changes in habit strength. In line with our observational results in the exercise domain, Orbell and Verplanken (2010) revealed that only those individuals who planned

where and when to floss their teeth reported higher levels of behaviour and habit strength at short-term follow-up. However, the authors did not provide information on whether increases in dental flossing frequency as a result of the experimental manipulation actually led to increases in habit strength.

Interestingly, the strength of the revealed associations between behaviour and habit strength was somewhat lower than the average weighted correlation (r_+=.44) reported by a recent meta-analyses (Gardner, et al., 2011). This may be attributed to the measurement of habit strength in the present studies. In both observational studies, habit strength was assessed with items that capture features of automaticity, rather than habit features that relate to the history of behaviour repetition. As argued by Sniehotta and Presseau (2011), behaviour repetition is a prerequisite of habit formation, rather than an actual characteristic of habits. Correlations reported by Gardner et al. (2011) may thus be inflated, due to the large construct overlap between habit as operationalized by the complete Self-report Habit Index (SRHI; Verplanken & Orbell, 2003), and exercise as operationalized by frequency and duration measures (Sniehotta & Presseau, 2011).

In sum, the hypothesized multiple-step pattern of habit formation (see Figure 1) could be replicated across university students and rehabilitation patients. Whereas results among university students referred to short-term effects of goal intentions, action planning, and exercise on habit strength, findings among rehabilitation patients revealed that hypothesized relationships also hold true for long-term changes in habit strength. To add depth to the understanding of how goal intentions direct exercise habits, it may be useful to incorporate habit strength into current models of behaviour change (de Bruijn, Kroeze, Oenema, & Brug, 2008) and intervention practice.

Limitations and Outlook

There are several limitations to this study. The employed exercise scales assessed behaviour regardless of the context in which it is performed (e.g., in the park after lunch). From simply investigating associations between action planning and behaviour, one cannot draw conclusions about whether individuals actually exercised in response to the cues specified by their action plans. Unconditional behavioural measures (Sniehotta, 2009) can only function as a proxy for whether individuals adhered to their plans (i.e., planning fidelity). Measuring the degree to which individuals adhere to their action plans, and how this affects healthy habit formation, opens up new avenues for research. Furthermore, behaviour enactment may be necessary but not sufficient for habit formation (Lally & Gardner, 2011). Subjective evaluation of experienced exercise outcomes (e.g., feeling

more attractive or having less pain as a result of exercising) may also affect whether or not individuals maintain exercise (Aarts, et al., 1997; Fleig, et al., 2011; Rothman, et al., 2009), and ultimately develop health habits (Lally & Gardner, 2011). Thirdly, we relied on a short-version measure of exercise habit strength. Future studies may include additional items of the SRHI (Verplanken & Orbell, 2003) to capture further facets of habitual automaticity (e.g., lack of control). In addition, it may be useful to consider context stability of behaviour when measuring habit strength (Sniehotta & Presseau, 2011). Finally, although causal conclusions require experimental tests, the longitudinal design with the predictor, mediators, and outcome variables measured at two (Study 1) or four points (Study 2) in time strengthen our conclusions. Ideally, future studies may apply an experimental causal chain design (Reuter, Ziegelmann, Wiedemann, & Lippke, 2008; Spencer, Zanna, & Fong, 2005) to further accumulate evidence on the theorized mechanisms of habit formation.

Conclusions

The two presented studies in university and rehabilitation settings extend common mediator models of successful goal pursuit: action planning and behaviour performance operated as sequential mediating processes in translating goal intentions into exercise habits. Incorporating these constructs jointly into behaviour change models and intervention practice (i.e., habit strength as intervention outcome) may improve the understanding of the mechanisms involved in habit formation.

Acknowledgements

Study 1 has been funded by the Freie Universität Berlin. Study 2 has been funded by the Deutsche Rentenversicherung Bund (DRV; German Pension Insurance) within the project FABA (Project ID 8011 - 106 - 31/31.91). The authors would like to thank the rehabilitation clinics and their patients for participating in this study. We especially appreciate the support of Mrs. Pimmer, Dr. Kiwus, Dr. Glatz, Dr. Milse, and Dr. Johnigk. None of the authors have any conflicting interests.

References

Aarts, H., & Dijksterhuis, A. (2000). Habits as knowledge structures: automaticity in goal-directed behaviour. Journal of Personality and Social Psychology, 78(1), 53-63.

Aarts, H., Paulussen, T., & Schaalma, H. (1997). Physical exercise habit: On the conceptualization and formation of habitual health behaviours. Health Education Research, 12(3), 363-374.

Aiken, L. S., & West, S. G. (1991). Multiple regression: Testing and interpreting interactions. Thousand Oaks, CA: Sage.

Ajzen, I. (2002). Residual effects of past on later behaviour: Habituation and reasoned action perspectives. Personality and Social Psychology Review, 6(2), 107-122.

Bargh, J. A. (1994). The four horsemen of automaticity: Awareness, intention, efficiency, and control in social cognition. In R. S. Wyer Jr. & T. K. Srull (Eds.), Handbook of social cognition (2nd ed., pp. 1-40). Hillsdale, NJ: Erlbaum.

Bélanger-Gravel, A., Godin, G., & Amireault, S. (2011). A meta-analytic review of the effect of implementation intentions on physical activity. Health Psychology Review, 1-32.

Craig, C. L., Marshall, A. L., Sjorstrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. Medicine & Science in Sports & Exercise, 35, 1381-1395.

de Bruijn, G. J., Kroeze, W., Oenema, A., & Brug, J. (2008). Saturated fat consumption and the theory of planned behaviour: Exploring additive and interactive effects of habit strength. Appetite, 51(2), 318-323.

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2011). Exercise maintenance after rehabilitation: How experience can make a difference. Psychology of Sport and Exercise, 12, 293-299.

Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A systematic review and meta-analysis of applications of the self-report habit index to nutrition and physical activity behaviours. Annals of Behavioural Medicine, 1-14.

Godin, G., & Shephard, R. J. (1985). A simple method to assess exercise behaviour in the community. Canadian Journal of Applied Sport Sciences, 10, 141-146.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. Advances in Experimental Social Psychology, 38, 69-119.

Hayes, A. F., Preacher, K. J., & Myers, T. A. (2010). Mediation and the estimation of indirect effects in political communication research. In Erik. P. Bucy, & R. Lance Holbert (Eds), Sourcebook for political communication research: Methods, measures, and analytical techniques. New York: Routledge.

Koring, M., Richert, J., Lippke, S., Parschau, L., Reuter, T., & Schwarzer, R. (2011). Synergistic effects of planning and self-efficacy on physical activity. Health Education and Behaviour. doi:10.1177/1090198111417621.

Lally, P., & Gardner, B. (2011). Promoting habit formation. Health Psychology Review. doi: 10.1080/17437199.2011.603640.

Lally, P., van Jaarsveld, C. H. M., Potts, H. W. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. European Journal of Social Psychology, 40(6), 998-1009.

Leventhal, H., Singer, R., & Jones, S. (1965). Effects of fear and specifity of recommendation upon attitudes and behaviour. Journal of Personality and Social Psychology, 2, 20-29.

Lippke, S., Schwarzer, R., Ziegelmann, J. P., Scholz, U., & Schüz, B. (2010). Testing stage-specific effects of a stage-matched intervention: a randomized controlled trial targeting physical exercise and its predictors. Health Education & Behaviour, 37(4), 533-546.

Lippke, S., Ziegelmann, J. P., & Schwarzer, R. (2004). Behavioural intentions and action plans promote physical exercise: A longitudinal study with orthopedic rehabilitation patients. Journal of Sport and Exercise Psychology, 26, 470-483.

Luszczynska, A. (2006). An implementation intentions intervention, the use of planning strategy, and physical activity after myocardial infarction. Social Science and Medicine, 62, 900-908.

Nigg, C. R. (2005). There is more to stages of exercise than just exercise. American College of Sports Medicine, 33, 32-35.

Orbell, S., & Verplanken, B. (2010). The automatic component of habit in health behaviour: Habit as cue-contingent automaticity. Health Psychology, 29(4), 374-383.

Plotnikoff, R. C., Lippke, S., Reinbold-Matthews, M., Courneya, K. S., Karunamuni, N., Sigal, R. J., & Birkett, N. (2007). Assessing the validity of a stage measure on physical activity in a population-based sample of individuals with type 1 or type 2 diabetes. Measurement in Physical Education and Exercise Science, 11, 73-91.

Reuter, T., Ziegelmann, J. P., Lippke, S., & Schwarzer, R. (2009). Long-term relations between intentions, planning, and exercise: A 3-year longitudinal study after orthopedic rehabilitation. Rehabilitation Psychology, 54(4), 363-371.

Reuter, T., Ziegelmann, J. P., Wiedemann, A. U., & Lippke, S. (2008). Dietary planning as a mediator of the intention behaviour relation: An experimental causal chain design. Applied Psychology, 57, 194-207.

Rhodes, R., De Bruijn, G. J., & Matheson, D. H. (2010). Habit in the physical activity domain: integration with intention temporal stability and action control. Journal of Sport and Exercise Psychology, 32(1), 84-89.

Rothman, A., Sheeran, P., & Wood, W. (2009). Reflective and automatic processes in the initiation and maintenance of dietary change. Annals of Behavioural Medicine, 38(0), 4-17.

Schwarzer, R. (2008). Modeling health behaviour change: How to predict and modify the adoption and maintenance of health behaviours. Applied Psychology: An International Review, 57, 1-29.

Schwarzer, R., Lippke, S., & Luszczynska, A. (2011). Mechanisms of health behaviour change in persons with chronic illness or disability: The Health Action Process Approach (HAPA). Rehabilitation Psychology, 56(3), 161-170.

Sheeran, P. (2002). Intention—behaviour relations: A conceptual and empirical review. European Review of Social Psychology, 12(1), 1-36.

Sheeran, P., & Orbell, S. (1999). Implementation intentions and repeated behaviour: Augmenting the predictive validity of the theory of planned behaviour. European Journal of Social Psychology, 29, 349-369.

Sniehotta, F. F., & Presseau, J. (2011). The habitual use of the Self-report Habit Index. Annals of Behavioural Medicine, 1-2.

Sniehotta, F. F., Gorski, C., & Araújo-Soares, V (2010). Adoption of community-based cardiac rehabilitation programs and physical activity following phase III cardiac rehabilitation in Scotland: A prospective and predictive study. Psychology and Health, 25(7), 839-854.

Reuter, T., Ziegelmann, J. P., Wiedemann, A. U., & Lippke, S. (2008). Dietary planning as a mediator of the intention behaviour relation: An experimental causal chain design. Applied Psychology, 57, 194-207.

Spencer, S. J., Zanna, M. P., & Fong, G. T. (2005). Establishing a causal chain: Why experiments are often more effective than mediational analyses in examining psychological processes. Journal of Personality and Social Psychology, 89(6), 845-851.

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. Psychology and Health, 20, 143-160.

Sniehotta, F.F., Schwarzer, R., Scholz, U., & Schüz, B. (2005). Action planning and coping planning for long-term lifestyle change: Theory and assessment. European Journal of Social Psychology, 35, 565-576.

Spencer, S. J., Zanna, M. P., & Fong, G. T. (2005). Establishing a causal chain: Why experiments are often more effective than mediational analyses in examining psychological processes. Journal of Personality and Social Psychology, 89(6), 845-851.

Verplanken, B. (2005). Habits and implementation intentions. In J. Kerr, R. Weitkunat & M. Moretti (Eds.), The ABC of behavioural change (pp. 99-109). Oxford: Elsevier Science.

Verplanken, B., & Melkevik, O. (2008). Predicting habit: The case of physical exercise. Psychology of Sport and Exercise, 9(1), 15-26.

Verplanken, B. & Orbell, S. (2003). Reflections on past behaviour: A self-report index of habit strength. Journal of Applied Social Psychology, 33, 1313-1330.

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. Journal of Public Policy & Marketing, 25(1), 90-103.

Webb, T. L., & Sheeran, P. (2007). How do implementation intentions promote goal attainment? A test of component processes. Journal of Experimental Social Psychology, 43(2), 295-302.

Weinstein, N. D. (2007). Misleading tests of health behaviour theories. Annals of Behavioural Medicine, 33(1), 1-10.

Wiedemann, A. U., Lippke, S., Reuter, T., Ziegelmann, J. P., & Schwarzer, R. (2011). How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. European Journal of Social Psychology, 41, 42-51.

Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. Psychological Review, 114(4), 843-863.

5

Telephone-delivered Booster Sessions Help Maintain Self-regulation, Physical Exercise, and Habit Strength: A Long-term Follow-up in Medical Rehabilitation

---

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (under review). Telephone-delivered booster sessions help maintain self-regulation, physical exercise, and habit strength: A long-term follow-up in medical rehabilitation.

Abstract

Background and purpose. After medical rehabilitation, booster sessions are supposed to help maintain physical exercise, self-regulation, and habit strength. Mechanisms are examined by which behaviour and habit strength are maintained.

Methods. Between 2009–2011, rehabilitation patients (*N*=554) were allocated to either a self-regulation intervention or an online questionnaire only. Booster sessions via computer-assisted telephone interviews for the intervention group followed at six weeks and six months. 12 months after discharge, exercise, self-regulatory resources, and habit were reassessed.

Results. The boosters prevented a decline in planning, self-efficacy, behaviour, and habit strength that occurred in the control group. Changes in exercise were mediated by changes in planning and self-efficacy. Changes in habit strength were sequentially mediated by planning and behaviour.

Conclusions. After rehabilitation, booster sessions may help maintain intervention effects. Declines in exercise may be prevented by planning and self-efficacy. Habits may develop as a result of planning and frequent behaviour enactment.

Keywords: intervention booster, computer-assisted telephone interview, physical exercise, exercise habit strength, action planning, self-efficacy

Introduction

In cardiac and orthopedic rehabilitation, a demanding exercise regimen is implemented. After medical rehabilitation, levels of exercise [1, 2] and self-regulatory resources [3] typically decline. This raises the question of how one may support long-term maintenance of the achieved outcomes.

Achieving Long-term Maintenance of Behaviour Changes Beyond Treatment

A systematic review on the maintenance of behaviour changes following a physical exercise intervention revealed that physical exercise trials using follow-up prompts were most successful in achieving sustained behaviour outcomes [4]. Follow-up prompts refer to "brief contacts beyond the main part of the intervention to reinforce previous intervention content" [4, p. 601]. Telephone-based interventions may be particularly suited to deliver such an intervention booster, for targets such as physical activity [5]. In the clinical context, telephone-delivered boosters have been successfully implemented to promote abstinence rates among smokers with somatic diseases [6, 7], and exercise outcomes among pulmonary [8] and orthopedic rehabilitation patients [1]. Further evidence is lacking, however, to support the effectiveness of telephone-delivered boosters on exercise and its social-cognitive antecedents after rehabilitation treatment. In addition, the long-term effectiveness of physical exercise trials has been primarily evaluated in terms of behaviour change. However, risk of relapse might be reduced, and maintenance of the behaviour ensured, only if newly performed behaviours develop into a habit [9, 10]. In a quasi-experimental field study, we therefore investigated whether telephone-delivered follow-up boosters may provide an effective strategy for achieving maintenance of behaviour, and enhancing exercise habit strength.

Habit Formation

Within psychology, habits are understood as behaviours that have acquired a high degree of automaticity [11]. In other words, habits are enacted in response to contextual cues with little conscious deliberation or effort [12, 13]. Habits are assumed to result from a history of frequent behaviour enactment in the presence of consistent situational cues [14-16]. For example, if a rehabilitation patient repeatedly goes for a walk in the park on Tuesdays at 5.30 pm, his or her walking behaviour will become closely tied to those contextual cues (i.e., time, location). As a result, behaviour enactment may gradually fall under the control of contextual cues rather than deliberate decision-making and self-regulation [12, 13]. Essentially then, frequent behaviour enactment in stable settings is a pre-requisite for habit formation [17, 18]. In turn, continued repetition of (context-

dependent) behaviour may be supported by post-intentional, self-regulatory strategies [17] such as action planning (i.e., implementation intentions [19]), as well as self-efficacy. In the present study, we aimed at shedding further light on the post-intentional processes involved in habit formation after the transition phase from a rehabilitation setting, to patients' home-based environment. To our knowledge, this is the first long-term field study to investigate whether an experimental manipulation of self-regulatory resources may affect behaviour maintenance and long-term changes in habit strength. In particular, we investigated whether long-term changes in exercise habit strength due to the intervention booster sessions, were mediated via a path from changes in self-regulatory resources (i.e., action planning and self-efficacy) to changes in behaviour.

Self-efficacy and planning as antecedents of behaviour change and habit formation.

According to social-cognitive theory (SCT; [20]) and the health action process approach (HAPA; [21]), behaviour is at least partly determined by a person's belief in his or her ability to perform a specific action in the face of barriers [20]. Self-efficacy has been consistently identified as one important predictor of exercise [22], particularly among rehabilitation patients [23]. In terms of interventions, previous research revealed that changes in self-efficacy due to a telephone-based counseling session explained intervention effects on exercise adherence [24]. Guiding the development of behaviour change techniques, SCT additionally assumes that self-efficacy beliefs are partly influenced by mastery experiences. Research among chronically ill individuals [25, 26] suggests that exercise-related mastery experiences indeed foster self-efficacy beliefs. Therefore, in the present study we introduced an intervention component focusing on positive exercise experiences [27] to strengthen self-efficacy beliefs in rehabilitation patients. Ultimately, changes in self-efficacy may foster habit formation by increasing behaviours.

Similarly, action planning may accelerate the process of habit formation [28]. The HAPA [21] refers to action planning as a deliberate, prospective self-regulatory strategy, in which people mentally link behavioural responses with specific situations [29]. There is ample empirical support that action planning promotes exercise, particularly among patients with diabetes or those engaged in rehabilitation programs [30, 31]. Previous field studies on the working mechanisms of planning trials revealed that generating action plans as part of an intervention may promote the use of action planning in everyday life and thereby support subsequent behaviour [32-34]. Examining planning processes in more detail, the implementation intentions approach [19] assumes that making action plans may help individuals to become perceptually ready to encounter a critical situation. Upon

encountering the situational cues specified by the plan, the intended behaviour is assumed to be enacted with little need for conscious effort [35]. In other words, behaviour execution is theorized to become cued by context rather than by deliberate decision-making [35, 36]. Consequently, intended behaviour should be performed more often and thus, theoretically, gradually acquires the features of a habit [37, 38].

Aims of the Present Study

The primary goal of the study was to evaluate the effectiveness of telephone booster sessions among cardiac and orthopedic rehabilitation patients. The purpose of the booster sessions was to maintain physical exercise, self-regulatory resources and habit strength in the year after rehabilitation. The second goal of the study aimed at revealing the social-cognitive mechanisms by which the booster interventions maintained exercise and habit strength. The following hypotheses on the effectiveness of the booster sessions were tested: (1) Patients receiving the additional telephone boosters were expected to have better outcomes than patients completing a telephone survey only. In particular, we hypothesized that those patients who received the boosters would report (1a) higher levels of exercise behaviour, (1b) higher levels of exercise habit strength, (1c) higher levels of self-efficacy, and (1d) higher levels of action planning than patients in the control group. Moreover, hypotheses on the working mechanisms of the intervention boosters were tested. The first was: (2a) changes in self-efficacy and action planning account for the effect of the intervention on exercise. Finally, the effect of the intervention on changes in exercise habit strength were hypothesized to be mediated by a path from (2b) changes in action planning via changes in behaviour and by (2c) changes in self-efficacy via changes in behaviour.

Method

Participants and Procedure

Patients with the recommendation to engage in regular exercise after rehabilitation were invited to participate in an exercise program during their first week of stay in two orthopedic rehabilitation centers (one in-patient and one out-patient) and one in-patient cardiac centre. All individuals participated in the regular clinic program that comprised a complex regimen of medical, physiotherapeutic, and psychological therapies with an average duration of 21.7 days (SD = 6.4).

At the beginning of rehabilitation, eligible individuals were randomly assigned to the exercise self-regulation intervention or the control group condition by a computer algorithm. Participants were blinded to their allocation throughout the duration of the study. We refer to [27] for a

more detailed description of the methods, procedures, and short-term effects regarding the intervention during rehabilitation.

The present analyses investigated the long-term effectiveness of telephone booster sessions provided to participants in the intervention group at six weeks and six months after discharge.

In the present analyses, only those participants who had already received a follow-up questionnaire 12 months after discharge were included. Online questionnaire data from the first assessment prior to the booster sessions (T1) was available from 554 patients (137 cardiac and 417 orthopedic patients). Of those, 484 (87.36% of initial sample) completed the second assessment prior to the boosters (T2) via Computer-Assisted Telephone Interviews (CATIs) six weeks after discharge. Participants in the intervention group subsequently received the first telephone booster at T2, followed by a second booster six months after discharge. Twelve months after discharge (T3) the follow-up measurement point took place with paper-pencil questionnaires, and 299 (53.97% of initial sample) patients returned their questionnaire. The participant flow throughout the stages of the study is illustrated in Figure 1.

The mean age of the longitudinal sample was 50.2 years (*SD* = 9.1; *range* 19–76 years), and the sample consisted of slightly more women (57.2%) than men. Of all participants, 72.9% were living with a partner. Two thirds of the longitudinal sample (60.5%) reported to have at least a high school degree. Ethical approval was granted by the Ethics Commission of the German Association of Psychology (DGPs).

Experimental Conditions

Computer-assisted telephone booster sessions. The intervention boosters consisted of two computer-assisted telephone sessions six weeks and six months after rehabilitation to help orthopedic and cardiac patients maintain exercise on a regular basis after discharge. The first intervention booster comprised the following volitional components: (a) the recall of up to three positive exercise experiences during the last four weeks [27], and (b) reflection on action plan adherence. In more detail, the interviewer first repeated back to the patient their individual action plans that were generated at the end of rehabilitation. Subsequently, patients were asked to rate up to what degree (in percent) they had implemented their action plans. Finally, patients were invited to (c) formulate up to three new action plans [27]. Six months after discharge, the second intervention booster focused on the following volitional approaches: (a) the recall of up to three positive exercise experiences during the last four weeks [27], and (b) the generation of up to four action plans per day. At

the end of the second intervention booster, the interviewer summarized the generated action plans in the form of a weekly timetable (e.g., "On Monday at 7 p.m. you plan to go jogging in the park for 45 minutes"). Patients in the booster group received a printed version of this weekly timetable containing their individual action plans, along with their subsequent follow-up questionnaire (T3).

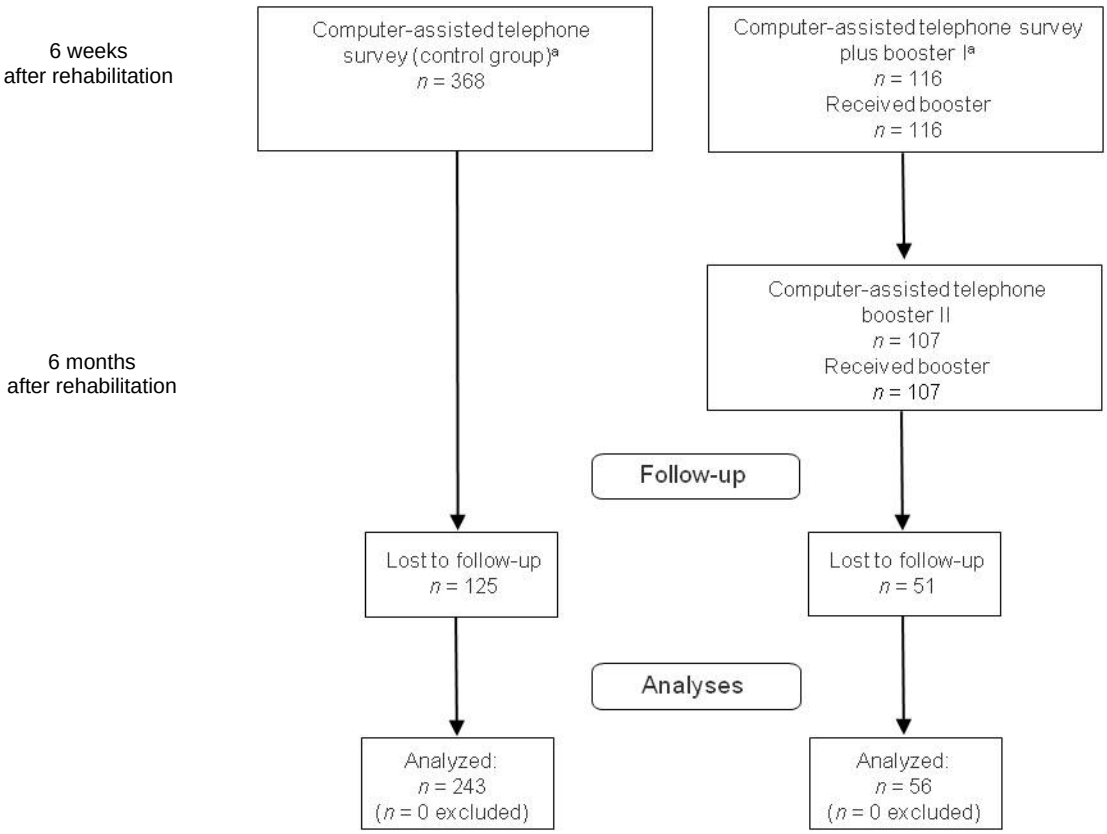

Figure 1. Flowchart of participants

Note. [a]Group membership (control vs. booster group) based on group assignment at the onset of rehabilitation.

Control group. Participants in the control group completed only a computer-assisted telephone survey six weeks after discharge.

Measures

Unless otherwise stated, response formats were six-point Likert scales, ranging from totally disagree (1) to totally agree (6). Scale scores were obtained by averaging item responses. Item examples given below are translated from German.

Behavioural outcome measures.

Physical exercise considering the *effort* of exercise was measured at T2 and T3 with a modified version of the Godin Leisure-Time Exercise Questionnaire (GLTEQ;[39, 40]). This self-report measure has been validated with physiological and anthropometric measures (i.e., VO_2 max and body fat; [39, 41]). Participants indicated how often per week and how long per session they performed strenuous exercise (fast heart rate, sweating) and moderate exercise (moderate heart rate, light sweating). Only activities outside of work duties and voluntary activities were addressed. Total exercise was the total number of sessions per week multiplied by minutes per session.

Exercise habit strength was assessed at T1 and T3 with two items adapted from [42]. Participants were asked to think about the past four weeks and their previous level of physical exercise. The items were worded: "being as physically active as I have been during the last month is something" (a) "…I do without thinking about it," (b) "...that has become a confirmed habit for me." Answers could be given on a 6-point Likert scale with the anchors "not at all" (1) to "very much" (6) (r_{T1} = .78, r_{T3} = .84).

Social-cognitive mediators.

Action planning was assessed at T2 and T3 with one item taken from [43]: "for the next month, I have already planned where, when, and how I will be physically active."

Perceived self-efficacy was assessed at T1 and T3 with one item adapted from [43]. Participants were asked to think about the past four weeks. The item was worded: "I am certain that I can be physically active on a regular basis, even if it is difficult."

Statistical Methods

Preliminary analyses and analyses of covariance (ANCOVAs) were run with SPSS 18. Manifest path analyses including the estimation of multiple indirect effects were conducted with Mplus5. Dropout analyses compared retained participants and those lost after T1 using *t*-tests for continuous measures and χ^2-tests for categorical variables. Pre-booster differences between participants in the two experimental conditions were tested by means of *t*-tests for continuous and χ^2-tests for categorical measures. Intervention effects on physical exercise and putative social-cognitive

mediators at follow-up were evaluated using ANCOVAs with the corresponding T3 variable as the dependent variable, condition (control vs. intervention) as the between-persons factor, and the corresponding pre-booster variable, gender, and patient group (cardiac vs. orthopedic) as covariates.

Multiple indirect effects were estimated to test whether the effects of the intervention boosters on changes in exercise may be explained by changes in action planning and self-efficacy (i.e., multiple mediation model). Simultaneously, additional indirect effects were estimated to test whether the effects of the intervention boosters on changes in exercise habit strength may be explained by sequential paths from action planning and self-efficacy via changes in behaviour (i.e., sequential mediation model). Changes in exercise, exercise habit strength, action planning and self-efficacy were operationalized as residualized change scores by regressing T3 scores on the corresponding pre-booster variables. Confidence intervals for indirect effects were estimated by applying the bootstrap approach (5,000 bootstrap resamples). Patient group, gender, and changes in behaviour and habit strength prior to the telephone boosters were entered as covariates. Missing data (< 10% on all variables) were imputed using the Expectation Maximization (EM) algorithm.

Results

Preliminary Results

Dropout analyses. We investigated differences on pre-booster measures between those patients who withdrew from the study versus those who remained across all measurement points. No significant differences were found in terms of gender, patient group, physical exercise, exercise habit strength, action planning, or self-efficacy. For age, a small difference was found $t(553) = 5.32$, $p = .04$, effect size $d = .15$, indicating that remaining patients were slightly older than those who dropped out, $M_{remaining} = 50.22$, $SD_{remaining} = 9.04$ vs. $M_{dropouts} = 48.74$, $SD_{dropouts} = 11.03$.

Pre-booster differences in outcome measures. Results revealed no significant differences at pre-booster measurement points across the two conditions regarding exercise habit strength, action planning, self-efficacy, and socio-demographic variables. Participants in the intervention group reported slightly higher levels of physical exercise than participants in the control group ($t(297) = 2.32$, $p = .08$, effect size $d = .13$, indicating that participants in the intervention group were slightly more active than those in the control group before the booster sessions, but after the initial rehabilitation intervention (see Table 1).

Table 1. Pre- and post-booster mean (*SD*; range) of primary outcome measures and mediators of the longitudinal sample

	Intervention condition (n = 56)		Control condition (n = 243)	
Outcomes	Pre-booster	Post-booster	Pre-booster	Post-booster
Physical exercise in minutes/week	182.33 (171.36; 0-780)[2]	150.92 (129.28; 0-540)	161.28 (139.13; 0-780)[2]	81.20 (103.39; 0-660)
Exercise habit strength	4.53 (1.53; 1-6)[1]	3.79 (1.75; 1-6)	4.56 (1.30; 1-6)[1]	3.24 (1.80; 1-6)
Action planning	4.25 (1.64; 1-6)[2]	4.10 (1.54; 1-6)	4.41 (1.50; 1-6)[2]	3.83 (1.74; 1-6)
Self-efficacy	4.84 (1.08; 1-6)[1]	4.90 (1.06; 1-6)	4.68 (1.31; 1-6)[1]	4.33 (1.52; 1-6)

Note. [1]Outcomes were measured at first assessment prior to booster (T1); [2]Outcomes were measured at second assessment prior to booster (T2); Post-booster assessments took place 12 months after discharge from rehabilitation.

Intervention Effects on Behavioural Outcomes

Intervention effects on physical exercise.

An ANCOVA identified intervention effects on physical exercise as a function of intervention condition, $p < .001$, partial $\eta^2 = .05$ (see Figure 2). T3 physical exercise was additionally dependent on pre-booster levels of exercise behaviour, $p < .001$, but not on patient group, $p = .58$ and gender, $p = .69$. As depicted in Figure 2, the intervention boosters led to a smaller decline in behaviour than the telephone survey only.

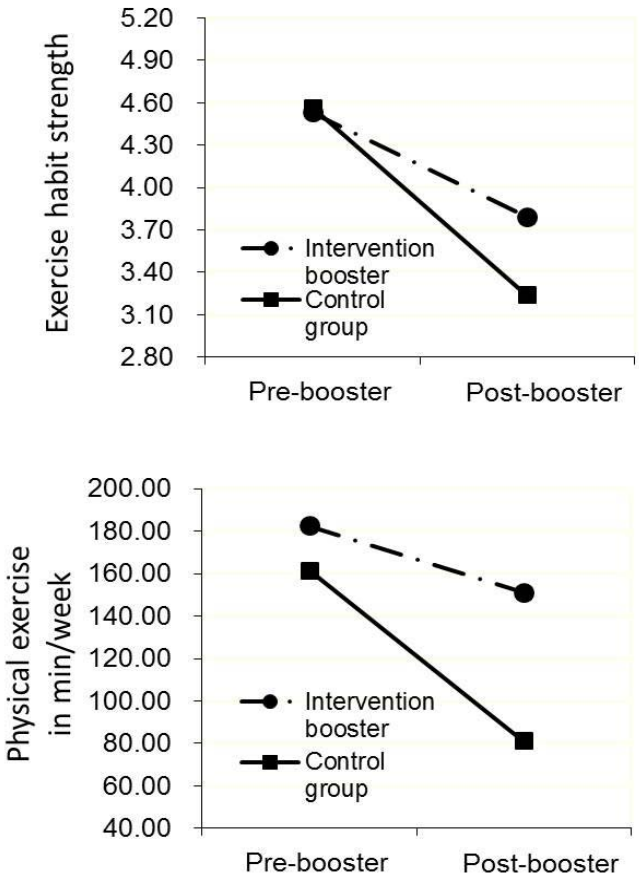

Figure 2. The intervention booster buffers declines in behaviour and exercise habit strength

Intervention effects on exercise habit strength.

Differences between the conditions were found regarding exercise habit strength ($p < .01$, partial $\eta^2 = 0.02$; see Table 1). T3 exercise habit strength was additionally influenced by habit strength T1, $p < .001$, but not by patient group, $p = .15$, and gender, $p = .93$. Figure 2 illustrates that

the intervention boosters led to less decline in exercise habit strength than the telephone survey only.

Intervention effects on self-regulatory resources.

At follow-up, individuals in the intervention booster group reported higher levels of self-efficacy ($p < .01$, partial $\eta^2 = 0.03$) and higher levels of action planning ($p < .001$, partial $\eta^2 = 0.04$) as compared to individuals in the control group (see Table 1 and Figure 3). T3 self-efficacy was additionally determined by the according pre-booster variable, $p = .72$, but not by patient group and gender $p = .69$. T3 action planning was influenced by the corresponding baseline variable, $p < .001$, but not by patient group, $p = .89$, and gender, $p = .74$. As shown in Figure 3, the intervention boosters led to a smaller decline in self-efficacy and action planning than the control group that had received the telephone survey only.

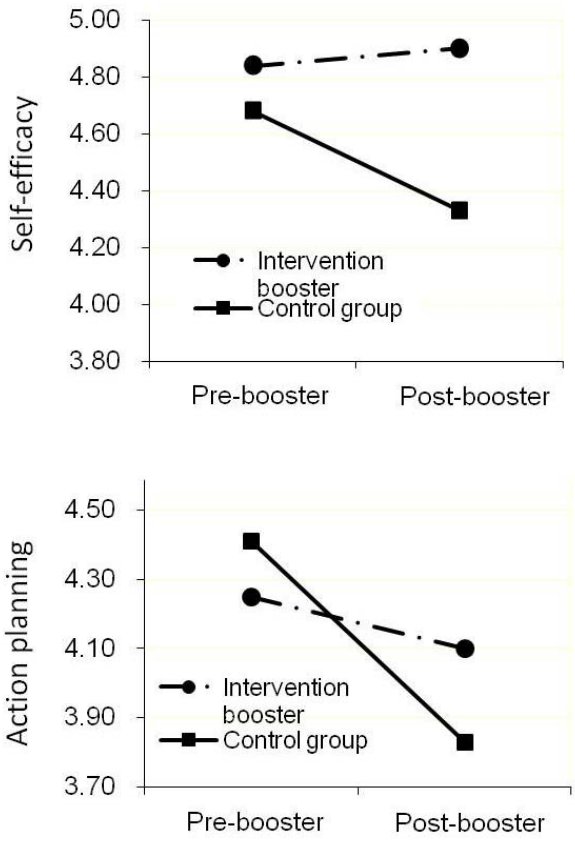

Figure 3. The intervention booster buffers declines in self-efficacy and action planning

Working Mechanism of Intervention Boosters

Exercise as the primary outcome variable (multiple mediation analyses).

Group assignment significantly predicted changes in action planning and in self-efficacy (see Figure 4). Both variables were also significantly associated with changes in exercise. The total effect of the intervention on physical exercise was lowered when the variables were entered, indicating partial mediation. Self-efficacy and action planning had significant indirect effects (see Table 2). Of all covariates, only changes in habit strength prior to the telephone boosters predicted positive changes in behaviour.

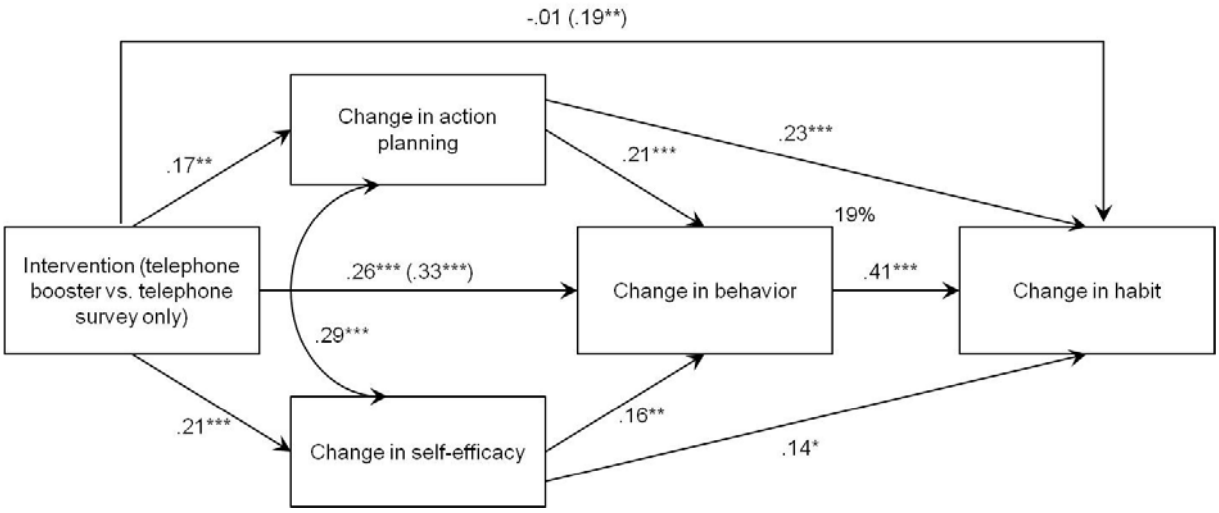

Figure 4. Path model (control group vs. intervention booster group) with exercise as primary and habit strength as secondary outcome ($N = 299$)

Note. *p <.05; **p <.01.; ***p<.001. Control variables were gender, patient group (cardiac vs. orthopedic), changes in habit strength and behaviour prior to the telephone booster.

Exercise habit strength as the secondary outcome variable (sequential mediation analyses). Group assignment significantly predicted changes in exercise habit strength (see Figure 4). Changes in behaviour, changes in self-efficacy, and changes in action planning were significantly associated with changes in exercise habit strength. After controlling for self-efficacy, action planning, and behaviour, the relation between the experimental group membership and habit strength was lowered. Of both sequential indirect effects, only the indirect effect from the intervention through action planning and exercise on habit strength reached the level of significance.

Table 2. Summary of Results for Estimation of Indirect Effects

model	independent variable (IV)	dependent variable (DV)	mediating variables (M1)	mediating variables (M2)	specific indirect effects	lower BC 95% CI for	higher BC 95% CI for
multiple mediation model	intervention group	physical exercise	action planning	-	0.04**	0.02	0.08
			self-efficacy	-	0.03*	0.01	0.09
sequential mediation model	intervention group	habit strength	action planning	physical exercise	0.02*	0.01	0.05
			self-efficacy		0.01†	0.00	0.04
	intervention group	habit strength	physical exercise	-	.11**	0.03	0.19
	intervention group	habit strength	action planning	-	.04*	0.02	0.06
	intervention group	habit strength	self-efficacy	-	.03*	0.01	0.05

Note. Reported are standardised path coefficients; n = 299; †p<.10; *p<.05; **p < .01; *** p <.001; BC = bias corrected, CI = bootstrapping confidence interval.

In addition, the specific indirect effects of the intervention on exercise habit strength via a) self-efficacy and b) action planning were significant (see Table 2).

Changes in exercise habit strength, prior to the boosters, negatively predicted changes in habit strength, whereas other covariates were not associated with exercise habit strength.

Discussion

Transferring exercise routines from a supervised clinical setting to a self-directed leisure-time context poses a major challenge for rehabilitation patients. In the present study, we therefore introduced telephone-delivered boosters to prevent the often observed long-term declines in self-regulatory resources [3], and relapse to sedentary behaviours [1, 2]. The second aim of the study was to evaluate the intervention in terms of habit strength as a secondary behavioural outcome. Drawing upon the framework of behavioural habits [12, 14, 38] and the HAPA model [21], the study aimed to reveal theory-based mechanisms of habit formation in a post-rehabilitation context.

Telephone-delivered Boosters Help Maintain Action Planning, Self-efficacy and Exercise

As hypothesized, the telephone-delivered booster sessions were effective in producing changes in exercise and its social-cognitive determinants at long-term follow-up. As expected, the untreated control group relapsed much more than the experimental group. In line with previous research, rehabilitation patients in the intervention group were more likely to maintain levels of self-efficacy, action planning [1] and physical exercise [3].This is an important finding, as it shows that introducing action plans as part of an intervention is an effective tool to increase the use of action planning in everyday life [33, 34]

Besides action planning, self-efficacy was successfully targeted in the present intervention boosters. Patients were encouraged to reflect on their positive exercise experiences. This behaviour change technique may not only be successful in increasing individuals' perceptions of satisfaction with exercise [31], but also as our results suggest, help maintain perceived levels of exercise self-efficacy. Positive exercise experiences may be interpreted as mastery experiences, which are assumed to be the major source of perceived self-efficacy [20]. Adding to previous observational studies [25, 26], our results show that an experimental manipulation of positive exercise experiences successfully promotes long-term maintenance of self-efficacy beliefs.

Changes in action planning and self-efficacy mediate the effect of intervention boosters on changes in exercise.

In theory-based interventions for long-term behaviour change, there is a need to not only to investigate the effects of the intervention on the underlying constructs, but also the mediating role of such constructs [44]. We therefore looked at whether long-term changes in behaviour were explained by changes in self-regulatory resources. In line with previous research, changes in action planning [32-34] and changes in self-efficacy [24] were identified as mediating mechanisms between the intervention and changes in exercise. Taken together, this suggests that computer-assisted telephone interviews may be a suitable delivery method to successfully boost self-efficacy beliefs and action planning, and to promote long-term exercise changes in rehabilitation patients.

Habit Formation: Working Mechanism of Intervention

Our analyses were novel in that we manipulated theory-based self-regulatory strategies and evaluated their effects on changes in habit strength. By introducing habit strength, we had a psychologically more relevant indicator of behaviour maintenance than behaviour per se. To our knowledge, only one previous trial on dental hygiene was evaluated in terms of changes in habit strength [38]. In line with our results in the exercise domain, Orbell and Verplanken [38] revealed that only those individuals who planned where and when to floss their teeth reported higher levels of behaviour and habit strength at short-term follow-up. However, the authors did not explicitly examine any mediating mechanism of habit formation. The present study therefore aimed at closing this gap. To analyze theory-driven mechanisms of long-term habit formation, a path analysis was performed with self-regulatory resources (i.e., action planning and self-efficacy) and exercise specified as sequential mediators between experimental condition (booster vs. no booster) and exercise habit strength. Results were partly in line with the hypotheses. Changes in habit strength due to the intervention were explained by a path from changes in action planning (but not self-efficacy) to changes in behaviour. First, the strong link between changes in behaviour and changes in habit strength supports the notion that frequent exercise enactment facilitates habit formation [17]. Although the path coefficient in our model reflected associations between change scores, the strength of the association between behaviour and habit (β=.43) was comparable to the average weighted correlation (r_+= .44) reported by a recent meta-analyses [15].These data can be well integrated with results from a previous longitudinal field study analyzing intra-individual changes in habit strength [16]. In this study, the authors found the following consistent intra-individual pattern: the more

frequently a behaviour was performed in response to stable context cues, the more it acquired features of a habit (i.e., automaticity; [16]). Second, the present findings add to the notion that habit formation may be promoted by self-regulatory strategies [17] such as action planning, which in turn promotes behaviour enactment. Some additional hints for this assumption can be found in the longitudinal field study by Lally, van Jaarsveld, Potts, and Wardle [16]. Authors initially asked students to choose from three different health behaviours which they (a) intended to do, and (b) could perform in response to a daily reoccurring, salient cue. It could be argued that initial instructions (i.e., choosing a goal behaviour, identification of critical cue) may have encouraged participants to form spontaneous action plans. The observed increase in habit strength may, therefore, not only be attributed to behaviour changes, but also to preceding action plans.

Although self-efficacy has been shown to facilitate habituation of taking medication among asthma patients [45], when tested simultaneously with action planning, its influence on habit strength via behaviour diminished. Overall, our results suggest that the use of action planning is the main indicator that may increase behaviour, which in turn facilitates habituation.

Limitations and Outlook

There are several important limitations to this work. Behaviour was measured with self-reports on the Godin scale [39] could have led to over- or underreporting. Second, the Godin scale assesses exercise without considering the context in which it is performed (e.g., in the gym after work). From simply looking at associations between action planning and behaviour, we cannot draw any final conclusions about whether individuals actually exercised in response to cues as specified by their action plans. Behaviour as assessed by the Godin scale may be understood as an unconditional measure of planning effects [46], and can only function as a proxy for whether individuals adhered to their plans (i.e., planning adherence/fidelity). Measuring the degree to which individuals adhere to their action plans, or the degree to which they modify parts of their plans (i.e., planning flexibility), and how this affects healthy habit formation, opens up new avenues for research. Furthermore, frequent and context-stable behaviour enactment may not be sufficient for habit formation [17]. Whether or not individuals are satisfied with their achieved outcomes (e.g., having less pain as a result of exercising) may also determine whether or not they maintain exercise, [9, 31] and ultimately develop health habits [17]. Thirdly, we relied on only two items to operationalize exercise habit strength. Future studies may include additional items of the self-report habit index (SRHI; [42]) to capture additional facets of habit strength (e.g., lack of intentionality,

controllability, efficiency). Since habits are conceptualized as behaviours that are cued in consistent settings, it may be also fruitful to consider this in future assessments of the construct [18]. Fourthly, selective drop-outs limit the generalizability of results to a slightly older population of rehabilitation patients. Further research is needed to replicate findings in other patient groups (e.g., psychosomatic patients) and nonclinical samples. In addition, our results are limited to the exercise domain. An avenue for future research is to further investigate processes of habituation in less complex health behaviours such as seatbelt use, and to examine how habituation in one health behaviour may promote behaviour change in another [27]. Finally, strengths of this study include the assessment of social-cognitive and behavioural measures following a six-month period of no intervention contact (i.e., after the second telephone booster six months after rehabilitation). However, to have an optimal temporal order of mediators to justify conclusions, changes of social-cognitions, behaviour and habit strength should be measured at distant points in time [47]. Although causal relations cannot be determined from the present analyses, the findings suggest that focusing on action plans and self-efficacy may promote the maintenance of behaviour, and thereby facilitate exercise habit formation among rehabilitation patients.

Conclusions

The development of theory- and evidence-based intervention boosters to assist individuals in sustaining exercise changes remains a challenge for secondary prevention. Telephone-delivered booster calls may provide an effective alternative to achieving maintenance of rehabilitation outcomes. In terms of intervention strategies, action plans and reflection on exercise experiences may provide promising tools in maintaining behaviour change by enhancing the use of action planning and self-efficacy. Use of action planning in particular may promote exercise maintenance, and thereby accelerate habit formation. Incorporating habit strength into behaviour change models, as well as intervention practice (e.g., as an intervention outcome), improves the understanding of the mechanisms involved in long-term behaviour change.

Acknowledgements

This work has been funded by the Deutsche Rentenversicherung Bund (DRV; German Pension Insurance) within the project FABA (Project ID 8011 - 106 - 31/31.91). The authors would like to thank the rehabilitation clinics and their patients for participating in this study. We especial-

ly appreciate the support of Mrs. Pimmer, Dr. Kiwus, Dr. Glatz, Dr. Milse, and Dr. Johnigk. None of the authors have any conflicting interests.

References

1. Fuchs R, Göhner W, Seelig H. Long-term effects of a psychological group intervention on physical exercise and health: The MoVo concept. J Phys Act Health. 2011; 8: 794-803.
2. Reuter T, Ziegelmann JP, Lippke S, Schwarzer R. Long-term relations between intentions, planning, and exercise: A 3-year longitudinal study after orthopedic rehabilitation. Rehabil. Psychol. 2009; 54: 363-371.
3. Göhner W, Seelig H, Fuchs R. Intervention effects on cognitive antecedents of physical exercise: A 1-year follow-up study. Appl. Psychol. Health Wellbeing. 2009; 1: 233-256.
4. Fjeldsoe B, Neuhaus M, Winkler E, Eakin E. Systematic review of maintenance of behaviour change following physical activity and dietary interventions. Health Psychol. 2011; 30: 99-109.
5. Eakin EG, Lawler SP, Vandelanotte C, Owen N. Telephone Interventions for Physical Activity and Dietary Behaviour Change: A Systematic Review. Am J Prev Med. 2007; 32: 419-434.
6. Metz K, Flöter S, Kröger C, et al. Telephone booster sessions for optimizing smoking cessation for patients in rehabilitation centers. Nicotine Tob Res. 2007; 9: 853-863.
7. Rigotti NA, Munafo MR, Stead LF. Smoking cessation interventions for hospitalized smokers: a systematic review. Arch Intern Med. 2008; 168: 1950-2002.
8. Ries AL, Kaplan RM, Myers R, Prewitt LM. Maintenance after pulmonary rehabilitation in chronic lung disease: A randomized trial. Am J Respir Crit Care Med. 2002: 200204318.
9. Rothman A, Sheeran P, Wood W. Reflective and Automatic Processes in the Initiation and Maintenance of Dietary Change. Ann Behav Med. 2009; 38: 4-17.
10. Verplanken B, Wood W. Interventions to break and create consumer habits. J Public Policy Mark. 2006; 25: 90-103.
11. Bargh JA. The four horsemen of automaticity: Awareness, intention, efficiency, and control in social cognition. In: Wyer RS, Srull TK, eds. Handbook of social cognition. Vol. 1. Hillsdale, NJ: Lawrence Erlbaum, 1996, 1-40.
12. Verplanken B, Melkevik O. Predicting habit: The case of physical exercise. Psychol. Sport Exerc. 2008; 9: 15-26.
13. Wood W, Neal DT. A new look at habits and the habit-goal interface. Psychol Rev. 2007; 114: 843-863.
14. Aarts H, Paulussen T, Schaalma H. Physical exercise habit: On the conceptualization and formation of habitual health behaviours. Health Educ Res. 1997; 12: 363-374.
15. Gardner B, de Bruijn G-J, Lally P. A systematic review and meta-analysis of applications of the self-report habit index to nutrition and physical activity behaviours. Ann Behav Med. 2011: 1-14.
16. Lally P, van Jaarsveld CHM, Potts HWW, Wardle J. How are habits formed: Modelling habit formation in the real world. Europ. J. Social Psychol. 2010; 40: 998-1009.
17. Lally P, Gardner B. Promoting habit formation. Health Psychol. Rev. 2011: 1-22.
18. Sniehotta FF, Presseau J. The habitual use of the self-report habit index. Ann Behav Med. 2011: 1-2.

19. Gollwitzer PM. Implementation intentions: strong effects of simple plans. Am Psychol. 1999; 54: 493-503.
20. Bandura A. Self-efficacy: The exercise of control. New York: Freeman; 1997.
21. Schwarzer R, Lippke S, Luszczynska A. Mechanisms of health behaviour change in persons with chronic illness or disability: The Health Action Process Approach (HAPA). Rehabil. Psychol. 2011; 56: 161-170.
22. McAuley E, Blissmer B. Self-efficacy determinants and consequences of physical activity. Exerc Sport Sci Rev. 2000; 28: 85-88.
23. Woodgate J, Brawley LR. Self-efficacy for exercise in cardiac rehabilitation. J Health Psychol. 2008; 13: 366-387.
24. Brassington GS, Atienza AA, Perczek RE, DiLorenzo TM, King AC. Intervention-related cognitive versus social mediators of exercise adherence in the elderly. Am J Prev Med. 2002; 23: 80-86.
25. Warner LM, Schüz B, Knittle K, Ziegelmann JP, Wurm S. Sources of perceived self-efficacy as predictors of physical activity in older adults. Appl. Psychol. Health Wellbeing. 2011; 3: 172–192.
26. Scholz U, Sniehotta FF, Schüz B, Oeberst A. Dynamics in self-regulation: Plan execution self-efficacy and mastery of action plans. J. Appl. Soc. Psychol. 2007; 37: 2706-2725.
27. Fleig L, Lippke S, Pomp S, Schwarzer R. Intervention effects of exercise self-regulation on physical exercise and eating fruits and vegetables: A longitudinal study in orthopedic and cardiac rehabilitation. Prev Med. 2011; 53: 182-187.
28. Verplanken B, Faes S. Good intentions, bad habits, and effects of forming implementation intentions on healthy eating. Europ. J. Social Psychol. 1999; 29: 591-604.
29. Sheeran P, Orbell S. Implementation intentions and repeated behaviour: Augmenting the predictive validity of the theory of planned behaviour. Europ. J. Social Psychol. 1999; 29: 349-369.
30. Bélanger-Gravel A, Godin G, Amireault S. A meta-analytic review of the effect of implementation intentions on physical activity. Health Psychol. Rev. 2011: 1-32.
31. Fleig L, Lippke S, Pomp S, Schwarzer R. Exercise maintenance after rehabilitation: How experience can make a difference. Psychol. Sport Exerc. 2011; 12: 293-299.
32. Lippke S, Schwarzer R, Ziegelmann JP, Scholz U, Schüz B. Testing stage-specific effects of a stage-matched intervention: a randomized controlled trial targeting physical exercise and its predictors. Health Educ Behav. 2010; 37: 533-546.
33. Luszczynska A. An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. Soc Sci Med. 2006; 62: 900-908.
34. Wiedemann AU, Lippke S, Reuter T, Ziegelmann JP, Schwarzer R. How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. Europ. J. Social Psychol. 2011; 41: 42-51.
35. Gollwitzer PM, Sheeran P. Implementation intentions and goal achievement: A meta-analysis of effects and processes. Adv Exp Soc Psychol. 2006; 38: 69-119.
36. Webb TL, Sheeran P. How do implementation intentions promote goal attainment? A test of component processes. J Exp Soc Psychol. 2007; 43: 295-302.
37. Gollwitzer PM, Brandstätter V. Implementation intentions and effective goal pursuit. J Pers Soc Psychol.1997; 73: 186-199.
38. Orbell S, Verplanken B. The automatic component of habit in health behaviour: Habit as cue-contingent automaticity. Health Psychol. 2010; 29: 374-383.

39. Godin G, Shephard RJ. A simple method to assess exercise behaviour in the community. Can. J. Appl. Sport Sci. 1985; 10: 141-146.
40. Plotnikoff RC, Lippke S, Reinbold-Matthews M, et al. Assessing the validity of a stage measure on physical activity in a population-based sample of individuals with type 1 or type 2 diabetes. Meas. Phys. Educ. Exerc. Sci. 2007; 11: 73-91.
41. Jacobs Jr DR, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med Sci Sports Exerc. 1993; 25: 81-91.
42. Verplanken B, Orbell S. Reflections on past behaviour: A self-report index of habit strength. J. Appl. Soc. Psychol. 2003; 33: 1313-1330.
43. Schwarzer R, Schüz B, Ziegelmann JP, et al. Adoption and maintenance of four health behaviours: Theory-guided longitudinal studies on dental flossing, seat belt use, dietary behaviour, and physical activity. Ann Behav Med. 2007; 33: 156-166.
44. Lewis BA, Marcus BH, Pate RR, Dunn AL. Psychosocial mediators of physical activity behaviour among adults and children. Am J Prev Med. 2002; 23: 26-35.
45. Bolman C, Arwert TG, Völink T. Adherence to prophylactic asthma medication: Habit strength and cognitions. Heart Lung. 2011; 40: 63-75.
46. Sniehotta FF. Towards a theory of intentional behaviour change: Plans, planning, and self-regulation. Brit. J. Health Psychol. 2009; 14: 261-273.
47. Weinstein ND. Misleading tests of health behaviour theories. Ann Behav Med. 2007; 33: 1-10.

6

General Discussion

General Discussion

Humans are generally thought of as creatures of habit. For many individuals, behaviours such as brushing one's teeth, wearing a seat-belt, or washing one's hands, have become routine to the point that they can be performed with little conscious effort (Ajzen, 2002). There is evidence that even complex preventive health behaviours, such as physical exercise (Lally, van Jaarsveld, Potts, & Wardle, 2010; Rhodes, De Bruijn, & Matheson, 2010) and healthy nutrition (Riet, Sijtsema, Dagevos, & De Bruijn, 2011) can become habituated, even though they are initially guided by goal intentions and deliberate self-regulation. Once a health behaviour has become habitual, risk of relapse might be reduced (Orbell & Verplanken, 2010; Study 2), and long-term maintenance of the behaviour (Rothman, Sheeran, & Wood, 2009; Verplanken & Wood, 2006) may be ensured. Moreover, habit development in one health behaviour may facilitate engagement in other health behaviours. The formation of healthy habits, therefore, is a desired goal of behavior change interventions (Lally & Gardner, 2011; Verplanken, 2010) aiming at the management and prevention of chronic diseases.

Health behaviour change interventions usually draw on theories of behaviour change which describe psychological determinants of health behaviour motivation and behaviour initiation (e.g., *social cognitive theory,* SCT; Bandura, 1997; *health action process approach*, HAPA; Schwarzer, 2008; Schwarzer, Lippke, & Luszczynska, 2011). To support individuals to maintain a healthy lifestyle, there is a need to extend previous approaches. Firstly, investigating psychological processes that come into play after behaviour initiation, such as behaviour outcome evaluations and satisfaction (Rothman, 2000; Rothman, Baldwin, & Hertel, 2004; Rothman et al., 2009) can inform interventions aiming at behavior maintenance. Secondly, behaviour maintenance implies "modulation […] via *deliberate* or *automated* use of specific mechanisms (Karoly, 1993, p. 25)". Habit strength is one promising theoretical construct to capture the relatively automatic nature of health behaviour (Verplanken, 2010) and can serve as an indicator for the sustainability of behavior changes following an intervention. Thirdly, describing and promoting the engagement in more than one health behaviour may call other concepts on the agenda than those relevant for single health behaviour change (Morabia & Costanza, 2010; Prochaska, Spring, & Nigg, 2008; Spring, Moller, & Coons, 2012).

The primary goal of this thesis was therefore to advance research on the prediction and promotion of single health behaviour maintenance, including deliberate and habitual processes. The

second aim of this thesis was to unveil theory-based mechanisms through which inviduals succeed in engaging in more than one health behavior (i.e., cross-behavior regulation). Firstly, the theory-driven relationships between behaviour outcome evaluations, action planning and behaviour maintenance were tested in a medical rehabilitation context (*Chapter 2*). Secondly, the effectiveness of an experience-based and self-regulation intervention was examined. An emphasis was placed on identifying the social-cognitive "ingredients" of the intervention that actively contributed to maintaining repeated behaviour engagement beyond rehabilitation treatment (*Chapter 3, part one*). Next, theoretically predicted relations (*Chapter 4, part two*) between intentions, action planning, behaviour repetition, and habituation were modeled among university students (i.e., primary prevention, *Chapter 4, part one*) and rehabilitation patients (i.e., secondary prevention, *Chapter 4, part two*). Fourthly, the effectiveness and working mechanisms of follow-up booster sessions in promoting exercise habit formation were examined in a post-rehabilitation field setting (*Chapter 5*). Finally, shifting from a single to a multiple health behaviour perspective, the effects of an exercise self-regulation intervention on healthy nutrition were investigated, and explanatory factors for such a transfer effect (Lippke, Nigg, & Maddock, 2012; Nigg, Lee, Hubbard, & Min-Sun, 2009) were tested in a clinical context (*Chapter 3 , part two*).

The following discussion is directed by the research questions presented in *Chapter 1*. Empirical results on the processes of behavior maintenance (part one) will be summarized and discussed by integrating findings into a framework of deliberate and habitual processes of health behaviour change. Thereafter, findings regarding the mechanisms of changing more than one health behavior (part two) will be interpreted. Finally, based on the findings of *Chapter 2* to *5*, directions for future research are suggested: methodological, theoretical, and practical implications are discussed to further theory, and to contribute to the design and evaluation of theory- and evidence-based health behaviour interventions. Table 1 provides a summary of the major findings of this study (part three).

Health Behaviour Maintenance: From Deliberate to Habitual Behavior Regulation

What Role Do Self-regulatory Strategies Play in the Prediction and Promotion of Repeated Behavior Engagement?

Whereas the formulation of action plans refers to a prospective self-regulatory strategy by which situational cues (when and where to act) are linked to specific behavioural responses (how to

Table 1. Summary of the Findings and Conclusions of this Thesis

Chapter	Aims & Hypotheses	Findings	Conclusions
2	Test for possible mediators that explain *how* exercise experiences during rehabilitation influence subsequent self-directed exercise	Action planning and satisfaction mediated the effects of experiences on subsequent exercise	Subjective evaluations of behaviour outcomes and self-regulatory strategies (action planning) additively contribute to behavior maintenance
	Hypothesized multiple mediatiors: action planning and satisfaction		Both constructs can serve as a starting point of interventions
3.1	Examine effects and working mechanisms of a computer-based self-regulation intervention targeting exercise after rehabilitation	Intervention effects on exercise were mediated by changes in satisfaction, and action control, but not action planning	Interventions combining experience-based and self-regulatory strategies contribute to sustained exercise outcomes
	Hypothesized multiple mediatiors: action planning, action control, and satisfaction		Standard rehabilitation can be optimized if psychological interventions are integrated
3.2	Analyze whether and how an exercise intervention promotes fruit and vegetable intake (FVI)	Effect of exercise intervention on FVI was mediated by change in exercise habit strength	A single health behavior intervention can facilitate other preventive health behaviors
	Hypothesized mediatior: exercise habit strength		By developing exercise habits, individuals may be more likely to apply previously utilized strategies to other behaviours (i.e., transfer effect)
4	Examine how exercise intentions direct habit formation in primary (*Study 1*) and secondary prevention settings (*Study 2*)	Similar prediction patterns across university students and rehabilitation patients: action planning and exercise operated as sequential mediators to bridge the gap between intentions and habit strength	Goal intentions direct exercise habit formation by increasing use of action planning, which, in turn, promotes behaviour repetition
	Hypyothesized sequential mediatiors: action planning, exercise		Including these constructs jointly into behaviour change models improves the understanding of the mechanisms involved in habit formation
5	Analyze *whether* and *how* telephone-delivered intervention booster sessions after rehabilitation affect exercise and exercise habit strength	Booster sessions prevented a decline in action planning, self-efficacy, exercise, and exercise habit strength	Telephone-delivered booster sessions can provide an effective alternative to achieving long-term maintenance of initial intervention effects
	Hypothesized multiple mediators (intervention effects on exercise): self-efficacy, action planning	Intervention-induced changes in exercise were mediated *simultaneously* by changes in action planning and self-efficacy	Habit strength serves as an indicator for the sustainability of behavior changes
	Hypothesized sequential mediators (intervention effects on habit strength): self-efficacy/action planning, exercise	Intervention-induced changes in exercise habit strength were *sequentially* mediated by action planning and exercise	Use of action planning in particular promotes exercise repetition, and thereby accelerates habit formation

act) (Gollwitzer & Sheeran, 2006; Leventhal, Singer, & Jones, 1965; Sniehotta, Schwarzer, Scholz, & Schüz, 2005), action control refers to an in situ self-regulation strategy that becomes relevant during behaviour enactment (Sniehotta, Scholz, & Schwarzer, 2005; Sniehotta, Scholz, Schwarzer, 2006). In more detail, action control comprises three strategies: being aware of one's goals, monitoring one's behavior, and investment of self-regulatory effort when behavior diverts from previously set goals (Sniehotta, Scholz, & Schwarzer, 2005; Sniehotta et al., 2006). To date, action control and action planning are among those volitional self-regulation variables that have been systematically and most commonly examined in relation to health behavior theories. Both the *health action process approach* (HAPA; Schwarzer, 2008; Schwarzer et al., 2011) and the *motivation volition model* (MoVo; Fuchs, Göhner, & Seelig, 2011; Göhner, Seelig, & Fuchs, 2009) assume that action control (i.e., volitional intention shielding, Fuchs et al., 2011) and action planning are proximal determinants of health behaviour initiation (see Table 1, *Chapter 1*). The HAPA (Schwarzer, 2008; Schwarzer et al., 2011), however, goes one step further than the MoVo (Fuchs et al., 2011; Göhner et al., 2009) and other models, as it integrates a phase of behaviour maintenance. According to the HAPA, processes of behavior maintenance are assumed to be guided by the same self-regulatory strategies (action planning, action control) as those relevant to behaviour initiation (Schwarzer, 2008; Schwarzer et al., 2011). In this thesis, evidence for these assumptions can be taken from observational (action planning; *Chapter 2, 4*) and experimental findings (action control, *Chapter 3, part one;* action planning, *Chapter 5*). Self-reported use of action planning measured at the end of medical rehabilitation was revealed to predict subsequent changes in self-directed exercise six weeks (*Chapter 2*), as well as and 12 months after discharge (*Chapter 4, part two*). This integrates well with previous observational studies in rehabilitation settings (e.g., Lippke, Ziegelmann, & Schwarzer, 2004a; Sniehotta et al., 2006).

Similar to prior studies in the primary prevention context (Conner, Sandberg, & Norman, 2011; Koring et al., 2011), *Chapter 4 (part one)* demonstrated that action planning was positively associated with frequency of behaviour engagement among university students.

Are Exercise Interventions that Target Self-Regulatory Strategies Effective in Promoting Repeated Behaviour Engagement?

In *Chapter 3 (part one)*, self-reported use of *action planning* and *action control* were measured before and after an experimental manipulation. In the *action plan component* of the intervention, participants were asked to generate up to three post-rehabilitation action plans, specifying

where and when they would perform a specific exercise (i.e., generation of action plans, Michie, Ashford, et al., 2011). *Action control* was addressed with a paper-pencil self-help diary which individuals received upon discharge from rehabilitation to monitor their behaviour in the first six weeks after treatment (i.e., self-monitoring, Michie, Ashford, et al., 2011). In contrast to the in the intervention described in *Chapter 3*, in *Chapter 5* a tailored approach (Noar, Benac, & Harris, 2007) was applied to promote an ongoing use of action planning skills. In more detail, participants were first reminded of their previously generated individual action plans, and were encouraged to rate as to what degree they had managed to realize their action plans. Individuals then had the opportunity to review their action plans in terms of how practical, suitable, and effective they were. Based on these evaluations, individuals finally had the opportunity to change parts of their previous action plans (e.g., time, location), or to generate completely new ones. In line with previous research in the clinical context (e.g., Fuchs et al., 2011; Lippke, Ziegelmann, & Schwarzer, 2004b; Sniehotta, Scholz, Schwarzer, Fuhrmann, et al., 2005), both interventions resulted in an increase in post-rehabilitation exercise when tested in a quasi-experimental design against an active control condition (i.e., standard rehabilitation treatment, *Chapter 3, part one*) and a passive control condition (*Chapter 5*).

Why are the Interventions Effective?

Though theory (i.e., HAPA; Schwarzer, 2008; Schwarzer et al., 2011) and experimental research indicates that both action planning strategies (Chapman & Armitage, 2010; Luszczynska, Scholz, & Sutton, 2007; Stadler, Oettingen, & Gollwitzer, 2010) and action control (Sniehotta, Scholz, Schwarzer, Fuhrmann, et al., 2005; Scholz & Sniehotta, 2006) are key facilitators of behaviour maintenance, results of *Chapter 3* revealed a different pattern. Among the two targeted self-regulatory strategies, only changes in action control contributed to the interventions' success (*Chapter 3, part one*). The failure to reveal intervention effects on planning may be interpreted against the background of the study design. Both, participants in the intervention group and the control group received standard rehabilitation treatment (Pfeifer, Sudeck, Brüggemann, & Huber, 2010). Action planning was also addressed in the standard rehabilitation treatment, although not as structured as in the intervention group. That is, during rehabilitation patients occasionally talked to their physicians and/or physiotherapists about where and how they would continue exercising after discharge from rehabilitation. Thus, the way action planning was targeted in the intervention may have not been sufficient to produce effects that go beyond those of the standard rehabilitation

treatment (Sniehotta, Scholz, Schwarzer, Fuhrmann, et al., 2005). This is underlined by the finding that individuals in the intervention, as well as in the active control group showed an increase in their use of action planning (*Chapter 3, part one)*.

Whereas effects of the intervention during rehabilitation (*Chapter 3, part one*) were tested against an active control group (i.e., standard rehabilitation treatment), intervention effects reported in *Chapter 5* were evaluated against a group of patients that responded to a telephone-delivered questionnaire only (i.e., passive control group). As individuals were discharged from rehabilitation, only those in the intervention group were further supported by two sequential telephone-delivered counselling sessions. These follow-up intervention booster repeatedly promoted the adaption and use of action planning which has been shown to be effective in smoking cessation (Conner & Higgins, 2010) and healthy dietary change (Chapman & Armitage, 2010). Contrary to the findings of *Chapter 3 (part one)*, *Chapter 5* demonstrated that changes in action planning as a result of telephone-delivered interventions are conductive to maintaining exercise. Taking into account the applied behaviour change techniques, one might argue that the focus on reviewing and modifying previous plans (*Chapter 5*), rather than generating completely new plans (*Chapter 3, part one*), may have accounted for the different findings. A second potential explanation may relate to the fact that, unlike in *Chapter 3 (part one)*, content, duration and context of the intervention group diverged from that of the control group: individuals in the control group did not receive any standard post-rehabilitation support except the follow-up questionnaire (i.e., passive control group).

Overall then, when structured exercise programs, such as exercise-based rehabilitation treatments, are completed, individuals have to rely heavily upon self-regulatory strategies to maintain their own self-directed, home-based exercise program (McAuley, Lox, & Duncan, 1993). Results from this thesis suggest that action control contributes to successfully mastering this challenge. Whereas observational results clearly support the use of action planning in behaviour maintenance, current experimental findings only tentatively underpin the usefulness of generating action plans. Intervention effects of action planning should be more carefully evaluated under consideration of the applied, theory-based behaviour change strategies (e.g., adaption of action plans vs. generation of completely new action plans) and to the type of control condition (e.g., active vs. passive control group; Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011).

Predicting and Promoting Repeated Behavior Enagement: Can Outcome Experiences Make a Difference?

Besides examining the usefulness of self-regulatory strategies, the present thesis investigated whether evalutations of behavior outcomes can make a difference in promoting long-term behavior change. Inspired by the framework of Rothman (Rothman, 2000; Rothman et al., 2004; Rothman et al., 2009), the MoVo (Fuchs et al., 2011; Göhner et al., 2009) integrates behaviour outcome experiences to describe and explain why individuals repeatedly engage in a behavior. The findings of *Chapter 2* suggest that outcome experiences become particularly relevant when supervised exercise routines at a rehabilitation center have to be translated into self-directed, independent exercise in one's home-based environment. More generally speaking, positive outcome experiences in one context promote continued behaviour engagement in another context. According to the *trans-contextual model* (Hagger, Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005; Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003), an autonomous sense of behaviour regulation is central to predicting exercise performance beyond structured exercise classes (Hagger et al., 2005; Hagger et al., 2003) and exercise-based rehabilitation treatment (Russel & Bray, 2009). The findings of *Chapter 2* suggest that positive exercise outcomes can be another potential candidate for promoting maintenance of behaviour across different contexts.

How Do Experiences Exert their Influence on Repeated Behaviour Engagement?

To identify starting points for interventions, *Chapter 2* additionally focussed on the question how exercise experiences affect subsequent behavior. Multiple mediation analyses supported theory-driven, underlying working mechanisms of exercise experiences. The results of *Chapter 2* revealed that rehabilitation-based, positive exercise experiences exert its influence on subsequent home-based exercise by stimulating use of action planning and by enhancing levels of satisfaction (*Chapter 2*). In other words, positive outcome experiences feedback on previously applied self-regulatory strategies (i.e., action planning) and thereby guide continuous behaviour engagement. The predictive role of behaviour outcome evaluations in promoting post-rehabilitation exercise was further supported by the experimental findings of *Chapter 3 (part one)*.

How Do Experience-Based Interventions Promote Behaviour Repetition?

In addition to changes in action control, changes in satisfaction were found to account for the intervention effects on post-rehabilitation exercise (*Chapter 3, part one*). Exercise experiences during rehabilitation were targeted by prompting individuals to recall up to three positive exercise

outcomes during rehabilitation. Although this experience-based component was combined with other self-regulatory change strategies (i.e., generation of action plans, self-monitoring), it can be cautiously inferred that changes in satisfaction at least partly resulted from recalling positive exercise outcomes.

The intervention presented in *Chapter 5* applied a similar behavior change strategy: Individuals in the intervention group were encouraged by the interviewer to recall positive exercise outcomes since discharge from rehabilitation. Whereas *Chapter 3 (part one)* supported that positive exercise experiences play a crucial role in enhancing perceptions of satisfaction, findings of *Chapter 5* show that this behaviour change strategy also helps to maintain self-efficacy beliefs. Supporting the assumptions of SCT (Bandura, 1997) and two meta-analyses (Ashford, Edmunds, & French, 2010; Wiliams & French, 2011), results of *Chapter 5* demonstrated that experience recall contributes to fostering self-efficacy beliefs. Changes in self-efficacy, in turn, were found to prevent long-term declines in behaviour. Moreover, individuals who participated in the intervention presented in *Chapter 5* were encouraged to rate the degree of action plan achievements. It can be concluded from *Chapter 5* that prompting action plan ratings in addition to experience recall fosters self-efficacy by making previous, behavioural achievements salient (i.e., mastery experiences, Bandura, 1997).

Overall, observational and experimental findings from this thesis provide evidence that theoretical assumptions on the interplay of experiences, satisfaction, and behaviour (Rothman, 2000; Rothman et al., 2004) hold true not only for smoking cessation (Baldwin et al., 2006), exercise (Williams et al., 2008), and weight management (Finch et al., 2005), but can also be applied to the domain of exercise in clinical samples. In addition, results suggest that experience-based variables and self-regulatory strategies contribute additively to behaviour maintenance. Including experience-related variables into health behavior models, such as the HAPA (Schwarzer, 2008; Schwarzer et al., 2011), can help to better understand the mechanisms of behaviour maintenance. Interventions may be improved by combining or even integrating experience-based components with components that target action planning and action control, respectively. Mapping theoretical constructs on behaviour change strategies helps to understand the underlying, theory-based mechanisms of an intervention. When designing interventions it should be taken into account that one behaviour change strategy (e.g., recall of positive exercise experiences) may affect multiple outcomes (e.g., satisfaction, self-efficacy).

How to Predict and Promote Habit Formation

There is more to behavior maintenance than continuous and effortful behavior engagement. According to Rothman, Sheeran, and Wood (2009) behavior maintenance covers both, deliberate and habitual processes. Habits refer to behaviours that have acquired a high degree of automaticity (Bargh, 1994). In other words, habits are behaviours that are performed in response to contextual cues with a substantial amount of ease and little conscious deliberation (Verplanken & Melkevik, 2008; Wood & Neal, 2007). Following Lally and Gardner (2011), the observational (*Chapter 4*) and experimental studies (*Chapter 3&5*) in this thesis conceptualized habits as the most distal exercise outcome. In *Chapters 3 to 5*, the degree of exercise habituation was psychometrically assessed with items adapted from the *Self-Report Habit Index* (SRHI; Verplanken & Orbell, 2003). Based on this assessment, results among university students (*Chapter 4, part two*) and rehabilitation patients (*3, part two, 4, part two, 5*) converged on the widespread notion that repeated exercise performance is associated with habit formation (Gardner, de Bruijn, & Lally, 2011; Lally et al., 2010; Orbell & Verplanken, 2010; Study 3). Whereas *Chapter 4 (part one)* investigated static relationships between exercise and habit (i.e., baseline exercise predicts habit strength), *Chapter 4 (part two)* replicated findings in a dynamic model: Changes in post-rehabilitation exercise predicted changes in exercise habit strength.

These observational findings were supported by the experimental studies conducted as part of *Chapter 3 (part one)* and *Chapter 5*. *Chapter 3 (part two)* revealed that changes in habit strength co-occurred with changes in exercise, replicating previous findings on dental hygiene behaviour (Orbell & Verplanken, 2010; Study 3). Similarly, *Chapter 5* added to this finding by revealing that intervention-induced, long-term changes in exercise were associated with changes in exercise habit strength. To further analyze the underlying mechanisms of habit formation, either prompted by goal intentions (*Chapter 4)* or by an intervention (*Chapter 5), Chapters 4 and 5* included mediation analyses.

How Do Intentions Guide Exercise Habit Formation?

Based on existing hypotheses around the mechanisms of habit formation (Lally & Gardner, 2011; see also Figure 1, *Chapter 1*), *Chapter 4* reports two longitudinal studies designed to test one possible predictive model of the pathways from goal intentions to exercise habit (*Chapter 4*). Findings of *Chapter 4* suggest that goal intentions may direct habit formation by facilitating use of action planning, which in turn promotes behaviour repetition. Theorized observational patterns

between goal intentions, action planning, behaviour, and habituation were revealed to hold true for younger (M = 24.9), healthy individuals (*Chapter 4, part one*), as well as for rehabilitation patients with a considerably higher mean age (48.9 years) (*Chapter 4, part two*). This might indicate that the processes of habit formation unfold similarly among these two groups of individuals.

How Can Effects of Exercise Booster Sessions on Habit Strength be Explained?

The latter observational patterns were further strengthened by experimental results presented in *Chapter 5*. In this intervention study, exercise habit strength was modelled as most distal intervention outcome. Path analyses indicated that intervention-induced changes in action planning, rather than self-efficacy, were conductive to sustained repetition of behaviour as required for habituation. When tested in a multiple, sequential mediation model, only the sequential path from the intervention to habit strength via action planning to exercise yielded a significant indirect effect (*Chapter 5*). It can therefore be inferred, that action planning is particularly beneficial for sustained exercise and habit strength, respectively. Action plans specify the context cues (i.e., time, location) in response to which a goal-directed behaviour will be performed. Continued use of action planning and commitment to action plans should therefore not only ensure behaviour consistency in terms of frequency, but also in terms of context stability relevant to habit formation (Aarts, Paulussen, & Schaalma, 1997; Lally & Gardner, 2011; Neal, Wood, & Quinn, 2006; Verplanken & Melkevik, 2008). Some additional indicators for these associations can be found in a previous longitudinal field study by Lally, van Jaarsveld, Potts, and Wardle (2010). Authors initially asked students to choose from three different health behaviours which they intended to do, and which they could perform in response to a daily reoccurring, salient cue. It could be argued that initial instructions (i.e., choosing a goal behaviour, identification of critical cue) may have encouraged participants to form spontaneous action plans. The observed increase in habit strength may, therefore, not only be attributed to repeated behaviour engagement, but also to preceding action plans. This would be in line with the findings of the experimental study described in *Chapter 5*.

To conclude, the present thesis delivers accumulated evidence that habit formation may be promoted by self-regulatory strategies (Lally & Gardner, 2011), such as action planning, which in turn promotes consistent behaviour enactment. The mechanisms involved in long-term behaviour change may be better understood by incorporating habit strength into behaviour change models (Riet et al., 2011) as well as into intervention practice (e.g., as a formal intervention objective). Adding telephone-delivered booster sessions to an initial treatment may provide an effective alter-

native to achieving maintenance of self-management competencies, behaviour (Fjeldsoe, Neuhaus, Winkler, & Eakin, 2011), and habit formation.

From Single to Multiple Health Behavior Change: Mechanisms of Cross-Behavior Regulation

The results of this thesis suggest that the formation of healthy habits is not only relevant for the promotion of single health behaviors but also for maintaining an overall healthy lifestyle (exercise, healthy nutrition). Extending *Chapters 2, 3 (part one), 4*, and *5*, in *Chapter 3* (*part two*) health behaviour change processes were investigated from a multiple health behaviour perspective.

Psychological interventions in secondary prevention often focus on the promotion of selected health behaviours (e.g., physical exercise only; Fuchs et al., 2011; Mangels, Schwarz, Worringen, Holme, & Rief, 2009). In line with previous controlled trials (Dutton, Napolitano, Whiteley, & Marcus, 2008) and field studies (Annesi & Marti, 2011; Mata et al., 2009), the findings of *Chapter 3 (part two)* revealed that such a single behavior approach may suffice to promote other health behaviors. In more detail, the exercise intervention presented in *Chapter 3* not only led to changes in the target behaviour (*part one*), but also resulted in concurrent improvements in fruit and vegetable intake (*part two*).

Changing multiple health behaviours can exhaust one's capacity of deliberate self-regulation (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Results presented in *Chapter 3 (part two),* however, imply that such a trend towards depletion can be attenuated once a single behaviour becomes habituated: change in exercise habit strength was found to explain the effects of the exercise intervention on changes in fruit and vegetable intake. Presumably, if self-regulatory resources related to exercise become vacant because of habituation, the very same resources become available to be applied to fruit and vegetable intake. Most likely, the strategies that were successfully applied to exercise will also be activated for fruit and vegetable intake (i.e., transfer). Whereas *Chapters 4* and *5* identified predictors of habituation, *Chapter 3 (part two)* provided initial evidence that habitual features of a single health behaviour itself constitute a correlate and antecedent of multiple health behaviour change, respectively.

Directions and Implications for Future Research

The results presented in the four empirical chapters support the significance of analysing processes and predictors of health behaviour change that go beyond a) behaviour initiation (i.e., from behaviour initiation to habituation), and b) single health behaviour change (i.e., from single to multiple health behaviour change). Both aspects are highly relevant for future research on the man-

agement and prevention of chronic diseases. In the following paragraphs, theoretical, methodological, and practical implications for intervention design and assessment are suggested.

Methodological Implications

Evaluation of Multi-component Interventions: Additive and Synergistic Intervention Effects

Usually, behaviour change interventions are very complex, as they include many interacting components (Michie, Abraham, et al., 2011; Michie, Ashford, et al., 2011). To improve intervention design, there is a need to disentangle which single techniques and which combination of techniques are effective in promoting behaviour (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). The findings revealed in *Chapters 3* and *5* relied on behaviour change interventions with multiple components. In more detail, the combined computer-based and paper-pencil intervention targeted action planning, action control, and satisfaction (*Chapter 3*). Similarly, the telephone-delivered intervention combined an experience-based component with an action plan component (*Chapter 5*). The joint application of techniques was based on the theoretical rationale presented in *Chapter 1* (Table 1): relationships between theoretical constructs as assumed by most health behaviour models call for the inclusion of more than one mediating variable of behaviour change. To statistically evaluate to what extent each variable explains (i.e., mediates) the effect of the intervention on exercise, multiple mediation analyses were conducted (Preacher & Hayes, 2008). Analyses revealed that, experience-based and self-regulation components were comparably effective in promoting behaviour maintenance (i.e., *Chapter 3 & 5*; additive intervention effects).

To further understand the interplay of different components, future evaluations may also look at the synergistic effects of intervention components on behaviour change. For example, intervention-induced changes in action planning may only translate into behaviour change if levels of other self-regulatory constructs (i.e., coping planning) are sufficiently high (e.g., Wiedemann, Lippke, Reuter, Ziegelmann, & Schwarzer, 2011). Against the background of this thesis, future studies may also examine whether the implementation of intervention-induced action plans depends on how individuals evaluate the outcomes of a behaviour (i.e., moderated mediation analyses*;* Preacher, Rucker, & Hayes, 2007).

However, to entirely understand the mechanisms by which multiple intervention components reveal their effects, full factorial designs are necessary in order to evaluate the incremental effects of the single intervention components (e.g., Wiedemann et al., 2011). To extend the results of this thesis, it may be fruitful to carefully investigate the interrelations between self-regulatory

strategies and experience-based variables. In a full factorial 2x2 design, one might compare an experience-based, an action planning, and a combined intervention, against a control group.

Intervention Effects on Distal (Intervention) Outcomes: Evaluating a Chain of Effects

An intervention may also be theorized to induce a sequence of causal effects. In *Chapter 5*, the intervention was hypothesized to induce a chain of effects. In detail, the exercise intervention was assumed to produce changes in action planning, which in turn affected behaviour frequency, which finally promoted exercise habituation. Similarly, in *Chapter 3*, goal intentions were hypothesized to guide exercise habituation through a sequential path from action planning to behaviour enactment. Hence, to evaluate intervention effects through two consecutive mediators, a sequential mediation model needs to be specified (Hayes, Preacher, & Myers, 2011). As mentioned above, experimental manipulations allow for more stringent hypothesis testing than "post-hoc" mediation analyses. Ideally, future intervention studies should apply an experimental causal chain design (Reuter, Ziegelmann, Wiedemann, & Lippke, 2008; Spencer, Zanna, & Fong, 2005) with several time-lagged assessments to accumulate evidence on the sequential mechanisms of habit formation.

Study Design

Chapter 5 reported results on the effects of telephone boosters on the maintenance of physical exercise over a follow-up period of 12 months after the end of participation in a medical rehabilitation program. These patients were either exposed to the booster intervention including two subsequent telephone sessions (intervention group) or simply answered telephone-delivered follow-up questionnaires (control group). Given that the participants in the booster intervention were also the participants in the previous intervention during rehabilitation (*Chapter 3*), a carry-over effect of the initial intervention after cessation can not be ruled out. In future intervention designs, participants could be rerandomized to either the new intervention (booster) or the control condition. Another aspect in which the two intervention conditions varied is the amount of contact which might itself have impacted on behavior maintenance (e.g., Fjeldsoe et al., 2011).

Measurement Instruments

Results of this thesis were solely based on self-reports of behavioural and social-cognitive variables. To resolve problems with self-reports such as social desirability, response shifts, or recall bias (Prince et al., 2008), objective behaviour measures may be favoured. However, objective assessments, such as the use of accelerometers also have its limits (Wilcox & Ainsworth, 2009). Future studies could profit from combining both approaches. Such a combined approach may not only

be applied to behavioural measures but also to health indicators relevant for evaluating the progression of chronic diseases (e.g., Lavie & Milani, 2011).

Measuring behaviour evaluations: Satisfaction and exercise outcome experience. Although the applied single-item measure of satisfaction was able to predict behaviour (*Chapter 2*) and was sensitive to experimental manipulation (*Chapter 3, part one*), these results should be replicated with multi-item measures of satisfaction (Baldwin et al., 2006; Sears & Stanton, 2001).

Theoretically, perceptions of satisfaction are assumed to be largely determined by the number of positive, behavioural outcomes that individuals experience (Rothman et al, 2000; Rothman et al., 2004). In the present thesis, positive exercise experiences were assessed with the *Exercise Experiences Scale* (EES; *Chapter 2*). The scale showed sufficient internal reliability and discriminant validity, and could be easily adapted for other health behaviours. The applied version of the EES (*Chapter 2*) mainly captured cognitive aspects of exercise experiences that patients may have during rehabilitation. An extended version of the scale could integrate emotional outcomes (e.g., "When I was physically active, I felt happier afterwards." or "When I was physically active, I felt less lonely afterwards.") to measure affective responses to exercise (e.g., Gauvin & Rejeski, 1993; Kendzierski & DeCarlo, 1991).

However, as theorized by Rothman (2000), positive exercise experiences per se do not necessarily lead to high levels of perceived satisfaction. Whether or not individuals are satisfied with their experiences may depend in parts on a) the *type of experience* (e.g., experiences that are related to different social, emotional, or cognitive outcomes; Ernst, 2010; Baldwin et al., 2009), and b) individuals' behavioural *outcome expectancies* (Baldwin, Rothman, Hertel, Keenan, & Jeffery, 2009; Rothman, 2000; Rothman et al., 2004). To the extent that actual exercise experiences are consistent with or even exceed expected outcomes, the likelihood of subsequent behavior may increase (Sears & Stanton, 2001). Expectancy violation (Sears & Stanton, 2001), on the other hand, may interfere with maintaining a behavior. Future research should consider both lines of research.

Habit strength. In the present thesis (*Chapters 3 to 5*), the degree of exercise habituation was psychometrically assessed with items adapted from the *Self-Report Habit Index* (SRHI; Verplanken & Orbell, 2003). In detail, *Chapters 3 (part two), 4 (part two),* and *5* applied two items that correspond to one facet of "habitual automaticity" (Orbell & Verplanken, 2010, p. 374): lack of awareness (e.g., "Being as physically active as I have been during the last four weeks, is something I do without thinking about it."). The items that were added in Chapter 4 (part one) captured further

aspects of automaticity such as lack of control (e.g., "Being as physically active as I have been during the last four weeks, is something I do automatically."). Future studies may include additional items of the SRHI (Verplanken & Orbell, 2003) to include all facets of automaticity (Bargh, 1994; e.g., mental efficiency, lack of conscious intent). In addition, habit strength as measured by the SRHI could serve as an indicator for the sustainability of behavioral changes following an intervention. In other words, behavior maintenance should not only be assessed by continuous behavioral measures (Seymour et al., 2010), but also by measures of habit strength.

Since habits are conceptualized as behaviours that are cued in consistent settings, it is promising to consider this in future measurements of the construct (Sniehotta & Presseau, 2011). Theory suggests that it is not the behaviour per se that becomes habituated but rather the cue-dependent behaviour initiation in a specific situation (Verplanken, 2010; Verplanken & Melkevik, 2008). This should also be reflected in the specificity of the habit assessment. For example, individuals could be asked to write down a specific exercise behaviour that they have been engaged in during the last four weeks (e.g., walking). Subsequently, they could be asked to specify the context in which they most frequently performed this specific behaviour (e.g., on Mondays after work). This could be followed by the usual items of the SRHI. Moreover, items may be rephrased so that they do not refer to behaviour engagement but rather to the initiation of behaviour in a specific situation. At best, such a specific, context-dependent version of the SRHI (i.e., micro perspective, conditional behaviour approach) should be combined with a more general version (i.e., macro perspective, unconditional behaviour approach).

Longitudinal analyses in the present thesis were based on two up to four time-lagged measurement points (for overview see Table 2, *Chapter 1*). To further elucidate the mechanisms of habit formation, it may be beneficial to reduce the time-lags between measurements, and to observe weekly or even day-to-day changes in habit strength. For example, Lally et al. (2011) employed daily assessments of habit strength and analyzed according intraindividual changes over a period of 90 days. Thereby, the authors revealed that habituation follows a curvilinear, rather than a linear pattern (Lally et al., 2011). It may be advantageous to enrich these daily habit assessments with day-to-day assessments of self-regulatory strategies (e.g., action control, action planning), personal resources and satisfaction.

From unconditional to conditional behaviour outcomes. Similarly to the habit measurement, the Godin scale (Godin & Shephard, 1985), as used in this thesis, assesses exercise without consid-

ering the context in which it is performed. It subsumes exercise that may be performed in multiple contexts (e.g., in the park, in the gym, at home). Behaviour as assessed by the Godin scale can therefore be understood as an unconditional measure of behaviour (Sniehotta, 2009). This distinction becomes particularly relevant when examining the mechanisms of action plans.

Action planning, adherence to action plans, and behaviour. Based on the associations discovered between psychometrically measured action planning and unconditional behavioural measures (*Chapters 2, 4*), it was concluded that action planning is beneficial for subsequent behaviour enactment (*Chapters 2, 4*). Similarly, results from *Chapter 5* indicate that making action plans as part of an intervention facilitates subsequent use of action planning beneficial for exercise (*Chapter 5*; Lippke, Schwarzer, Ziegelmann, Scholz, & Schüz, 2010; Luszczynska, 2006; Wiedemann et al., 2011). From simply looking at associations between action planning and behavior, one can not, however, draw any final conclusions about whether individuals actually exercised in response to cues as specified by their action plans. Measuring the degree to which individuals adhere to their action plans (i.e., planning adherence; conditional behaviour) and how this affects behaviour and healthy habit formation, opens up new avenues for future research.

Measuring multiple health behavior change and concepts of cross-behavior regulation. Results of this dissertation suggest that habits are central to analyzing and understanding the mechanisms of cross-behaviour regulation: once a behaviour takes on habitual features, potential experiences of ego-depletion (i.e., lack of resources) may be reduced, as previously occupied self-regulatory resources are available for mastering other behavioural tasks. Most likely, those self-regulatory strategies that have been successfully applied in the exercise domain may be also applied to increasing one's fruit and vegetable intake (i.e., transfer; e.g., Annesi & Marti, 2011).

However, conclusions regarding the occurrence and mechanisms of multiple health behavior change are limited, as revealed associations between changes in exercise, exercise habit strength and fruit and vegetable consumption were of correlational nature in the present thesis (*Chapter 3 part one*). Future studies regarding the effectiveness of a single health behaviour intervention on other health behaviours should go beyond examining the co-occurrence of changes (i.e., simultaneous changes in target behavior of intervention and other behaviors). One might alternatively analyze whether changes in the target behaviour of an intervention lead to subsequent changes in another health behavior.

In addition, the present analyses lack the inclusion of an explicit measure of *transfer* and perceptions of *ego-depletion*, respectively. To provide a stricter test of the assumed mechanisms of multiple health behavior change tapped into by this thesis, multi-item measures of perceived resource *depletion* (e.g., "When I exercise regularly, I find it difficult to also keep an eye on my healthy diet.") and *transfer* (e.g., "To improve my nutrition, I can draw on those strategies that have helped me to exercise regularly.") should be developed and investigated in relation to other social-cognitive and behavioural variables. As a first step, it could be tested whether higher levels of exercise habit strength correspond with higher levels of transfer and lower levels of depletion.

Theoretical Implications

Beyond Behaviour Initiation

When it comes to modelling health behaviour change, the question arises as to which set of variables should be integrated to most readily capture the processes of behaviour maintenance. In this dissertation, the concept of behavioural habits (Aarts et al., 1997; Lally & Gardner, 2011; Neal et al., 2006; Verplanken & Melkevik, 2008) and behaviour outcome evaluations (Fuchs et al., 2011; Göhner et al., 2009; Rothman, 2000; Rothman et al., 2004) were integrated into theory of health behaviour change (HAPA; Schwarzer, 2008; Schwarzer et al., 2011) to model processes of behaviour maintenance. By following a mediation approach (e.g., Schwarzer et al., 2011), the proposed theoretical framework (see Figure 1, *in Chapter 1*) was found, at least in part, to readily capture the mechanisms that unfold after behaviour initiation. In particular, results of this thesis support the importance of considering additive effects of behaviour outcome evaluations (*Chapters 2,3*), self-regulatory strategies (*Chapters 2,3,5*), and self-efficacy (*Chapter 5*) on behaviour repetition (*Chapter 2, 3, 4, 5*) and habituation (*Chapter 4,5*). Finally, the findings underpin the value of integrating the concept of habit into health behaviour change models, such as the HAPA (Schwarzer, 2008; Schwarzer et al., 2011) or the MoVo (Fuchs et al., 2011; Göhner et al., 2009), as well as into intervention practice (e.g., as intervention outcome). The proposed heuristic (*Chapter 1*) may serve as a working model to inspire future research on health behaviour maintenance. Future research may pursue the question of whether an inclusion of these and other volitional variables can explain incremental variance of health behaviours and habit strength (Schwarzer, 2008).

Beyond Single Health Behavior Change

Changes in single health behaviors are usually predicted by behavior specific social-cognitions, such as intentions, planning, or self-efficacy. To describe and predict, however, how

individuals change more than one health behavior, other variables and more comprehensive theories are needed (Morabia & Costanza, 2010; Prochaska et al., 2008; Spring et al., 2012). Results from *Chapter 3 (part two)* suggest that habituation in one health behavior goes along with changes in another health behaviour. Theoretically, this may be accounted for by concepts such as *ego-depletion* (Baumeister, Muraven, & Tice, 2000) and *transfer* (Barnett & Ceci, 2002). Future studies could develop measures (*see section on measures*) to assess these contructs and set them in relation to changes in different health behaviors. This would contribute to furthering theory on cross-behavior regulation.

Overall, results of *Chapter 3 (part two)* demonstrate that changes in physical exercise and nutrition change in concert rather than interfering with each other. This is in line with previous research which suggests, that health behaviours with common health themes, such as weight management (e.g., nutrition, exercise; Annesi & Marti, 2011; Johnson et al., 2008; Mata et al., 2009) are more closely related and entail higher rates of change than those behaviours with diverging health goals (e.g., smoking and exercise; Boudreaux, Francis, Carmack Taylor, Scarinci, & Brantley, 2003). That is, joint improvements in smoking and nutrition, for example, may be hindered by *compensatory health beliefs* (e.g., "Smoking is ok as long as I eat healthy"; Radtke, Scholz, Keller, & Hornung, 2011). To further elucidate predictors and mechanisms of multiple health behaviour change, overreaching health goals or even life goals could be assessed. Thereby, it would be easier to identify synergies or rather conflicts between behaviors.

Finally, besides focusing on psychological, intraindividual mechanisms (i.e., transfer, ego-depletion, compensatory health beliefs), social processes (e.g., mobilization of social support to counteract ego-depletion), as well physiological process (e.g., energy metabolism, appetite; Martins, Morgan, & Truby, 2008) may be accounted for when studying multiple health behaviour change.

Implications for Intervention Practice

Integrating Theory- and Evidence-Based Health Behaviour Change Interventions into Medical Rehabilitation

Statuary pension insurances (e.g., German Pension Insurance) increasingly invest in the development, evaluation, and implementation of programs that can potentially increase the effectiveness of standard rehabilitation treatments by promoting individuals' health behaviours. Only recently, theory- and evidence-based behaviour changes strategies (e.g., self-monitoring) have been

explicitly included into guidelines for psychological interventions in cardiac and orthopedic rehabilitation treatments in Germany (Reese et al., 2012a, 2012b). The findings of this dissertation further support these theory-driven recommendations, and open up new avenues for using interactive communication technologies in supporting patients during and after rehabilitation. The results of this thesis suggest that adding a combined, paper-pencil and computer-based exercise intervention to either a standard cardiac and/ or orthopedic rehabilitation treatment may not only lead to improved exercise outcomes, but also affect healthy nutrition. With regard to post-rehabilitation support, the telephone-assisted, computer-based generation of action plans appeared to be particularly relevant in establishing effortless exercise routines up to 12 months after discharge (*Chapter 5*).

Both standard rehabilitation care and post-rehabilitation support may be complemented by psychological interventions that promote positive experiences, enhance satisfaction, and teach self-regulatory skills to improve behavior-, and work-related rehabilitation outcomes (e.g., occupational reintegration).

Creating Healthy Habits, Breaking Unhealthy Habits

In this thesis, the development of healthy exercise habits was not only investigated in a rehabilitation context, but also among university students. Observational results in both samples *(Chapter 4)* suggest that action planning promotes the habituation of exercise. Experimental results among rehabilitation patients further revealed that it is particularly useful to focus on action plan adherence and to offer opportunities to adapt action plans once a behaviour has been initiated (*Chapter 5*).

Generally, the planning intervention components employed as part of this thesis may be strengthened by other strategies to facilitate consistent behaviour repetition as required for habit formation, respectively. Relevant to effective action plans is the identification of suitable environmental cues (e.g., location for exercising). *Environmental tailoring* can be one option to increase the effectiveness of action plans effectiveness in promoting behaviour repetition. Prior to making action plans, individuals may be informed (e.g., via google maps) about potential locations where they could exercise based on their work or home location (Prins, van Empelen, Beenackers, Brug, & Oenema, 2010). Moreover, individuals may be rewarded or *reward* themselves (Lally & Gardner, 2011; Riet et al., 2011) for successfully implementing their action plans. Finally, individuals could also be encouraged to actively integrate behaviour-promoting, environmental cues in their environment to create healthy habits. This strategy is known as *stimulus control* (Riet et al., 2011)

and could for example include putting training shoes out of the dresser or a gym mat in front of the television.

The introduced framework (see Figure 1, *Chapter 1*) of habit formation focused on how individuals develop healthy lifestyle habits. However, the concepts may also be applied to model the processes that individuals go through when they try to break unhealthy habits. Related to that is the question of how one can optimally support individuals to break unhealthy habits, such as unhealthy snacking (Adriaanse, Gollwitzer, De Ridder, de Wit, & Kroese, 2011). Research on the promotion of smoking cessation (Webb, Sheeran, & Luszczynska, 2009) suggests that simple planning interventions alone are not sufficient to support highly habituated smokers with their quitting attempts. Alternatively, *mental rehearsal of plans* (Webb et al., 2009) may attenuate unhealthy, habitual cue-response associations. Symbolic rehearsal of managing a high-risk situation is, for example, also an important ingredient of habit reversal therapy (Bate, Malouff, Thorsteinsson, & Bhullar, 2011). Finally, structural changes such as moving to a new place or staying in rehabilitation can additionally help to break unhealthy habits (i.e., *habit-discontinuity hypotheses*; Neal, Wood, Wu, & Kurlander, 2011; Study 1; Verplanken, 2010; Verplanken, Walker, Davis, & Jurasek, 2008). Recent experimental research in the diet domain (i.e., popcorn consumption) even suggests that habit automaticity can be disrupted if individuals eat with their non-dominant hand (Neal et al., 2011; Study 2).

To conclude, individual self-regulatory strategies could be combined with environmental approaches to create and break (un)healthy habits. An avenue for future research is to examine the interplay between environmental factors and individual self-regulation (e.g., Gubbels et al., 2011; van Nieuw-Amerongen, Kremers, de Vries, & Kok, 2011; van Stralen, De Vries, Mudde, Bolman, & Lechner, 2009).

Recommendations for Future Inteventions: Theory-Based Behaviour Change Techniques and Procedures

The behavior change interventions presented in this thesis each included several components. The more complex an intervention, however, the more important it is to draw on a comprehensive framework, in order to report an intervention. Thereby, knowledge is accumulated for interventions to become more effective, and easier to replicate and implement (Michie, Abraham, et al., 2011). Within Michie's behaviour change framework (Michie, Ashford, et al., 2011), intervention components refer to two aspects of an intervention: first, they include the specific behaviour

change technique to improve behaviour; second they refer to the procedures related to the delivery of the techniques (Michie, Abraham, et al., 2011). Based on this framework, the interventions introduced in *Chapters 3* and *5* can be described much more comprehensively and thereby give recommendations for future applications in secondary and primary prevention practice. By disentangling theoretical constructs, behaviour change techniques, and procedures, Table 2 provides an overview of the behaviour change interventions introduced in this thesis.

Feasible modes of delivery: Interactive communication technologies. The results of this thesis indicate that interactive communication technologies, such as self-administered, *computer-delivered interventions* (*Chapter 3*), and *computer-assisted telephone interviews* (CATIs; *Chapter5*) are particularly suited to implement behaviour change techniques aiming at exercise maintenance (see Table 2). Generally, interactive technologies offer intervention developers the option to tailor intervention materials (*Chapter 5*) and thus increase intervention effectiveness (Noar, Grant Harrington, Van Stee, & Shemanski Aldrich, 2011). For example, tailoring computer-based interventions to individuals' level of exercise intention has been shown to have a greater impact on behaviour changes among healthy (Fleig et al., 2010; Lippke et al., 2010) and clinical samples (Lippke et al., 2004b), than a non-tailored intervention. Another benefit of computer-based technologies relates to the standardization of interventions. CATIs, in particular, have the advantage that intervention protocols can be standardized across multiple interviewers (e.g., nurses, physiotherapists, etc.) and thereby facilitate the implementation of interventions in clinical practice (Eakin, Lawler, Vandelanotte, & Owen, 2007; White et al., 2006). The reach, delivery, and effectiveness of such telephone-delivered interventions can even be enhanced by new communication technologies (Eakin et al., 2007), such as text messages (Prestwich, Perugini, & Hurling, 2009, 2010). Future studies could test different delivery channels (e.g., computer-based vs. CATI vs. text messages) against each other. This could be done, for example, by letting indivdiuals chose their preferred type of intervention mode (i.e., *preference-based interventions*). Similarly, the number of dosages can be either pre-determined by means of randomization or self-selected by individuals (Jacobs, De Bourdeaudhuij, Thijs, Dendale, & Claes, 2011). Both approaches may be helpful for tailoring post-rehabilitation booster interventions to different target groups (e.g., age, gender, medical indication).

Table 2. Recommendations for the Use of Theory-Based Behaviour Change Techniques and Procedures Based on the Results of this Thesis (Adapted from Bartholomew, Parcel, Kok, Gottlieb & Fernandez, 2011; Michie, Ashford, et al., 2011)

Theoretical Construct	***Behaviour Change Techniques (BCTs)***	***Procedures***	
		Strategies	*Mode of delivery*[3]
Self-efficacy	Prompt recall of positive, experienced behaviour outcomes/focus on past success[2]	- Recall of up to three positive, exercise outcome experiences - Provision of examples if individual cannot recall (tailored to gender and patient type)	Computer (self-directed, technical support on request) Telephone (interviewer-assisted)
	Prompt review of action plan adherence[2]	- Feedback of previously generated individual action plan (tailoring) - Rating to what degree (in percent) individuals adhered to action plan	Telephone (interviewer-assisted)
Action planning	Generation of action plans[1,2]	- Planning up to three exercise activities - Specify when (time, weekday), where, and with whom one wants to be active	Computer (self-directed, technical support on request) Telephone (interviewer-assisted)
	Prompt review of action plan adherence[2]	- Feedback of previously generated individual action plan (tailoring) - Rating to what degree (in percent) individuals adhered to action plan	Telephone (interviewer-assisted)
	Prompt review of suitability practicality, and effectiveness of action plans (including subsequent modification of action plans)[2]	- Feedback of previously generated individual action plan (tailoring) - Review of action plan regarding the following three questions: Does it really fit you? Is it really practical? Is it effective in progressing you towards your health goal? - Possibility to modify parts of action plans or generate new action plans	Telephone (interviewer-assisted) Paper-Pencil (self-directed)
Action control	Prompt self-monitoring of behaviour[1]	- Provision of diary sheet for six weeks - Weekly review of planning adherence (including personal behaviour goal) including a rating to what degree (in percent) individuals realized their specific action plans	Paper-pencil (self-directed)
Satisfaction	Prompt recall of positive, experienced behaviour outcomes[1]	- Recall of up to three positive, exercise outcome experiences - Provision of tailored (i.e.,, gender and patient type) examples if individual cannot recall any	Computer (self-directed, technical support on request) Telephone (interviewer-assisted)

Note. [1]BCT's used in initial intervention; [2]BCT's used in follow-up intervention booster; [3]Mode of delivery refer to those delivery modes that were applied in the according studies of this thesis (from the perspective of the participant).

Promoting a Healthy Lifestyle

In the exercise intervention presented in *Chapter 3* it was revealed that intervention-induced exercise changes go along with changes in fruit and vegetable intake. To promote a healthy lifestyle it may therefore suffice to focus on a single health behavior as changes in another preventive behavior may naturally follow. Developing a single behavior intervention to change multiple health behaviors would be most efficient and cost-effective (Charnigo, Kryscio, Bardo, Lynam, & Zimmerman, 2011). Ideally, future intervention studies should include an experimental manipulation that actively strengthens synergies between health behaviors. For example, at the end of an exercise intervention, individuals could be encouraged to transfer learned skills (e.g., action planning) to other health behaviors. Closely related to this issue is the yet understudied question of whether some health behaviors when intervened upon are more likely to entail changes in other health behaviors (Nigg, et al., 2009). Results of *Chapter 3 (part two)* imply that physical exercise is a potential gate-way behavior to an overall healthier lifestyle.

In the future, applied research is needed to identify the optimal number of behaviors to intervene upon and to determine how target behaviors are best selected (e.g., pre-determined vs. preference-based; Spring et al., 2012). Different intervention modalities could be tested against each other: Interventions that target a single health behaviours may be tested against interventions that a) separately address two or more health behaviours (e.g., Johnson et al., 2008; Krebs, Prochaska, & Rossi, 2010), and interventions that b) intensely address one health behavior and also include a short component to promote transfer. Thereby intervention design that "accounts for […] complementary relationships" among a set of health behaviors could be advanced (Spring et al., 2012, p. 1).

In conclusion, the results in this dissertation are relevant for both theory and practice: Processes of exercise habit formation and its potential consequences for regulating healthy nutrition were further clarified. Moreover, theory-based self-regulation interventions were investigated regarding their effects on single and multiple health behaviours with an emphasis on their underlying working mechanisms in promoting exercise maintenance. Future studies may pursue the theoretical rationale of the empirical studies, and employ the introduced behaviour change techniques, procedures (i.e., delivery modes) and evaluation strategies to further the understanding of behaviour maintenance, and the development of effective theory-driven and evidence-based interventions.

References

Aarts, H., Paulussen, T., & Schaalma, H. (1997). Physical exercise habit: On the conceptualization and formation of habitual health behaviours. *Health Education Research, 12*(3), 363-374.

Adriaanse, M. A., Gollwitzer, P. M., De Ridder, D. T. D., de Wit, J. B. F., & Kroese, F. M. (2011). Breaking habits with implementation intentions: A test of underlying processes. *Personality and Social Psychology Bulletin, 37*(4), 502.

Adriaanse, M. A., Vinkers, C. D. W., De Ridder, D. T., Hox, J. J., & De Wit, J. B. F. (2011). Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. *Appetite, 56*(1), 183-193.

Ajzen, I. (2002). Residual effects of past on later behaviour: Habituation and reasoned action perspectives. *Personality and Social Psychology Review, 6*(2), 107-122.

Annesi, J. J., & Marti, C. N. (2011). Path analysis of exercise treatment-induced changes in psychological factors leading to weight loss. *Psychology & Health, 26*(8), 1081-1098.

Ashford, S., Edmunds, J., & French, D. P. (2010). What is the best way to change self-efficacy to promote lifestyle and recreational physical activity? A systematic review with meta-analysis. *British Journal of Health Psychology, 15*(2), 265-288.

Baldwin, A., Rothman, A., Hertel, A., Keenan, N., & Jeffery, R. (2009). Longitudinal associations between people's cessation-related experiences and their satisfaction with cessation. *Psychology and Health, 24*(2), 187-201.

Baldwin, A. S., Rothman, A. J., Hertel, A. W., Linde, J. A., Jeffery, R. W., Finch, E. A., et al. (2006). Specifying the determinants of the initiation and maintenance of behaviour change: An examination of self-efficacy, satisfaction, and smoking cessation. *Health Psychology, 25*(5), 626-634.

Baldwin, A. S., Rothman, A. J., & Jeffery, R. W. (2009). Satisfaction with weight loss: Examining the longitudinal covariation between people's weight-loss-related outcomes and experiences and their satisfaction. *Annals of Behavioural Medicine, 38*(3), 213-224.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bargh, J. A. (1994). The four horsemen of automaticity: Awareness, intention, efficiency, and control in social cognition. In R. S. Wyer Jr. & T. K. Srull (Eds.), *Handbook of social cognition* (2nd ed., pp. 1-40). Hillsdale, NJ: Erlbaum.

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn?: A taxonomy for far transfer. *Psychological Bulletin, 128*(4), 612-637.

Bartholomew, L. K., Parcel, G. S., Kok, G., Gottlieb, N. H., & Fernandez, M. E. (2011). *Planning health promotion programs: An intervention mapping approach*. San Fransisco: Jossey-Bass.

Bate, K. S., Malouff, J. M., Thorsteinsson, E. T., & Bhullar, N. (2011). The efficacy of habit reversal therapy for tics, habit disorders, and stuttering: A meta-analytic review. *Clinical Psychology Review, 31*(5), 865-871.

Baumeister, R. F., Muraven, M., & Tice, D. M. (2000). Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Psychological Bulletin, 18*(2), 130-150.

Boudreaux, E. D., Francis, J. L., Carmack Taylor, C. L., Scarinci, I. C., & Brantley, P. J. (2003). Changing multiple health behaviours: smoking and exercise. *Preventive Medicine, 36*(4), 471-478.

Chapman, J., & Armitage, C. J. (2010). Evidence that boosters augment the long-term impact of implementation intentions on fruit and vegetable intake. *Psychology & Health, 25*(3), 365-381.

Charnigo, R., Kryscio, R., Bardo, M. T., Lynam, D., & Zimmerman, R. S. (2011). Joint modeling of longitudinal data in multiple behavioral change. *Evaluation & the Health Professions, 34*(2), 181-200.

Conner, M., & Higgins, A. R. (2010). Long-term effects of implementation intentions on prevention of smoking uptake among adolescents: a cluster randomized controlled trial. *Health Psychology, 29*(5), 529-538.

Conner, M., Sandberg, T., & Norman, P. (2011). Using action planning to promote exercise behavior. *Annals of Behavioral Medicine, 40*(1), 65-76.

Dutton, G. R., Napolitano, M. A., Whiteley, J. A., & Marcus, B. H. (2008). Is physical activity a gateway behaviour for diet? Findings from a physical activity trial. *Preventive Medicine, 46*(3), 216-221.

Ernst, J. (2010). *Aufrechterhaltung von körperlicher Aktivität bei orthopädischen und kardiologischen Rehabilitanden: Die Rolle von sportbezogenen Konsequenzerfahrungen und Zufriedenheit* [Maintenance of physical exercise in orthopedic and cardiac rehabilitation patients: The role of exercise-related outcome experiences and satisfaction]. (Unpublished master's thesis). Freie Univeristät Berlin, Berlin.

Eakin, E. G., Lawler, S. P., Vandelanotte, C., & Owen, N. (2007). Telephone Interventions for Physical Activity and Dietary Behaviour Change: A Systematic Review. *American Journal of Preventive Medicine, 32*(5), 419-434.

Finch, E. A., Linde, J. A., Jeffery, R. W., Rothman, A. J., King, C. M., & Levy, R. L. (2005). The effects of outcome expectations and satisfaction on weight loss and maintenance: Correlational and experimental analyses-a randomized trial. *Health Psychology, 24*(6), 608-616.

Fjeldsoe, B., Neuhaus, M., Winkler, E., & Eakin, E. (2011). Systematic review of maintenance of behaviour change following physical activity and dietary interventions. *Health Psychology, 30*(1), 99-109.

Fleig, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T., & Gravert, C. (2010). Förderung von körperlicher Aktivität im betrieblichen Kontext: Ein randomisiertes Kontrollgruppen-Design zur Untersuchung von stadienspezifischen Interventionseffekten [Promoting physical activity in a workplace setting: A randomized control trial investigating stage-specific intervention effects].. *Zeitschrift für Gesundheitspsychologie, 18*(2), 69-78.

Fuchs, R., Göhner, W., & Seelig, H. (2011). Long-term effects of a psychological group intervention on physical exercise and health: The MoVo concept. *Journal of Physical Activity & Health, 8*(6), 794-803.

Gardner, B., de Bruijn, G.-J., & Lally, P. (2011). A systematic review and meta-analysis of applications of the self-report habit index to nutrition and physical activity behaviours. *Annals of Behavioural Medicine*, 1-14.

Gauvin, L., & Rejeski, W. J. (1993). The Exercise-Induced Feeling Inventory: Development and initial validation. *Journal of Sport and Exercise Psychology, 15*, 403-423.

Godin, G., & Shephard, R. J. (1985). A simple method to assess exercise behaviour in the community. *Canadian Journal of Applied Sport Science, 10*(3), 141-146.

Göhner, W., Seelig, H., & Fuchs, R. (2009). Intervention effects on cognitive antecedents of physical exercise: A 1-year follow study. *Applied Psychology: Health and Well-Being, 1*(2), 233-256.

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology, 38*, 69-119.

Gubbels, J. S., Kremers, S. P. J., van Kann, D. H. H., Stafleu, A., Candel, M. J. J. M., Dagnelie, P. C., et al. (2011). Interaction between physical environment, social environment, and child characteristics in determining physical activity at child care. *Health Psychology, 30*(1), 84-90.

Hagger, M. S., Chatzisarantis, N. L. D., Barkoukis, V., Wang, C. K., & Baranowski, J. (2005). Perceived autonomy support in physical education and leisure-time physical activity: a cross-cultural evaluation of the trans-contextual model. *Journal of Educational Psychology, 97*(3), 376-390.

Hagger, M. S., Chatzisarantis, N. L. D., Culverhouse, T., & Biddle, S. J. H. (2003). The processes by which perceived autonomy support in physical education promotes leisure-time physical activity intentions and behaviour: a trans-contextual model. *Journal of Educational Psychology, 95*(4), 784-795.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological Bulletin, 136*(4), 495-525.

Hayes, A. F., Preacher, K. J., & Myers, T. A. (2011). Mediation and the estimation of indirect effects in political communication research. In E. P. Bucy & R. L. Holbert (Eds.), *Sourcebook for political communication research: Methods, measures, and analytical techniques.* (pp. 434-446). New York: Routledge.

Jacobs, N., De Bourdeaudhuij, I., Thijs, H., Dendale, P., & Claes, N. (2011). Effect of a cardiovascular prevention program on health behaviour and BMI in highly educated adults: A randomized controlled trial. *Patient Education and Counseling, 85*(1), 122-126.

Johnson, S. S., Paiva, A. L., Cummins, C. O., Johnson, J. L., Dyment, S. J., Wright, J. A., et al. (2008). Transtheoretical Model-based multiple behaviour intervention for weight management: Effectiveness on a population basis. *Preventive Medicine, 46*(3), 238-246.

Karoly, P. (1993). Goal systems: An organizing framework for clinical assessment and treatment planning. *Psychological Assessment, 5*(3), 273.

Kendzierski, D., & DeCarlo, K. J. (1991). Physical activity enjoyment scale: two validation studies. *Journal of Sport and Exercise Psychology, 13*, 50-64.

Krebs, P., Prochaska, J. O., & Rossi, J. S. (2010). A meta-analysis of computer-tailored interventions for health behavior change. *Preventive Medicine, 51*(3-4), 214-221.

Koring, M., Richert, J., Lippke, S., Parschau, L., Reuter, T., & Schwarzer, R. (2011). Synergistic effects of planning and self-efficacy on physical activity. *Health Education & Behavior*. doi: 10.1177/1090198111417621

Lally, P., & Gardner, B. (2011). Promoting habit formation. *Health Psychology Review*, 1-22. doi: 10.1080/17437199.2011.603640

Lally, P., van Jaarsveld, C. H. M., Potts, H. W. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *European Journal of Social Psychology, 40*(6), 998-1009.

Lavie, C. J., & Milani, R. V. (2011). Cardiac rehabilitation and exercise training in secondary coronary heart disease prevention. *Progress in Cardiovascular Diseases, 53*(6), 397-403.

Leventhal, H., Singer, R., & Jones, S. (1965). Effects of fear and specificity of recommendation upon attitudes and behavior. *Journal of Personality and Social Psychology, 2*(1), 20-29.

Lippke, S., Nigg, C. R., & Maddock, J. E. (2012). Health-promoting and health-risk behaviours: Theory-driven analyses of multiple health behaviour change in three international samples. *International Journal of Behavioural Medicine*, 1-13.

Lippke, S., Schwarzer, R., Ziegelmann, J. P., Scholz, U., & Schüz, B. (2010). Testing stage-specific effects of a stage-matched intervention: a randomized controlled trial targeting physical exercise and its predictors. *Health Education & Behaviour, 37*(4), 533-546.

Lippke, S., Ziegelmann, J. P., & Schwarzer, R. (2004a). Behavioral intentions and action plans promote physical exercise: A longitudinal study with orthopedic rehabilitation patients. *Journal of Sport and Exercise Psychology, 26*(3), 470.

Lippke, S., Ziegelmann, J. P., & Schwarzer, R. (2004b). Initiation and maintenance of physical exercise: Stage-specific effects of a planning intervention. *Research in Sports Medicine, 12*(3), 221-240.

Luszczynska, A. (2006). An implementation intentions intervention, the use of a planning strategy, and physical activity after myocardial infarction. *Social Science & Medicine, 62*(4), 900-908.

Luszczynska, A., Scholz, U., & Sutton, S. (2007). Planning to change diet: A controlled trial of an implementation intentions training intervention to reduce saturated fat intake among patients after myocardial infarction. *Journal of Psychosomatic Research, 63*(5), 491-497.

Mangels, M., Schwarz, S., Worringen, U., Holme, M., & Rief, W. (2009). Evaluation of a behavioural-medical inpatient rehabilitation treatment including booster Sessions: A randomized controlled study. *The Clinical Journal of Pain, 25*(5), 356-364.

Martins, C., Morgan, L., & Truby, H. (2008). A review of the effects of exercise on appetite regulation: an obesity perspective. *International Journal of Obesity, 32*(9), 1337-1347.

Mata, J., Silva, M. N., Vieira, P. N., Carraça, E. V., Andrade, A. M., Coutinho, S. R., et al. (2009). Motivational "spill-over" during weight control: Increased self-determination and exercise intrinsic motivation predict eating self-regulation. *Health Psychology, 28*(6), 709-716.

McAuley, E., Lox, C., & Duncan, T. E. (1993). Long-term maintenance of exercise, self-efficacy, and physiological change in older adults. *Journal of Gerontology, 48*(4), 218-224.

Michie, S., Abraham, C., Eccles, M. P., Francis, J. J., Hardeman, W., & Johnston, M. (2011). Strengthening evaluation and implementation by specifying components of behaviour change interventions: a study protocol. *Implementation Science: IS, 6*, 10-10.

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*(6), 690-701.

Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. *Psychology & Health, 26*(11), 1479-1498.

Morabia, A., & Costanza, M. C. (2010). Multiple health behaviour change interventions: Tell us what you see. *Preventive Medicine, 50*, 1-2.

Neal, D. T., Wood, W., Wu, M., & Kurlander, D. (2011). The pull of the Past: When do habits persist despite conflict with motives? *Personality and Social Psychology Bulletin, 37*(11), 1428-1437.

Neal, D. T., Wood, W., & Quinn, J. M. (2006). Habits - A repeat performance. *Current Directions in Psychological Science, 15*(4), 198-202.

Nigg, C. R., Lee, H., Hubbard, A. E., & Min-Sun, K. (2009). Gateway health behaviours in college students: Investigating transfer and compensation effects. *Journal of American College Health, 58*(1), 39-44.

Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behaviour change interventions. *Psychological Bulletin, 133*(4), 673.

Noar, S. M., Grant Harrington, N., Van Stee, S. K., & Shemanski Aldrich, R. (2011). Tailored health communication to change lifestyle behaviours. *American Journal of Lifestyle Medicine, 5*(2), 112-122.

Orbell, S., & Verplanken, B. (2010). The automatic component of habit in health behaviour: Habit as cue-contingent automaticity. *Health Psychology, 29*(4), 374-383.

Pfeifer, K., Sudeck, G., Brüggemann, S., & Huber, G. (2010). DGRW-update: bewegungstherapie in der medizinischen rehabilitation–wirkungen, qualität, perspektiven, [DGRW-update: exercise therapy in medical rehabilitation–effects, quality, perspectives]. *Rehabilitation, 49*(4), 224-236.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behaviour Research Methods, 40*(3), 879-891.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioural Research, 42*, 185-227.

Prestwich, A., Perugini, M., & Hurling, R. (2009). Can the effects of implementation intentions on exercise be enhanced using text messages? *Psychology and Health, 24*(6), 677-687.

Prestwich, A., Perugini, M., & Hurling, R. (2010). Can implementation intentions and text messages promote brisk walking? A randomized trial. *Health Psychology, 29*(1), 40-49.

Prince, S. p. A., Adamo, K. B., Hamel, M. E., Hardt, J., Gorber, S. C., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *The International Journal Of Behavioural Nutrition And Physical Activity, 5*, 56-56.

Prins, R., van Empelen, P., Beenackers, M., Brug, J., & Oenema, A. (2010). Systematic development of the YouRAction program, a computer-tailored physical activity promotion intervention for Dutch adolescents, targeting personal motivations and environmental opportunities. *BMC Public Health, 10*(1), 474.

Prochaska, J. J., Spring, B., & Nigg, C. R. (2008). Multiple health behaviour change research: An introduction and overview. *Preventive Medicine, 46*(3), 181-188.

Radtke, T., Scholz, U., Keller, R., & Hornung, R. (2011). Smoking is ok as long as I eat healthily: Compensatory health beliefs and their role for intentions and smoking within the Health Action Process Approach. *Psychology & Health*, 1-17.

Reese, C., Mittag, O., Bengel, J., Deck, R., Ehlebracht-König, I., Faller, H., Fleig, L., Geigges, W., Glombiewski, J., Grande, G., Hautzinger, M., Höder, J., Jäckel, W.H., Kortenhaus, H., Lüking, M., Mai, B., Niebling,W., Pfingsten, M., Pomp, S., Rink, M., Schmucker, D., Wörner, S. & Worringen, U. (2012a). *Praxisempfehlungen für psychologische Interventionen in der Rehabilitation: Chronische Rückenschmerzen.* [Practical guidelines for psychological interventions in rehabilitation: chronic back pain]. Retrieved from http://www.uniklinik-freiburg.de/aqms/live/Praxisempfehlungen/Orthopaedie.pdf

Reese, C., Mittag, O., Bengel, J., Deck, R., Ehlebracht-König, I., Faller, H., Fleig, L., Geigges, W., Glombiewski, J., Grande, G., Hautzinger, M., Höder, J., Jäckel, W.H., Kortenhaus, H., Lüking, M., Mai, B., Niebling,W., Pfingsten, M., Pomp, S., Rink, M., Schmucker, D., Wörner, S. & Worringen, U. (2012b). *Praxisempfehlungen für psychologische*

Interventionen in der Rehabilitation: Koronare Herzerkrankung. [Practical guidelines for psychological interventions in rehabilitation: coronary heart disease]. Retrieved from http://www.uniklinik-freiburg.de/aqms/live/Praxisempfehlungen/Kardiologie.pdf

Reuter, T., Ziegelmann, J. P., Wiedemann, A. U., & Lippke, S. (2008). Dietary planning as a mediator of the intention behaviour relation: An experimental causal chain design. *Applied Psychology, 57*, 194-207.

Rhodes, R., De Bruijn, G. J., & Matheson, D. H. (2010). Habit in the physical activity domain: integration with intention temporal stability and action control. *Journal of Sport & Exercise Psychology, 32*(1), 84-89.

Riet, J., Sijtsema, S. J., Dagevos, H., & De Bruijn, G. J. (2011). The importance of habits in eating behaviour: An overview and recommendations for future research. *Appetite, 57*(3), 585-596.

Rothman, A. J. (2000). Toward a theory-based analysis of behavioural maintenance. *Health Psychology, 19*, 64-69.

Rothman, A. J., Baldwin, A. S., & Hertel, A. W. (2004). Self-regulation and behaviour change: Disentangling behavioural initiation and behavioural maintenance. In K. Vohs & R. Baumeister (Eds.), *The handbook of self-regulation* (pp. 130-148). New York: Guilford Press.

Rothman, A. J., Sheeran, P., & Wood, W. (2009). Reflective and automatic processes in the initiation and maintenance of dietary change. *Annals of Behavioural Medicine, 38*, 4-17.

Russell, K. L., & Bray, S. R. (2009). Self-determined motivation predicts independent, home-based exercise following cardiac rehabilitation. *Rehabilitation Psychology, 54*(2), 150-156.

Scholz, U., & Sniehotta, F. F. (2006). Langzeiteffekte einer Planungs- und Handlungskontrollintervention auf die körperliche Aktivität von Herzpatienten nach der Rehabilitation [Long-term effects of a planning and action control intervention on physical activity of cardiac patients after rehabilitation]. *Zeitschrift für Gesundheitspsychologie, 14*(2), 73-81.

Schwarzer, R. (2008). Modeling health behaviour change: How to predict and modify the adoption and maintenance of health behaviours. *Applied Psychology: An International Review, 57*, 1-29.

Schwarzer, R., Lippke, S., & Luszczynska, A. (2011). Mechanisms of health behaviour change in persons with chronic illness or disability: The Health Action Process Approach (HAPA). *Rehabilitation Psychology, 56*(3), 161-170.

Seymour, R. B., Hughes, S. L., Ory, M. G., Elliot, D. L., Kirby, K. C., Migneault, J., et al. (2010). A lexicon for measuring maintenance of behavior change. *American Journal of Health Behavior, 34*(6), 660-668.

Sears, S. R., & Stanton, A. L. (2001). Expectancy-value constructs and expectancy violation as predictors of exercise adherence in previously sedentary women. *Health Psychology, 20*(5), 326-333.

Sniehotta, F. F. (2009). Towards a theory of intentional behaviour change: Plans, planning, and self-regulation. *British Journal of Health Psychology, 14*(2), 261-273.

Sniehotta, F. F., & Presseau, J. (2011). The habitual use of the Self-report Habit Index. *Annals of Behavioural Medicine*, 1-2.

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health, 20*(2), 143-160.

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2006). Action plans and coping plans for physical exercise: A longitudinal intervention study in cardiac rehabilitation. *British Journal of Health Psychology, 11*(1), 23-37.

Sniehotta, F. F., Scholz, U., Schwarzer, R., Fuhrmann, B., Kiwus, U., & Völler, H. (2005). Long-term effects of two psychological interventions on physical exercise and self-regulation following coronary rehabilitation. *International Journal of Behavioral Medicine, 12*(4), 244-255.

Sniehotta, F. F., Schwarzer, R., Scholz, U., & Schüz, B. (2005). Action planning and coping planning for long-term lifestyle change: Theory and assessment. *European Journal of Social Psychology, 35*(4), 565-576.

Spencer, S. J., Zanna, M. P., & Fong, G. T. (2005). Establishing a causal chain: Why experiments are often more effective than mediational analyses in examining psychological processes. *Journal of Personality and Social Psychology, 89*(6), 845-851.

Spring, B., Moller, C. M., & Coons, M. J. (2012). Multiple health behaviours: Overview and implications. *Journal of Public Health, 34*(1), 3-10.

Stadler, G., Oettingen, G., & Gollwitzer, P. M. (2010). Intervention effects of information and self-regulation on eating fruits and vegetables over two years. *Health Psychology, 29*(3), 274-283.

van Nieuw-Amerongen, M. E., Kremers, S. P. J., de Vries, N. K., & Kok, G. (2011). The use of prompts, increased accessibility, visibility, and aesthetics of the stairwell to promote stair use in a university building. *Environment and Behavior, 43*(1), 131-139.

van Stralen, M. M., De Vries, H., Mudde, A. N., Bolman, C., & Lechner, L. (2009). Determinants of initiation and maintenance of physical activity among older adults: A literature review. *Health Psychology Review, 3*(2), 147-207.

Verplanken, B. (2010). By force of habit. In A. Steptoe, K. Freedland, J. R. Jenning, M. Liabre, S. Manuck & E. Susman (Eds.), *Handbook of behavioural medicine* (pp. 73-82). New York: Springer.

Verplanken, B., & Melkevik, O. (2008). Predicting habit: The case of physical exercise. *Psychology of Sport and Exercise 9*(1), 15-26.

Verplanken, B., & Orbell, S. (2003). Reflections on past behaviour: A self-report index of habit strength. *Journal of Applied Social Psychology, 33*(6), 1313-1330.

Verplanken, B., Walker, I., Davis, A., & Jurasek, M. (2008). Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. *Journal of Environmental Psychology, 28*(2), 121-127.

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing, 25*(1), 90-103.

Webb, T. L., Sheeran, P., & Luszczynska, A. (2009). Planning to break unwanted habits: Habit strength moderates implementation intention effects on behaviour change. *British Journal of Social Psychology, 48*(3), 507-523.

White, M. J., Stark, J. R., Luckmann, R., Rosal, M. C., Clemow, L., & Costanza, M. E. (2006). Implementing a computer-assisted telephone interview (CATI) system to increase colorectal cancer screening: A process evaluation. *Patient Education and Counseling, 61*(3), 419-428.

Wiedemann, A. U., Lippke, S., Reuter, T., Ziegelmann, J. P., & Schwarzer, R. (2011). How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. *European Journal of Social Psychology, 41*(1), 42-51.

Wilcox, S., & Ainsworth, B. E. (2009). The measurement of physical activity. In S. A. Shumaker, J. K. Ockene & K. A. Riekert (Eds.), *The handbook of health behavior change*. New York: Springer Publishing Company, LLC.

Williams, S. L., & French, D. P. (2011). What are the most effective intervention techniques for changing physical activity self-efficacy and physical activity behaviour - and are they the same? *Health Education Research, 26*(2), 308-322.

Williams, D. M., Lewis, B. A., Dunsiger, S., Whiteley, J. A., Papandonatos, G. D., Napolitano, M. A., et al. (2008). Comparing psychosocial predictors of physical activity adoption and maintenance. *Annals of Behavioural Medicine, 36*(2), 186-194.

Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. *Psychological Review, 114*(4), 843-863.

Curriculum Vitae

Lena Fleig (geb. Remme)

For reasons of data protection, the curriculum vitae is not included in this version.

For reasons of data protection, the curriculum vitae is not included in this version.

List of Publications

ARTICLES IN PEER-REVIEWED JOURNALS (* indicates those that are part of the thesis)

In press

Pomp, S., Fleig, L., Schwarzer, R., & Lippke, S. (in press). Depressive symptoms interfere with post-rehabilitation exercise: Outcome expectancies and experience as mediators. *Psychology, Health, & Medicine.*

2010 - 2011

*Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2011). Exercise maintenance after rehabilitation: How experience can make a difference. *Psychology of Sport & Exercise, 12*, 293-299.

*Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2011). Intervention effects of exercise self-regulation on physical exercise and eating fruits and vegetables: A longitudinal study in orthopedic and cardiac rehabilitation. *Preventive Medicine, 53*(3), 182-187.

Fleig, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T., & Gravert, C. (2010). Förderung von körperlicher Aktivität im betrieblichen Kontext: Ein randomisiertes Kontrollgruppen-Design zur Untersuchung von stadienspezifischen Interventionseffekten. [Promoting physical activity in a workplace setting: A randomized controlled trial investigating stage-specific intervention effects] *Zeitschrift für Gesundheitspsychologie, 18*, 69-78.

Lippke, S., Fleig, L., Pomp, S., & Schwarzer, R. (2010).Validity of a stage algorithm for physical activity in participants recruited from orthopedic and cardiac rehabilitation clinics. *Rehabilitation Psychology, 55(*4), 398-408.

Pomp, S., Lippke, S., Fleig, L., & Schwarzer, R. (2010).Synergistic effects of intention and depression on action control: Longitudinal predictors of exercise after rehabilitation. *Mental Health and Physical Activity, 2*, 78-84.

Schwarzer, R., Richert, J., Kreausukon, P., Remme, L., Wiedemann, A. U., & Reuter, T. (2010). Translating intentions into nutrition behaviours via planning requires self-efficacy: Evidence from Thailand and Germany. *International Journal of Psychology, 45*, 260-268.

Under Review in Peer Reviewed Journals

*Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. (2012). Telephone-delivered booster sessions help maintain self-regulation: A long-term follow-up in medical rehabilitation. Manuscript submitted for publication.

*Fleig, L., Lippke, S., Pomp, S., Parschau, L., Koring, M., Lange, D., & Schwarzer, R. (2012). Beyond goal intentions: Processes of habit formation in the exercise domain. Manuscript submitted for publication.

Koring, M., Parschau, L., Lange, D., Fleig, L., & Schwarzer, R. (2012). Picking up a complimentary pedometer as a preparatory action. Manuscript submitted for publication.

Parschau, L., Koring, M., Lange, D., Fleig, L., Lippke, S., & Schwarzer, R. (2012). Positive experience, self-efficacy, and action control predict physical activity. Manuscript submitted for publication.

Pomp, S., Lippke, S., Fleig, L., & Schwarzer, R. (2011). Conscientiousness moderates the intention-planning-behaviour chain. Manuscript submitted for publication.

Pomp, S., Lippke, S., Fleig, L., & Schwarzer, R. (2012). The effect of a self-regulation intervention on physical exercise is moderated by depressive symptoms: A study in orthopedic rehabilitation. Manuscript submitted for publication.

BOOK CHAPTER

Lippke, S., Fleig, L., Pomp, S., & Schwarzer, R. (2010). Soziale Unterstützung und die Aufrechterhaltung von Reha-Erfolgen. In Arbeitskreis Klinische Psychologie in der Rehabilitation BDP (Hrsg.). *Trends in der Medizinischen Rehabilitation* (pp. 27-39). Bonn: Deutscher Psychologen Verlag.

MISCELLANEOUS

Fleig, L. (2010). CREAT(E)ing new research network opportunities for early career scientists: From riding a tandem and other ventures. *European Health Psychologist, 12*, 59-60.

Reese, C., Mittag, O., Bengel, J., Deck, R., Ehlebracht-König, I., Faller, H., Fleig, L., Geigges, W., Glombiewski, J., Grande, G., Hautzinger, M., Höder, J., Jäckel, W.H., Kortenhaus, H., Lüking, M., Mai, B., Niebling,W., Pfingsten, M., Pomp, S., Rink, M., Schmucker, D., Wörner, S. & Worringen, U. (2012a). *Praxisempfehlungen für psychologische Interventionen in der Rehabilitation: Chronische Rückenschmerzen.* [Practical guidelines for psychological interventions in rehabilitation: chronic back pain]. Retrieved from http://www.uniklinik-freiburg.de/aqms/live/Praxisempfehlungen/Orthopaedie.pdf

Reese, C., Mittag, O., Bengel, J., Deck, R., Ehlebracht-König, I., Faller, H., Fleig, L., Geigges, W., Glombiewski, J., Grande, G., Hautzinger, M., Höder, J., Jäckel, W.H., Kortenhaus, H., Lüking, M., Mai, B., Niebling,W., Pfingsten, M., Pomp, S., Rink, M., Schmucker, D., Wörner, S. & Worringen, U. (2012b). *Praxisempfehlungen für psychologische Interventionen in der Rehabilitation: Koronare Herzerkrankung.* [Practical guidelines for psychological interventions in rehabilitation: coronary heart disease]. Retrieved from http://www.uniklinik-freiburg.de/aqms/live/Praxisempfehlungen/Kardiologie.pdf

SELECTED PRESENTATIONS (first authorships only)

Fleig, L., Pomp, S., Schwarzer, R., Pimmer, V., & Lippke, S. *Reha-Nachsorge per computergestützter Telefonberatung? Effektivität und Wirkmechanismen eines psychologischen Nachsorgeprogrammes zur Aufrechterhaltung von körperlicher Aktivität bei kardiologischen und orthopädischen Rehabilitanden.* Präsentation auf dem 21. Reha-Wissenschaftlichen Kolloqium, 5.-7. März 2012, Hamburg, Deutschland.

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. *Effectiveness of a computer-based exercise intervention in rehabilitation: Self-regulatory mechanisms in physical exercise and dietary behaviour.* Präsentation auf der Annual Conference of the European Health Psychology Society, 20.-24. September 2011, Kreta, Griechenland.

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. *Ist eine Steigerung der körperlichen Aktivität mit einer gesünderen Ernährung assoziiert? Effektivität und Wirkmechanismen einer computergestützten Bewegungsberatung bei Rehabilitanden*. Präsentation 10. Kongress für Gesundheitspsychologie der Deutschen Gesellschaft für Psychologie, 31. August – 02. September 2011, Berlin, Deutschland.

Fleig, L., Lippke, S., Pomp, S., & Schwarzer, R. *Auch nach der Rehabilitation am Ball bleiben: Wie Sporterfahrungen einen aktiven Bewegungs-Alltag fördern*. Präsentation auf der 30. Jahrestagung Klinische Psychologie in der Rehabilitation, 14.-16. Oktober 2010, Erkner, Deutschland.

Fleig, L., Lippke, S., Wiedemann, A. U., Reuter, T., & Pomp, S. *Translating intentions into healthy nutrition behaviour: Do individuals benefit from having experience in other behaviour domains?* Präsentation auf der Annual Conference of the European Health Psychology Society, 1.-4. September 2010, Cluj, Romänien.

Fleig, L., Lippke, S., & Pomp, S. *Healthy Lifestyle Patterns among Rehabilitation Patients: Physical Activity as a Gateway Behaviour?* Präsentation auf dem 27th Conference of the International Association of Applied Psychology, 11.-16. Juli 2010, Melbourne, Australien.

Fleig, L., Küper, C., Lippke, S., Wiedemann, A. U., & Reuter T. *Mechanisms of multiple healthbehaviour change: Do people change simultaneously or sequentially?* Präsentation auf der Annual Conference of the European Health Psychology Society, 23.-26. September 2009, Pisa, Italien.

Fleig, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T. & Gravert, C. (2008). *Förderungvon körperlicher Aktivität im betrieblichen Kontext: Stadienspezifischen Effekte eines theoriebasierten Expertensystems.* Präsentation auf dem 9th Congress for Health Psychology, 26.-28. August 2009, Zürich, Schweiz.

Remme, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P. & Reuter, T. (2008). *Health promotion at work: How effective are stage-matched interventions?* Präsentation auf der Annual Conference of the European Health Psychology Society, 8.-12. September, Bath, England.

Remme, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T. & Gravert, C. (2008). *The effectiveness of stage-matched interventions in promoting multiple health behaviours.*

Präsentation auf dem at the 29th International Congress of Psychology, 20.-25. Juli 2008, Berlin, Deutschland.

Remme, L., Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T. & Schwarzer, R. *Beratungsprogramme im betrieblichen Kontext: Effekte eines computerbasierten Expertensystems zur Förderung von körperlicher Aktivität*. Präsentation auf der 11. Tagung der DGPs-Fachgruppe Pädagogische Psychologie, 19. September 2007, Berlin, Deutschland.

Erklärung

Hiermit versichere ich, dass ich die vorgelegte Arbeit selbständig verfasst habe. Andere als die angegebenen Hilfsmittel habe ich nicht verwendet. Die Arbeit ist in keinem früheren Promotionsverfahren angenommen oder abgelehnt worden.

Lena Fleig

Berlin, März 2012