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# Insights into the Mechanisms of Action Planning Interventions in the Context of Fruit and Vegetable Consumption

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## Abstract

Healthy eating has a relevant impact on overall health. A sufficient fruit and vegetable (FV) intake, for instance, is associated with physical and mental health. However, the majority of the German population consumes less fruit and vegetables than recommended by public guidelines (e.g., "5 a day"). Even though many people intend to eat healthily, they frequently fail to translate their good intentions into action. This so-called *intention-behaviour gap* has been addressed in theory and empirical research, indicating that planning strategies are important predictors for overall behaviour change. The Health Action Process Approach (HAPA) states that *action planning* is a highly relevant self-regulatory strategy when it comes to bridging the intention-behaviour gap. With action plans, people form a mental link between situational cues (*when* and *where*) and a planned behavioural response (*what*), for instance: "I will eat an apple (*what*) at 8 am (*when*) in the kitchen (*where*)".

In empirical research, action planning has mainly been found to improve overall FV intake. This thesis aims at extending prior research by specifically focusing on high-resolution mechanisms of action planning interventions, thereby answering the question of when and how an action planning intervention unfolds its effects. The first chapter (Chapter 1) of this thesis introduces literature and empirical evidence on FV intake and action planning. In Chapters 2 to 4, three studies on action planning interventions in the context of FV intake will be presented: In Chapter 2, the frequency of plan enactment and its link to plan characteristics (i.e., plan specificity and type of the planned behaviour) and time variables (i.e., times of the day and plan calendar day) was investigated. Chapter 3 aimed at examining the frequency of cue detection and the execution of the planned behaviour and their links to overall FV intake, while accounting for interindividual as well as intraindividual differences. In Chapter 4, the short-term effects of an action planning intervention on FV intake and volitional self-regulatory outcome variables (i.e., self-efficacy and action control) were examined. The general discussion (Chapter 5) focuses on integrating the findings into the literature, discussing strengths and limitations, and providing an outlook as well as future implications for theory and practice. In the following, the main findings of this thesis will be summarized:

Results of Chapter 2 indicated that plans were enacted for the majority of cases (68.7%). Fruit plans were more likely being enacted than vegetable plans. Plan specificity was unrelated to plan enactment, but specific morning plans were more likely being enacted than unspecific morning plans. Plan enactment rates decreased over the day and over the 7-day planning period. In Chapter 3, cue detection and the execution of the planned behaviour were reported in the majority of cases (63% and 69%, respectively). Within-person cue detection and between- and within-person execution of the planned behaviour were positively associated with overall FV intake. No additional effect of joint cue detection and the execution of the planned behaviour beyond each predictor's main effect was found. In Chapter 4, FV intake and self-efficacy but not action control showed an immediate increase after an action planning intervention and subsequent maintenance of heightened levels.

To conclude, this thesis (1) underlines the importance of plan enactment as conditional behavioural outcome, creating a link between action planning and unconditional health behaviour change, and (2) points to the need to integrate high-resolution temporal dynamics of health behaviour change into the research.

**Zusammenfassung**

Gesunde Ernährung ist ein wichtiger Faktor für allgemeine Gesundheit. Ein ausreichender Obst- und Gemüsekonsum (OGK) beispielsweise steht im Zusammenhang mit sowohl körperlicher als auch mentaler Gesundheit. Jedoch konsumiert der Großteil der deutschen Bevölkerung weniger Obst und Gemüse als von der Weltgesundheitsorganisation empfohlen. Obwohl ein großer Teil der Menschen die Intention hat, sich gesund zu ernähren, gelingt es oft nicht, diese Intentionen in Handlungen umzusetzen. Diese sogenannte *Intentions-Verhaltens-Lücke* ist Bestandteil theoretischer Modelle und empirischer Forschung, welche gezeigt hat, dass Handlungsplanung ein wichtiger Prädiktor für Gesundheitsverhaltensänderung ist. Das sozial-kognitive Prozessmodell des gesundheitlichen Handelns (Health Action Process Approach; HAPA) geht davon aus, dass Handlungsplanung eine wichtige selbstregulatorische Strategie ist, die die Intentions-Verhaltens-Lücke überbrücken kann. Handlungspläne kreieren dabei eine mentale Verbindung zwischen situationalen Hinweisreizen (*wann* und *wo*) und der geplanten Verhaltensantwort (*was*), zum Beispiel: „Morgen um 8 Uhr (*wann*) werde ich einen Apfel (*was*) in der Küche (*wo*) essen."

Empirische Forschung hat gezeigt, dass Handlungsplanungsinterventionen dazu beitragen, den OGK zu erhöhen. Es ist jedoch wenig bekannt darüber, wie genau dies geschieht. Aus diesem Grund ist das Ziel der vorliegenden Arbeit, verschiedene Mechanismen (z.B. die kurzfristige zeitliche Entwicklung der Interventionseffekte) hochaufgelöst zu untersuchen. Im ersten Kapitel der Dissertation werden Literatur und empirische Forschung zu OGK und Handlungsplanung eingeführt. In den Kapiteln 2 bis 4 werden drei Studien vorgestellt, die sich mit unterschiedlichen Mechanismen von Handlungsplanungsinterventionen im Kontext von OGK beschäftigen: In Kapitel 2 wurde die Häufigkeit von Planausführung und deren Zusammenhang zu Planeigenschaften (i.e., Planspezifität und Art des geplanten Verhaltens) und Zeitvariablen (i.e., Tageszeit und Tag des Plankalenders) untersucht. In Kapitel 3 wurde die Häufigkeit untersucht, mit der nach

dem Aufstellen eines Obst- und Gemüseplans das Eintreten der geplanten Situation und die Ausführung des geplanten Verhaltens berichtet wurden. Außerdem wurde, unter Berücksichtigung von inter- und intraindividuellen Unterschieden, der Zusammenhang zwischen dem Eintreten der geplanten Situation sowie der Ausführung des geplanten Verhaltens und einer allgemeinen Gesundheitsverhaltensänderung (i.e., Steigerung des OGK) untersucht. Kapitel 4 beschäftigt sich mit der Fragestellung, wann der Interventionseffekt nach einer Handlungsplanungsintervention auf das Verhaltens-Outcome (i.e., OGK) und auf volitionale Outcome-Variablen (i.e., Selbstwirksamkeitserwartung und Handlungskontrolle) einsetzt und wie sich dieser über die Zeit entwickelt. In der abschließenden allgemeinen Diskussion werden die Ergebnisse in die Literatur integriert, Stärken und Schwächen der vorliegenden Studien aufgezeigt sowie Implikationen für Forschung, Theorie und Praxis diskutiert. Im Folgenden werden die Hauptergebnisse der empirischen Kapitel vorgestellt:

In Kapitel 2 zeigten die Ergebnisse, dass ein Großteil der Obst- und Gemüsepläne (68.7%) ausgeführt wurde wie geplant. Es wurden mehr Obst- als Gemüsepläne ausgeführt. Die Planspezifität hatte keinen Zusammenhang mit Planausführung, jedoch wurden spezifische Morgenpläne häufiger ausgeführt als unspezifische Morgenpläne. Planausführung nahm über den Tag und über die 7-tägige Planungsperiode ab. In Kapitel 3 wurde in den meisten Fällen berichtet, dass die geplante Situation eingetreten ist (63%) und das geplante Verhalten ausgeführt wurde (69%). Das Eintreten der geplanten Situation war auf intraindividueller Ebene und die Ausführung des geplanten Verhaltens auf inter- und intraindividueller Ebene positiv mit OGK assoziiert. Es wurde kein zusätzlicher Effekt von gemeinsamem Eintreten der geplanten Situation und der Ausführung des geplanten Verhaltens, der über die Haupteffekte der einzelnen Prädiktoren hinausging, gefunden. In Kapitel 4 zeigten sich für OGK und Selbstwirksamkeitserwartung, aber nicht für Handlungskontrolle eine unmittelbare Steigerung direkt nach der Intervention sowie eine darauffolgende Aufrechterhaltung der erhöhten Ausprägung.

Zusammenfassend trägt diese Dissertation dazu bei, ein genaueres Bild davon zu zeichnen, wie und wann es nach dem Aufstellen eines Obst- und Gemüseplanes zur Steigerung des OGK kommt. Dabei zeigte sich (1) die Wichtigkeit von Planausführung als konditionales Verhaltens-Outcome sowie (2) eine hohe Relevanz, die zeitliche Entwicklung von Tag zu Tag in die Untersuchung von Gesundheitsverhaltensänderung zu integrieren.

# Chapter 1

## General Introduction

## Introduction

A healthy diet contributes substantially to overall health. For instance, a sufficient fruit and vegetable (FV) intake is not only associated with reduced risks for chronic diseases (e.g., cardiovascular disease and cancer) and all-cause mortality (Aune et al., 2017; Yip et al., 2019) but also with mental health (e.g., depressive symptoms; Głąbska et al., 2020). The World Health Organization (WHO) recommends the consumption of at least five daily FV servings ("5 a day"), of which two should consist of fruit and three of vegetables (Guilbert, 2003). However, although many people hold the intention to eat healthily (e.g., Pietersma & Dijkstra, 2011), few people adhere to these recommendations (Hall et al., 2009). In Germany, only 46% of the general population consumes fruit on a daily basis, whereas the consumption of vegetables is even lower: 32% consume at least one serving of vegetables per day (Mensink et al., 2017a, 2017b). These findings indicate the urgent need to foster overall FV intake.

In health behaviour research, theoretical models serve to describe the underlying mechanisms of health behaviour change, that is, why and how people change their behaviour. Whereas motivational models focus on intention as a strong predictor of behaviour (e.g., Theory of Planned Behaviour; Ajzen, 1991), volitional models take into account that, despite good intentions, individuals often fail to translate their intentions into behaviour (Godin & Conner, 2008; Inauen et al., 2016). This phenomenon is described as the *intention-behaviour gap* (Sheeran & Orbell, 1999). As one prominent health behaviour change model, the Health Action Process Approach (HAPA; Schwarzer, 2008) explicitly addresses the intention-behaviour gap by including planning strategies (i.e., *action planning* and *coping planning*) that help to initiate behavioural changes (Zhang et al., 2019). The HAPA particularly emphasizes action planning, a frequently used and evidence-based self-regulatory strategy, as an antecedent of behaviour change.

Action planning is used to translate one's intention into actual behaviour by making detailed plans on *what* to do (behavioural response) *when* (an occasion or time), *where* (a place), and *with whom* (other persons; Hagger & Luszczynska, 2014). When people hold good intentions to eat healthily, they could form a plan like "I will eat an apple (*what*) at 8 am (*when*) in the kitchen (*where*)". Such an action plan creates a mental link between the situational cue (*when* and *where*) and the behavioural response (*what*). These cue-response associations increase the likelihood of the planned behavioural response when individuals encounter the planned situation (Hagger & Luszczynska, 2014). In the context of healthy nutrition, a meta-analysis has shown medium effect sizes for improvements in healthy eating after planning interventions (Adriaanse et al., 2011).

Given the detrimental health impacts of insufficient FV intake on the one hand and, on the other hand, the effectiveness of action planning interventions targeting improvements in healthy nutrition, implementing effective interventions is of great importance for global health (Luszczynska et al., 2007). To gain more insights into the question of how planning affects healthy eating, more research is needed. Therefore, this thesis aims at shedding light on specific mechanisms underlying action planning interventions, deepening the understanding of when and how action planning interventions unfold their effects. More precisely, within the present thesis, intensive longitudinal data from two study projects were analysed to examine (1) the frequency of plan enactment as well as its relationship to plan characteristics (i.e., the level of plan specificity and the type of the planned behaviour) and time variables (i.e., times of the day and plan calendar day; Chapter 2), (2) the frequency of cue detection and the execution of the planned behaviour as well as their between- and within-person links to overall FV intake (Chapter 3), and (3) when action planning interventions unfold their effects in the short term and how these effects evolve over time (Chapter 4). The general discussion (Chapter 5) focuses on integrating the empirical findings into the literature, discussing strengths and limitations, and providing an outlook and implications for future research.

**Fruit and Vegetable Intake as the Health Behaviour**

An early definition of health behaviour was established by Kasl and Cobb (1966) who referred to health behaviour as behavioural actions that are performed by subjectively healthy persons in order to prevent diseases or detect them in early (i.e., asymptomatic) stages. According to this definition, there is a huge variety of health behaviours, with many of them being thoroughly studied in the field of health psychology, for instance, physical activity, healthy eating, hand hygiene, dental flossing, medication adherence, and vaccination (Conner & Norman, 2017). The health behaviour that is examined within this thesis is the consumption of fruit and vegetables, which has a high impact on people's physical and mental health (e.g., Aune et al., 2017; Głąbska et al., 2020). At the same time, there is a need for increasing the general population's FV intake as most people do not consume enough fruit and vegetables daily (for instance in Germany; Mensink et al., 2017a, 2017b). Thus, investigating possibilities to enhance overall FV intake would contribute to improvements in global health. Moreover, there are several reasons why FV consumption is a suitable health behaviour for answering the present research questions (see below):

First, FV intake is an everyday health behaviour (Mensink et al., 2017b, 2017a) as every person consumes food daily and is, thus, confronted with food choices several times a day. Therefore, the threshold for FV consumption is relatively low when compared to other health behaviours such as physical activity, which is not necessarily performed daily. Second, the possibilities to consume fruit or vegetables are manifold so that each person has the possibility to choose according to their preferences (e.g., specific FV types, raw or cooked, as a side dish or main meal). This creates a wide range of options and, thus, high variability between and also within persons. Third, guidelines clearly define the recommended amount of fruit and vegetables one should consume daily ("5 a day"; Guilbert, 2003). Thus, interventions to improve FV consumption share the advantage of an easily defined overall goal, which, in addition, is easy to grasp and understand. However, it should be noted that methodological heterogeneities exist when defining what type of food is considered to be fruit or vegetable and what is not (Roark & Niederhauser, 2013). Fourth, there is a wide range of empirical evidence on FV consumption that can be used as a basis for further studies and facilitates integrating new insights into already existing findings. Besides studies in other disciplines such as medicine (e.g., Blanch et al., 2015), FV consumption is well studied in health psychology research (e.g., Guillaumie et al., 2010) and, most importantly for the present thesis, FV consumption has been studied thoroughly in the context of action planning interventions (for a review see Adriaanse et al., 2011).

To summarize, FV consumption is a highly relevant health behaviour that comes with several advantages, which can be used to expand existing theories and evidence beyond previous research.

**Planning in the Context of Health Behaviour Research**

The term *action planning* (originally *plan for action*) was introduced by Leventhal et al. in 1965, showing that an action planning intervention led to increased levels of tetanus vaccination within a student population (Leventhal et al., 1965). However, only in the 1990s, did action planning become of increased interest in health behaviour research and was studied intensely in the last decades (Hagger & Luszczynska, 2014). The two most prominent planning concepts used in health behaviour change interventions are “implementation intentions” (Gollwitzer, 1993, 1999) and “action planning” (Schwarzer, 1992).

*Implementation intentions* create a link between a specific cue referring to a future situation and a goal-directed behavioural response in form of *if-then* plans: “If I enter the planned situation, then I will perform the planned behaviour” (Gollwitzer, 1999). The situational cue accounts for *when* and *where* the planned behaviour (i.e., *what*) will be enacted (Gollwitzer, 1999). By linking a highly specific cue to a highly specific target behaviour, it is assumed that the increased mental accessibility of the cue leads to the automatic activation of the planned behavioural response (Webb & Sheeran, 2008).

For *action planning*, there seems to be no explicit definition in the literature (Hagger & Luszczynska, 2014). However, it is present in several health behaviour change models such as the HAPA (Schwarzer, 2008). Similar to implementation intentions, action plans create a mental link between a situational cue (*when* and *where*) and the behavioural response (*what*), for instance, "I will eat an apple (*what*) at 8 am (*when*) in the kitchen (*where*)." In addition, action plans often also specify *how* the planned behaviour should be executed upon cue detection (Hagger & Luszczynska, 2014; Schwarzer, 2008), for instance, "I will eat a *sliced* apple at 8 am in the kitchen". To further enhance the likelihood of executing the planned behaviour after forming an action plan, action plans are accompanied by additional components such as *coping plans* (Sniehotta et al., 2005). With coping plans, potential barriers to enacting the planned behaviour are anticipated and alternative behaviours or situations are formulated, for instance, "If I don't have an apple at home, then I will eat a banana instead" (alternative behaviour) or "If I am late for work, I will eat the apple at 10 am in the office" (alternative situation).

Implementation intentions and action planning have often been used interchangeably in health behaviour research and, in fact, both concepts have a high conceptual overlap (Hagger & Luszczynska, 2014). Thus, in health behaviour research, action planning and implementation intentions are often combined under one broader planning category (e.g., Adriaanse et al., 2011; Bélanger-Gravel et al., 2013). In this thesis, the term *action planning* will be used.

**Empirical Evidence on Action Planning Interventions**

As proposed by behaviour change theories (e.g., HAPA; Schwarzer, 2008), action planning is a volitional self-regulatory factor that initiates behaviour changes by translating one's intentions into actual behaviour (Zhang et al., 2019). Thereby, action planning is suggested to mediate the intention-behaviour relationship and, thus, might help to overcome the intention-behaviour gap (Gollwitzer, 1999; Schwarzer, 2008). Action planning interventions have generally been shown to effectively promote increases in health behaviour with satisfactory effect sizes. For instance, meta-analyses have shown that planning interventions lead to increases in overall goal achievement ($d$ = 0.65; Gollwitzer & Sheeran, 2006), physical activity ($d$ = 0.31; Bélanger-Gravel et al., 2013), and healthy nutrition ($d$ = 0.51; Adriaanse et al., 2011). However, these meta-analyses also show that effect sizes vary across studies and some studies found non-significant planning-health behaviour relationships (e.g., for FV consumption; Jackson et al., 2005). Accordingly, research has also focused on barriers to eating healthy. Pinho et al. (2018) identified lack of willpower, time constraints, and taste preferences as most strongly associated with less FV consumption among participants. In qualitative research, John and Ziebland (2004) concluded that the reported high cost and lack of access to fruit and vegetables are the most consistent barriers. To overcome such barriers, more detailed insights into how action planning interventions actually lead to health behaviour changes are of great importance.

## Action Planning Interventions at High Resolution

Whereas health behaviour research has generally supported the benefits of action planning interventions for overall health behaviour change (e.g., Gollwitzer & Sheeran, 2006), the link between action planning and actual health behaviour change is not yet fully understood. Thus, in this thesis, a more fine-grained picture shall be drawn, providing insights into the questions of *how* and *when* action planning results in overall behaviour change. The next sections will introduce selected aspects of action planning interventions that will be explored empirically in Chapters 2 to 4.

**Plan enactment as a conditional behavioural outcome.** To evaluate the effects of action planning interventions, research has mainly focused on its effects on unconditional health behaviour outcomes, such as overall physical activity (e.g., Bélanger-Gravel et al., 2013) or healthy eating (e.g., Adriaanse et al., 2011). These outcome measures summarize all goal-directed health behaviours, that is, in the context of FV consumption, unconditional health behaviour change refers to an overall change in FV intake, including any consumption of any fruit or vegetable. However, action plans are of conditional nature, that is, by forming an action plan one determines the exact behavioural response (e.g., eating an apple) upon detecting the specified situational cue (e.g., at 8 am in the kitchen). This leads to conditional outcome measures that display whether the planned behavioural response is enacted given that the planned situation is encountered (conditional probability; Sniehotta, 2009). In this vein, de Vries et al. (2013) established the term *plan enactment* for the conditional behavioural outcome describing the extent to which individuals execute their plan exactly as planned. That is, successful plan enactment refers to encountering and detecting the planned situation (e.g., entering the kitchen at 8 am) and subsequently executing the planned behaviour (e.g., eating an apple). This outcome measure can provide a more fine-grained picture of the behavioural response after forming an action plan while taking into account the conditional nature of action plans.

Plan enactment has been a rare object of study in health behaviour research. However, evidence showed heterogeneous but rather high plan enactment scores, which, in the context of healthy nutrition, ranged from 50.0% to 69.4% (Kasten et al., 2017). Moreover, in different health behaviour domains, a positive relationship between plan enactment and health behaviour change was found. For instance, in the context of smoking cessation, de Vries et al. (2013) found that individuals who executed their plan as intended were more likely to quit smoking. In the same domain, Verbiest et al. (2014) provided evidence that general practitioners who enacted their plans on providing smoking cessation care to their patients were more likely to act accordingly. This positive relationship was confirmed in the physical activity domain (Fleig et al., 2017) as well as, in the nutritional context, for fruit consumption (Kasten et al., 2017). Whereas these findings underline the importance of considering conditional outcomes (i.e., plan enactment) when investigating the effects of action planning, not much is known about which plans support the successful translation into action, leading to the open question of which plan characteristics lead to successful plan enactment.

**Which action plan characteristics matter?** As action planning requires individual decision-making, self-generated plans (as opposed to researcher-generated plans; Hagger & Luszczynska, 2014) may vary highly between persons regarding their content and its characteristics. This might be especially prominent when complex behaviours such as nutritional dietary changes are involved (Sniehotta, 2009). Plan characteristics, such as *plan specificity*, are considered important aspects that account for the quality of action plans, which, in turn, may affect subsequent plan enactment and overall behaviour change (van Osch et al., 2010). Moreover, most research on plan characteristics has focused on unconditional health behaviour outcomes and behavioural aggregates (e.g., de Vet et al., 2011; Dombrowski et al., 2016). Only a few studies examined the relationship between plan characteristics and conditional behavioural outcome measures (i.e., plan enactment; e.g., Fleig et al., 2017; Keller et al., 2017).

*Plan specificity* is the most frequently examined plan characteristic and seems to be highly relevant for successful plan enactment (Fleig et al., 2017). It refers to the specificity of the planned situational cues and the planned behavioural response. That is, the action plan “Tomorrow morning, I will eat an apple at home” may be recognised as such because it contains all structural elements of an action plan, i.e., the situational cue (*when* and *where*) and the behavioural response (*what*). However, its level of specificity is rather low as it could be enacted in numerous situations (e.g., different locations or times). In contrast, the action plan “Tomorrow morning, I will eat porridge with a sliced apple on top for breakfast at 8 am in the kitchen” is highly specific as it also contains a concrete time (“at 8 am”), location (“in the kitchen”), routine (“for breakfast”), and information about the rest of the meal (“porridge with a sliced apple on top”). Gollwitzer (1999) proposed that highly specific plans (i.e., plans that include a very precise description of the planned situational cues and the planned behavioural response) should lead to easier recognition of the critical situation and, subsequently, to a higher likelihood of executing the planned behaviour as intended. Thus, when plans are highly specific, the likelihood of plan enactment may be increased (van Osch et al., 2010).

Regarding unconditional health behaviour outcomes, the positive link with plan specificity was found in several health behaviour domains, such as physical activity (de Vet, Oenema, et al., 2011), condom use (de Vet, Gebhardt, et al., 2011), smoking cessation (van Osch et al., 2010), and weight loss (for individuals who were motivated to change; Dombrowski et al., 2016). However, empirical evidence on the link between plan specificity and plan enactment is scarce and mixed. In the study by Verbiest et al. (2014), a positive relationship between the specificity of self-generated action plans on smoking cessation care and plan enactment levels was found in a sample of general practitioners. Equivocally, two studies in the domain of physical activity found the specificity of the planned behavioural response to being negatively related (Fleig et al., 2017) or unrelated (Keller et al., 2017) to plan enactment. Considering the specificity of the situational cues, results on the link between the specificity of when-cues and plan enactment are inconsistent, indicating a positive (Fleig et al., 2017) or negative association (Keller et al., 2017), respectively. For where-cues (i.e., location), no associations with plan enactment were found (Fleig et al., 2017; Keller et al., 2017). These heterogeneous findings point to the need to further investigate how the specificity of plans can contribute to higher levels of plan enactment. Furthermore, to our knowledge, these relations have not yet been studied in the context of healthy nutrition, which would extend prior research even more.

In a nutritional health behaviour context, it is common to jointly investigate the consumption of fruit and vegetables (see Adriaanse et al., 2011). This is reasonable as fruit and vegetables share important characteristics, e.g., the consumption of both fruit and vegetables is associated with health benefits (e.g., Aune et al., 2017). However, the nutrient content differs between fruit and vegetables (Slavin & Lloyd, 2012) and unique health benefits for either fruit or vegetable consumption have been found (Armitage, 2007). For instance, Wark (2005) showed that the consumption of fruit but not the consumption of vegetables is positively associated with the protection from a specific type of colon cancer (i.e., hMLH1 protein-deficient colon cancer). Moreover, Kellar and Abraham (2005) found a correlation of $r = 0.41$ ($p = 0.01$) between the consumption of fruit and vegetables, emphasizing the need for a distinct investigation of FV consumption.

In this vein, Armitage (2007) argues that the cognitions underlying fruit consumption may be different from those underlying vegetable consumption. For instance, whereas fruit can be consumed with little or even without preparation (i.e., raw or as a snack), vegetables are most often part of larger meals and require more preparational effort (e.g., cooking). This might lead to higher consumption of fruit than vegetables, with time constraints being a relevant barrier to eating healthy (Pinho et al., 2018). Moreover, Pinho et al. (2018) found differences in barriers to eating healthy between the consumption of fruit and vegetables, that is, lack of willpower mainly led to less consumption of fruit, whereas a busy lifestyle impeded the consumption of vegetables. Another notable difference between fruit and vegetables is their taste: Due to a high fructose level (Slavin & Lloyd, 2012), fruit usually tastes sweeter than vegetables and might be preferred therein. In this vein, evidence shows that vegetables are consumed less than fruit (Mensink et al., 2017a, 2017b), which leads to the assumption that integrating the consumption of fruit into one's daily diet seems to be an easier task than integrating the consumption of vegetables.

Based on these outlined differences, it seems to be valuable to consider the consumption of fruit and vegetables separately and to investigate the *type of the planned behaviour* (i.e., nutritional choice) as another plan characteristic, which refers to whether the consumption of either fruit or vegetables is planned. As the differential intake of fruit and vegetables is rarely examined, this will provide a more detailed picture of the differential impacts of either fruit or vegetable consumption on plan enactment.

**Plan pursuit: What happens after the intervention?** As outlined above, health behaviour research tends to evaluate the effects of action plans on unconditional health behaviour outcomes (e.g., healthy nutrition; Sniehotta, 2009). However, Sniehotta (2009) argued that to better understand the effects of action planning interventions, conditional and unconditional planning effects should be distinguished. Unconditional planning effects refer to any goal-directed behaviour and are independent of whether the plan was enacted or not (i.e., overall health behaviour change). Conditional planning effects, in contrast, describe a selective part of behaviour, that is, the performance of the planned behaviour after the planned situational cues were detected (i.e., plan enactment). However, the link between conditional and unconditional planning effects has not yet been fully understood. In empirical research, results indicate that effects on overall health behaviour outcomes could be the result of regular plan enactment (de Vries et al., 2013). However, in the context of healthy nutrition, Kasten et al. (2017) found heterogeneous correlations between the enactment of fruit action plans and overall fruit consumption ($-0.01 \leq r \geq 0.59$). Thus, changes in overall health behaviour might be partly but not fully explained by successful plan enactment.

Moreover, another issue that research has not yet resolved is the heterogeneity of plan enactment operationalizations: Some studies used dichotomous (de Vries et al., 2013), 4-point (Kasten et al., 2017) or 5-point scales (Verbiest et al., 2014) to assess the enactment of plans. Results were then, for instance, aggregated into a plan enactment scale (de Vries et al., 2013) or merged into distinct plan enactment categories (Verbiest et al., 2014). In the domain of physical activity, Keller et al. (2017) applied coding procedures in which the self-reported behavioural outcome (i.e., physical activity) was compared with the “what”-part of the corresponding plan and Fleig et al. (2017) let participants rate the extent to which they had enacted each of up to three self-generated action plans on a scale from 0% (not enacted as planned) to 100% (completely enacted as planned). Thus, these previous studies comprised broader operationalizations of plan enactment that did not take into account whether one had encountered the planned situation when the planned behaviour was performed. What is missing in prior research is the distinct evaluation of the two components of plan enactment: (1) the exposure to and detection of the planned situational cue (versus no cue detection) and (2) the execution of the planned behaviour (versus the performance of a different goal-directed behaviour). Combining these, the behavioural action after forming an action plan could be categorized into four different types of plan pursuit in which either none, one or both of the two plan enactment components deviate from the actual plan. Given the sample action plan of eating an apple at 8 am in the kitchen, the following four scenarios are of relevance:

(1) The planned behaviour is performed in the planned situation (i.e., conditional planning effect; Sniehotta, 2009; e.g., an apple was eaten at 8 am in the kitchen).

(2) A different goal-directed behaviour is performed in the planned situation (e.g., a banana was eaten at 8 am in the kitchen).

(3) The planned behaviour is executed in a different situation (i.e., a different time and/or location; e.g., an apple was eaten at 1 pm in the cafeteria).

(4) A different goal-directed behaviour is performed in a different situation (e.g., a banana was eaten at 1 pm in the cafeteria).

In theoretical approaches, detecting the planned cue is defined as a prerequisite for executing the planned behaviour, that is, no rationale for health behaviour change is provided when the planned situation is not encountered (Gollwitzer, 1999). Thus, from a theoretical point of view, only those scenarios that include successful cue detection (i.e., scenarios 1 and 2) would lead to changes in the overall health behaviour (Gollwitzer, 1999). However, each of these four scenarios would in fact lead to the consumption of one serving of fruit, irrespectively of whether the planned cue was detected or not. To disentangle which of these scenarios would effectively contribute to changes in the overall health behaviour, the individual contribution of cue detection and the execution of the planned behaviour to overall behaviour change needs to be investigated.

**Considering temporal dynamics for health behaviour change.** The recent position paper by Scholz (2019) addresses the need for a stronger consideration of temporal dynamics in health psychology. This call for stronger theorizing on temporal matters has been discussed in various disciplines, for instance in occupational health psychology (Spector & Pindek, 2016) but did not yet gain much attention in health psychology (Spruijt-Metz et al., 2015). Only a few theories addressed the explicit role of time in the conceptualisation of psychological constructs and theorised about the dynamic development of relationships between constructs (i.e., when do effects unfold and cease; Mitchell & James, 2001; Spruijt-Metz et al., 2015). For instance, the Transtheoretical Model (TTM; Prochaska & DiClemente, 1983) postulates six stages of behaviour change (i.e., precontemplation, contemplation, preparation, action, maintenance, and termination) that unfold over time. However, the model has been criticized for simplifying human behaviour by restricting it to certain temporal stages that might not be capable of fully depicting complex health behaviour changes such as increases in physical activity (Adams & White, 2005). However, not considering temporal matters might lead to missed opportunities in gaining knowledge about temporal dynamics of relevant constructs (Scholz, 2019). This already applies to the conceptualisation of constructs (i.e., the chosen reference of time for, e.g., the amount of fruit and vegetables consumed) in cross-sectional studies (Scholz, 2019). In longitudinal research designs, intervention studies, and randomized controlled trials (RCTs), the question of temporal matters is even more important as miss-specified time lags might cause non-negligible consequences such as underestimating or even completely missing the detection of relationships between variables over time (Dormann & Griffin, 2015; Mitchell & James, 2001). For instance, in the meta-analysis by Adriaanse et al. (2011), the time lag between the action planning intervention and the assessment of the outcome measure (i.e., healthy eating) varied highly, ranging from directly after the intervention to nine months afterwards. Although Adriaanse et al. (2011) found an overall effect size of $d = 0.51$ for improvements in healthy eating, effects between studies vary. Thus, the timing of the measurement can have profound effects on the outcome, demonstrating the need for investigating intervention effects on different time scales (Boker et al., 2009).

To evaluate the effectiveness of an intervention, many studies used a limited number of assessments and, subsequently, aggregations of the behavioural outcome measure over a certain time period (e.g., over the past seven days; Adriaanse et al., 2011). Thus, evidence concerning middle- or long-term effects of action planning interventions exists in the literature, but research lacks the investigation of day-to-day measurements of behaviour change right after an intervention and information about short-term intervention effects. For this goal, the assessment of intensive longitudinal data, for instance, obtained by ecological momentary assessment (EMA; Stone & Shiffman, 1994) or daily diaries, is useful. Intensive longitudinal data have many benefits, such as reduced recall biases and high ecological validity (Bolger & Laurenceau, 2013), and enables both considering interindividual between-person differences and intraindividual temporal dynamics (i.e., at the within-person level) by using elaborated statistical techniques (e.g., *multilevel modelling*), which leads to a more process-oriented investigation of psychological constructs (Hamaker et al., 2015; Hamaker & Wichers, 2017).

Regarding the context of healthy nutrition, previous studies assessed intensive longitudinal data (i.e., used daily nutrition-related outcome measures) but aggregated the outcomes across different time periods. For instance, Brookie et al. (2017) conducted a smartphone-based intervention study, evaluating the effects of a 13-day text messaging intervention. The daily FV measure was aggregated across two weeks and showed increased FV consumption over time (Brookie et al., 2017). When considering action planning interventions, aggregated daily diary measures were used by Gratton et al. (2007) and

Verplanken and Faes (1999): Verplanken and Faes (1999) found increases in healthy eating from the 1st to the 5th day and Gratton et al. (2007) from the 8th to the 14th day following the intervention. Though these studies reveal insights into the uptake of FV consumption shortly after the action planning intervention, analysing these data at a higher resolution, that is, accounting for interindividual differences between persons and intraindividual changes over time, would provide a much more detailed picture of the unfolding of intervention effects (i.e., when and for how long the behaviour was changed).

As examples of innovative analytical approaches for intensive longitudinal data in health psychology, Berli et al. (2016) and Inauen et al. (2017) modelled discrete changes between study phases while accounting for interindividual between-person differences and intraindividual (i.e., temporal) within-person changes. That is, in addition to examining day-to-day effects on the respective study outcomes differentially in two phases (e.g., during the intervention and following the intervention; Berli et al., 2016), the models comprised a discrete change between both phases, indicating if there was an immediate effect for the first day of the second study phase (e.g., the first day after the intervention). Whereas for the action control intervention on physical activity (Berli et al., 2016) and the social support intervention on healthy eating (Inauen et al., 2017) group effects (i.e., participants in the intervention group were more likely to show the desired behaviour) were found, no discrete changes between study phases emerged. However, different active ingredients of interventions might lead to different change dynamics in health behaviour outcomes. Thus, applying these analytical approaches to action planning interventions on healthy eating would add to a more fine-grained picture of underlying temporal dynamics between psychological constructs.

**Aims and Research Questions**

Much research has been done to examine the effects of action planning interventions on FV consumption (e.g., Adriaanse et al., 2011). However, what is missing in previous research is a more fine-grained picture of specific mechanisms of action planning interventions regarding the open question of how and when an action planning intervention unfolds its effects. Thus, this thesis aims to reveal high resolution-insights into specific mechanisms of action planning interventions by investigating the following research questions in the context of FV consumption:

First, this thesis aimed at investigating plan enactment as conditional health behaviour outcome (de Vries et al., 2013; Sniehotta, 2009). As plan enactment has not yet been studied comprehensively, the frequency and temporal development of plan enactment were examined to further explore the behavioural response after forming an action plan. Several studies highlighted the importance of distinguishing the characteristics of action plans to understand how action planning interventions unfold their effects over time (Fleig et al., 2017; Keller et al., 2017). By adapting a framework on plan characteristics (cf. Fleig et al., 2017; Keller et al., 2017), the aim was to investigate the relationship between plan characteristics (i.e., plan specificity and type of planned behaviour) as well as time variables (i.e., times of day and plan calendar day) and plan enactment. The following research questions were examined (Chapter 2):

*How often do people enact their self-generated action plans? Which plan characteristics are associated with plan enactment? How do time variables influence plan enactment and its relationship to plan characteristics?*

Second, to add to an even more comprehensive picture of plan enactment and the behavioural response after forming an action plan, in Chapter 3, the aim was to gain a detailed picture of how exactly plans are enacted by, first, investigating the frequency of cue detection and the execution of the planned behaviour and, second, their links to changes in overall FV intake. Considering theoretical approaches, Gollwitzer (1999) emphasized the importance of cue detection for successful plan enactment. However, in empirical research not much is known about the individual contribution of cue detection and the execution of the planned behaviour to overall behaviour change. The research questions (Chapter 3) were as follows:

*How often are cue detection and the execution of the planned behaviour shown after forming an action plan? What role do cue detection and the execution of the planned behaviour at the between- and within-person level as well as their within-person interaction play in predicting overall FV consumption?*

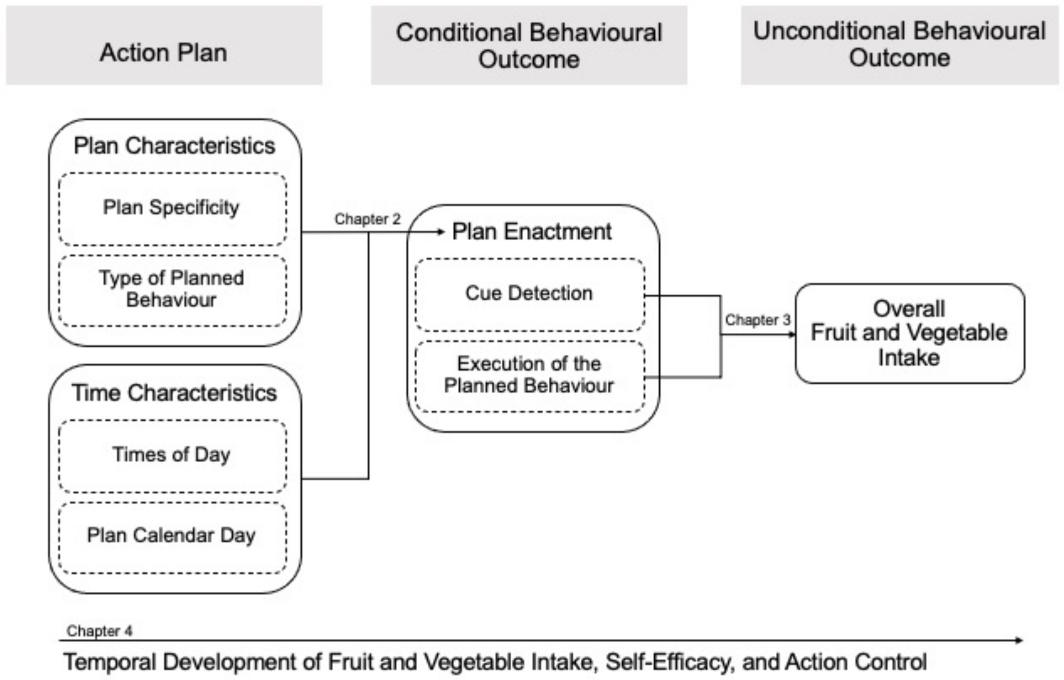
Third, another aspect of action planning interventions that has not yet been studied thoroughly, is the day-to-day temporal development of unconditional planning effects following an intervention. Yet, investigating health behaviour change at a high temporal resolution allows for a better understanding of when exactly interventions unfold their effects and, therefore, provides important practical insights into starting and end points of health behaviour change (Scholz, 2019). Thus, another aim of this thesis was to investigate the temporal development of unconditional health behaviour change immediately following an action planning intervention. The following research questions were examined (Chapter 4):

*When does an action planning intervention unfold its effects on the unconditional behavioural outcome (i.e., FV intake) and volitional outcome variables (i.e., self-efficacy and action control) and how do these intervention effects evolve over time?*

Figure 1 shows the conceptual model of this thesis, summarizing the research questions and outlining the associations between conditional and unconditional behavioural outcomes after forming an action plan.

**Figure 1**

*Conceptual Model of this Thesis, Summarizing the Research Questions of Chapters 2 to 4*



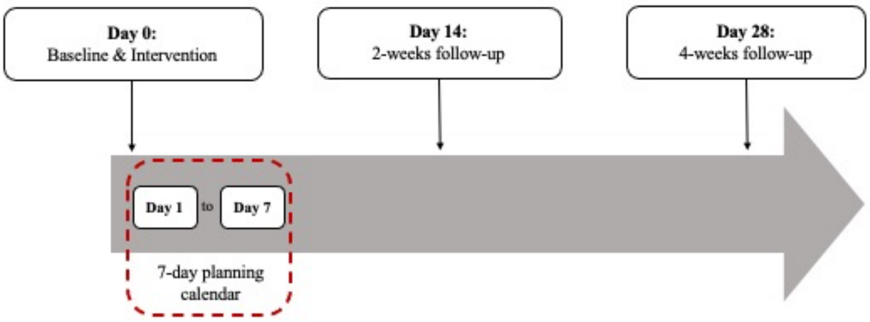

## Study Projects

The two study projects used in this thesis investigated the health behaviour context of FV intake after an action planning intervention. The respective study designs as well as information about the analysed samples will be summarized within the next sections.

**Happy 5.** The two-arm online-based RCT aimed at increasing FV consumption through an action planning (standard intervention condition) and a combined action planning and self-efficacy intervention (enhanced intervention condition) in an adult population (*N* = 279). The RCT consisted of a baseline assessment including the intervention session as well as two follow-up sessions after two and four weeks (Figure 2). In the intervention session, participants received a 7-day planning calendar in which they should enter self-generated action plans on when, where, and/or with whom they would consume which type of fruit and vegetables. In primary data analyses, Keller et al. (2018) found an increase in FV consumption over time for the enhanced as well as for the standard intervention condition. As the standard and the enhanced intervention condition received the same planning intervention, the subsample used for secondary analyses (Chapter 2) consists of participants from both conditions who submitted complete plan calendars. In sum, data from *n* = 92 participants (*n* = 66 women, *n* = 26 men; mean age = 33.37 years, *SD* = 14.80 years, range = 19–70 years; mean body mass index (BMI) = 22.24, *SD* = 2.66, range = 17.56–32.08) were used for present secondary analyses.

**Figure 2**

*Study Design of the Happy 5 Project*




*Note.* Data used for secondary analyses (Chapter 2) are marked by the red box.

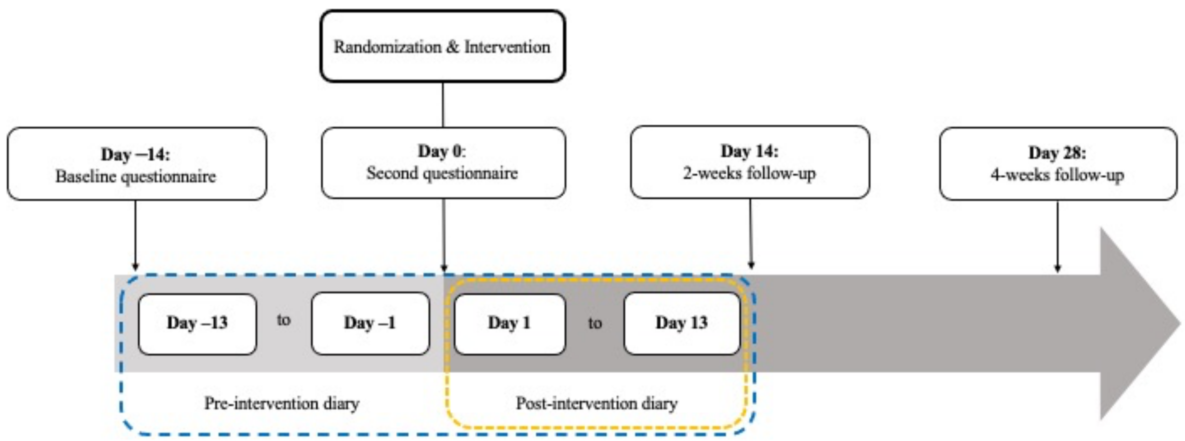
**Von Birnen und Bohnen (BiBo) [About pears and beans].** The aim of this intensive longitudinal two-condition RCT was to increase adults' daily FV consumption by a very brief action planning intervention. The RCT consisted of a baseline questionnaire, followed by a 13-days end-of-day diary (i.e., pre-intervention diary), a subsequent second questionnaire including the intervention, another 13-days diary (i.e., post-intervention diary) as well as follow-up sessions two and four weeks following the intervention (Figure 3). The intervention for participants assigned to the planning condition comprised the formulation of an action plan for one additional daily FV serving.

In primary analyses (Chapter 4), data from both intervention conditions and from the pre- and post-intervention diary were used. Thus, the full sample of *N* = 206 participants who were randomly assigned to the action planning condition (*n* = 106; *n* = 83 women, *n* = 23 men; mean age = 32.80 years, *SD* = 12.25 years, range = 19–63 years; mean BMI = 22.72, *SD* = 3.13, range = 18.00–32.77) or the waiting-list control condition (*n* = 100; *n* = 75 women, *n* = 25 men; mean age = 30.59 years, *SD* = 10.06 years, range = 20–66 years; mean BMI = 22.25, *SD* = 3.23, range = 16.80–32.85) was analysed.

For secondary analyses (Chapter 3), only participants assigned to the planning condition and data from the 13-days post-intervention diary were used (see Figure 3). That is, data of *n* = 90 participants who returned the post-intervention diary and provided at least one daily report on their FV plan (*n* = 72 women, *n* = 18 men; mean age = 32.26 years, *SD* = 12.55 years, range = 19–63 years; mean BMI = 22.47, *SD* = 3.00, range = 18.00–32.77) were analysed.

**Figure 3**

*Study Design of the BiBo Project*




*Note.* Data used for primary analyses (Chapter 4) and secondary analyses (Chapter 3) are marked by the blue and yellow boxes, respectively.

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# Chapter 2

## What makes a good action plan? Characteristics and enactment of fruit and vegetable plans

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**Abstract**

*Background:* One promising intervention strategy to increase fruit and vegetable (FV) consumption is action planning. However, conditions of successful plan enactment, i.e., the translation of plans into action, have rarely been studied. Therefore, the relationship between plan characteristics and plan enactment is being examined.

*Methods:* Secondary analyses of an existing data set were conducted, based on a larger behavioural intervention study with a baseline assessment as well as a 2-weeks and a 4-weeks follow-up. After baseline assessment, participants completed action plan calendars for the following seven days and subsequently reported on each plan's enactment. Two independent raters coded 1732 morning, noon/afternoon, and evening plans by $n = 92$ individuals regarding the level of specificity (unspecific vs. specific) and type of planned behaviour (fruit vs. vegetable intake). To predict plan enactment, multilevel logistic regression analyses were conducted.

*Findings:* Overall specificity of plans was unrelated to plan enactment, but interacted with time of day in predicting plan enactment. Only in the morning, specific plans were more likely being enacted than unspecific plans. Overall, plan enactment decreased during the day and throughout the seven days of the plan calendar. Furthermore, fruit plans were more likely being enacted than vegetable plans.

*Discussion:* Specific morning plans were found most beneficial for the enactment of FV plans. Here, possible underlying mechanisms such as stable morning routines should be further investigated. Moreover, the nutritional choice appeared to make a difference for plan enactment: Increasing one's fruit consumption may be easier than integrating more vegetables into one's daily diet.

*Keywords:* fruit and vegetable intake, plan enactment, plan characteristics, plan specificity

## Introduction

Fruit and vegetable (FV) intake has been shown to reduce the risk of cardiovascular disease, cancer, and overall mortality rates (Aune et al., 2017). Consequently, a variety of public health recommendations exist. The World Health Organization (WHO) recommends an individual FV intake of at least five portions a day (WHO/FAO, 2003). Although many people intend to eat healthily (e.g., Pietersma & Dijkstra, 2011), a representative survey of the adult German population showed that the vast majority fails to meet the recommended diet. Among participants responding to this survey, only 56% consumed fruit on a daily basis, whereas the daily intake of vegetables was even less (32%) (Mensink et al., 2017b, 2017a). Therefore, it is of great importance to implement effective interventions targeting increased FV consumption (Luszczynska et al., 2007).

Intention has been referred to as a primary determinant of behaviour (e.g., Ajzen, 1991). However, many motivated individuals fail to translate their intentions into action, a phenomenon commonly called “intention-behaviour-gap” (e.g., Godin & Conner, 2008). The Health Action Process Approach (HAPA; Schwarzer, 2008) focuses on closing this gap by including action planning as a predictor of behaviour change. Action planning is a self-regulatory skill used to translate one's intention into actual behaviour (Hagger & Luszczynska, 2014). It pertains to making detailed plans with multiple discrete components, such as a behavioural response (i.e., what to do), an occasion or time (i.e., when), a place (i.e., where), and other persons (i.e., with whom). Systematic reviews have generally shown positive links between planning and health behaviour outcomes (Gollwitzer & Sheeran, 2006), such as physical activity (Bélanger-Gravel et al., 2013) and healthy nutrition (Adriaanse et al., 2011). However, more insights into the mechanisms underlying the relationship between planning and healthy nutrition are needed. For instance, little is known about how nutritional plans should be formed to increase the chances of plan enactment.

**Plan Enactment as a Behavioural Outcome**

The success of action plans is mostly evaluated by their effect on distal health behaviour outcomes, such as general physical activity (Knoll et al., 2017) or healthy eating (Adriaanse et al., 2011). Plan enactment (de Vries et al., 2013; Kasten et al., 2017) as a more proximal behavioural outcome is rarely examined (Sniehotta, 2009) and refers to the extent to which individuals enact their exact plans as opposed to generally increasing the target behaviour per se. Plan enactment, therefore, provides a more fine-grained picture of health behaviour change due to action planning. In the nutritional context, the study by Kasten et al. (2017) targeted the link between plan enactment and overall behaviour change and found a positive relationship between plan enactment and fruit consumption. This positive relationship was confirmed for other health behaviours such as physical activity (Fleig et al., 2017) or smoking cessation (de Vries et al., 2013; Verbiest et al., 2014). However, relationships between plan enactment and plan characteristics have rarely been studied. To close this gap, this study refers to Fleig et al. (2017) and Keller et al. (2017) who established and tested conceptual frameworks on plan characteristic-plan enactment links in the context of physical activity.

**Plan Characteristics as Predictors of Plan Enactment**

*The type of planned behaviour* (nutritional choice) refers to whether the consumption of either fruit or vegetables is planned. It is recommended to eat at least five portions of fruit and vegetables a day whereby three of these portions should consist of vegetables and two of fruit (WHO/FAO, 2003). Many studies have addressed the overall increase in fruit and vegetable consumption (e.g., Wiedemann et al., 2012), however, the differential intake of either fruit or vegetables and respective correlates of both behaviours are rarely examined. For instance, time constraints are considered as a barrier of overall healthy nutrition (Pinho et al., 2018). However, the preparation effort for eating fruit differs from the effort for eating vegetables as many types of fruit can be consumed with little or without preparation (i.e., raw or as a snack) whereas vegetables are more often part of larger meals and therefore need more time to be prepared. Moreover, due to a high fructose level (Slavin & Lloyd, 2012), fruit usually tastes sweet or, for many people, at least better than vegetables and are therefore preferred. In this sense, it might be easier to integrate fruit than vegetables into one's daily diet.

*Plan specificity* is a frequently investigated plan characteristic. For example, Reinwand et al. (2016) found that about 60% of their participants generated highly specific plans for their fruit and vegetable intake. Gollwitzer (1999) assumed that individuals who describe planned behaviour and situational cues very precisely will recognize the critical situation more easily and will, therefore, be more likely to act as planned. The positive link between plan specificity and general health behaviour outcomes has to our knowledge not yet been studied in a nutritional context but has been supported in several studies regarding physical activity (de Vet, Oenema, et al., 2011), smoking cessation (van Osch et al., 2010), condom use (de Vet, Gebhardt, et al., 2011), and weight loss (Dombrowski et al., 2016).

However, few studies have linked plan specificity to plan enactment, and empirical evidence is mixed. For instance, Verbiest et al. (2014) found a positive relationship between health care professionals forming highly specific plans and their subsequent plan enactment regarding providing patients with smoking cessation care. In contrast, two physical activity studies demonstrated that highly specifically planned physical activities were negatively related (Fleig et al., 2017) or unrelated (Keller et al., 2017) to plan enactment. Therefore, links between plan specificity and plan enactment need further study.

**The Present Study and its 7-Day Plan Calendar Intervention**

In the present action planning intervention, FV plans were formed in a 7-day calendar format for the seven days following the intervention session (i.e., day 1 to day 7) and for three distinct pre-defined *times of day* (i.e., morning, noon/afternoon, and evening). Since plans might be formulated in a specific order, that is, participants start with day 1 and end with day

7, a *linear calendar day trend* needs to be considered as a correlate of plan enactment (cf. linear plan rank; Keller et al., 2017). For instance, plans generated first could be best elaborated and could have the highest chance of enactment (Keller et al., 2017). Furthermore, FV plans might differ between distinct times of day (i.e., morning, noon/afternoon, or evening) regarding the type of planned behaviour (e.g., planning to eat an apple in the morning and peas in the evening) or levels of specificity. Plan characteristics and their combinations could be distinctly related to plan enactment and should be explored in more detail.[1]

**Aims and Hypotheses**

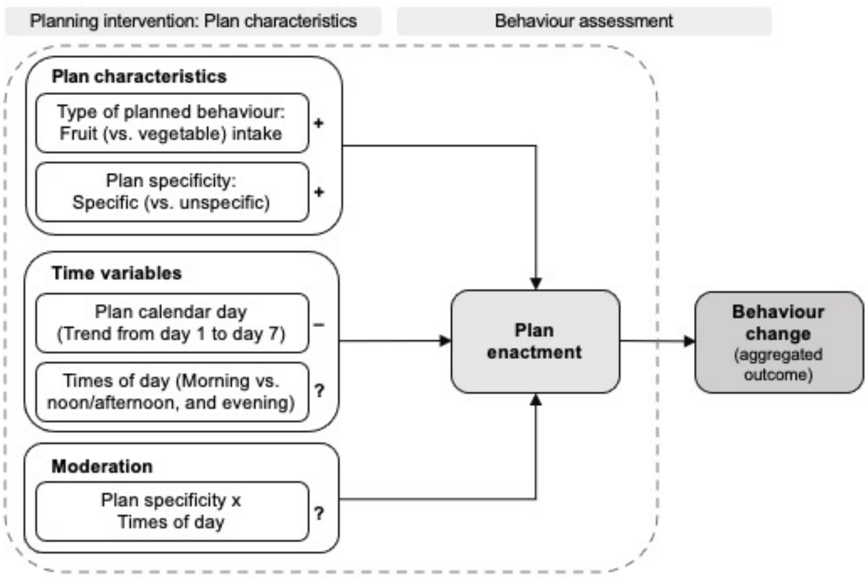
Based on existing frameworks distinguishing characteristics of plans (cf. Fleig et al., 2017; Keller et al., 2017), the present study aims to develop a framework of plan characteristics for FV plans formed in a 7-day calendar format and to investigate links between plan characteristics and plan enactment (see Figure 1). In a 7-day calendar format, persons' FV plan entries can differ regarding characteristics such as the type of planned behaviour, that is, planning to consume fruit or vegetables, and plan specificity, that is, the precision with which persons provide information about their planned behaviour (e.g., eat an apple vs. eat an apple at home after work). In previous research, evidence on the relationship between plan enactment and type of planned behaviour is rare. However, barriers to healthy nutrition such as time constraints (Pinho et al., 2018) might be associated with FV intake differentially in favour of consuming more fruit. Therefore, it was assumed that individuals would be more likely to enact fruit plans when compared to vegetable plans (Hypothesis 1). Moreover, different levels of a plan's specificity can be related to different levels of subsequent plan enactment. As a larger body of research reports positive relationships between plan specificity and health behaviour outcomes (e.g., de Vet, Oenema, et al., 2011;

[1] Present analyses do not aim to examine the total amount of FV consumption which was done in detail in primary analyses (Keller et al., 2018) showing an increase in FV consumption over time (T1/day 0 to T3/day 28) for the enhanced as well as for the standard intervention condition.

Verbiest et al., 2014), we assumed positive relationships between plan specificity and plan enactment (Hypothesis 2). Furthermore, it was expected that plans formed at the beginning of the plan calendar (e.g., for day 1) should be more likely to be enacted than later plans (e.g., for day 7) (cf. Keller et al., 2017). Thus, a negative association between plan enactment and the linear calendar day was assumed (Hypothesis 3). To gain more insights into the question "When are which kinds of plans more effective?", this study further explores time characteristics of participants' plans. It shall be explored whether plan enactment differs by plans formed for the morning (vs. noon/afternoon, and evening) as well as by interactions between morning (vs. noon/afternoon, and evening) plans and different levels of plan specificity.

**Figure 1**

*Conceptual Model: Plan Characteristics-Plan Enactment-Relationships for Plans formed in a 7-Day Calendar Format based on Fleig et al. (2017) and Keller et al. (2017)*




*Note.* --- focus of the present analyses; + hypothesized positive relationship; - hypothesized negative relationship; ? exploratory analyses.

## Methods and Materials

### Participants and Procedure

This study presents secondary analyses of a two-arm online randomized controlled trial (RCT; Keller et al., 2018) aiming to increase fruit and vegetable consumption to at least five portions a day. The RCT took place between September and November 2016 and consisted of a baseline assessment including the intervention session (T1/day 0) as well as two follow-up sessions after two (T2/day 14) and four (T3/day 28) weeks. Participants were healthy German-speaking adults, being at least 18 years old, who received the chance to win one out of six vouchers (about 50 EUR) if they completed all three measurement points in time. More detailed information regarding the recruitment approach, the participant flow, and the procedures are provided elsewhere (Keller et al., 2018). In primary data analyses, the effectiveness of an enhanced intervention (i.e., planning intervention with self-efficacy training) was compared to a standard intervention (i.e., the same planning intervention, but without self-efficacy training) with respect to FV consumption as a primary outcome at a 2-week and a 4-week follow-up assessment. In the present secondary analyses, we aim to investigate how characteristics of participants' action plans formed in the planning intervention (see Figure A1 for the instructions of the planning intervention) are linked with successful plan enactment. As the standard and the enhanced intervention condition received the same planning intervention, we collapsed both conditions in the present analyses.

At the first online session (T1/day 0), $N$ = 275 of two hundred and seventy-nine consenting participants responded to a baseline questionnaire that was followed by the (planning) intervention. During the intervention, participants received information about the common recommendations of eating at least five portions of fruit and vegetables per day and were then asked to generate ideas on how to integrate a fruit- and vegetable-rich diet into their daily lives. Subsequently, participants received a planning calendar in which they could enter their action plans to consume more fruit and vegetables for the subsequent seven days (see

Figure A1). This planning calendar consisted of seven columns (i.e., for the subsequent seven days) and three rows for times of the day (i.e., “morning”, “noon/afternoon”, and “evening”), thus, providing 21 text fields for participants' FV plans. Participants were instructed to form action plans fitting into their daily lives and were encouraged to generate action plans on when, where, or with whom they planned to consume fruit or vegetables. After completing their plan calendar, participants were asked to print their plan calendar and keep it in a well-visible place at home. At the end of each day for the following seven days (day 1 to day 7), they completed the printed plan calendar by labelling whether they had enacted each individual plan (+) or not (-) (see Figure A2 for an example of a completed plan calendar). Subsequently, participants were asked to return a photograph or scan of the completed plan calendar via e-mail.

A total of $n$ = 119 participants from both intervention conditions returned their plan calendar, however, 9 of these calendars could not be used for further analyses due to, e.g., poor quality of the photograph or scan. In 92 out of 110 plan calendars, participants reported the enactment of their plans as instructed, whereas plan enactment scores of 18 plan calendars could not be determined (due to, e.g., complete lack of labels). Hence, for present analyses, a subsample was used, consisting of data from $n$ = 92 participants ($n$ = 66 women, $n$ = 26 men; mean age = 33.37 years, $SD$ = 14.80 years, range = 19–70 years; mean body mass index (BMI) = 22.24, $SD$ = 2.66, range = 17.56–32.08) who produced a total of 1732 action plans. Using G*Power 3.1 (Faul et al., 2009), a post-hoc power analysis on the basis of the actual sample size $n$ = 92, alpha = .05, two groups (i.e., specific vs. unspecific plans), 21 measurement occasions, an assumed effect size of $f$ = 0.10 was conducted, indicating an estimated power of $\beta$ = 0.986.

The institutional review board of Freie Universität Berlin granted ethics approval for this study.

## Measures

**Plan enactment (outcome).** As participants reported by use of their plan calendar (day 1 to day 7) whether they had enacted an individual action plan (+) or not (-), plan enactment was operationalized by dichotomous scores indicating enactment (1) vs. no enactment (0) of each action plan.

**Plan characteristics (independent variables).** Plan characteristics were coded from the plans formed at the 7-days plan calendar intervention (at T1/day 0). Two trained independent raters coded characteristics of each plan based on newly developed (for the type of planned behaviour) or adapted (for plan specificity) coding manuals (Fleig et al., 2017). Inter-rater reliability coefficients (Cohen's kappa) were calculated. In case of differences in coding, discussions between both raters were conducted to reach a consensus which was then used as the final coding. For coding manuals see Table A1 (type of planned behaviour) and Table A2 (plan specificity).

*The type of planned behaviour (nutritional choice)* was coded with regard to the target behaviour reflected by three coding categories: 1 = *fruit plan*, 2 = *vegetable plan*, and 3 = *mixed plan* (consisting of fruit and vegetables). Pre-consensus inter-rater agreement (Cohen's kappa) across all plans was $\kappa = 0.95$. A dichotomous variable using vegetable plans as the reference group (0 = *vegetable plan,* 1 = *fruit plan*) was created. Mixed plans accounted for only 19.3% of all plans and were not considered for subsequent analyses.

*Plan specificity* was coded on a three-point scale with 1 = *unspecific*, 2 = *medium specific*, and 3 = *highly specific*. An action plan was unspecific if it only included the planned fruit or vegetable, but no additional cue. Additional cues were defined as information about the time (i.e., when-cue), location (i.e., where-cue), another person (i.e., with whom-cue), or about the rest of the meal (e.g., a cheese sandwich with cucumber, i.e., what else-cue). A plan was coded as medium-specific if it included one additional cue. If a plan consisted of at least two additional cues, it was coded as highly specific. Coding examples are: “an apple” (1 =

*unspecific*), “yogurt with an apple” (2 = *medium specific*), and “yogurt with an apple at home” (3 = *highly specific*; more examples are provided in Table A2). Inter-rater reliability across all plans was Cohen's kappa $\kappa = 0.84$. Due to the underrepresentation of the 3 = *highly specific* category (i.e., occurred in only 12.9% of the plans), the categories 2 = *medium specific* and 3 = *highly specific* were collapsed into the broader category “*specific*” (i.e., occurred in 65.7% of the plans). Thus, a dichotomous plan specificity variable was computed which differentiated between 0 = *unspecific plans* and 1 = *specific plans*.

Regarding *time variables*, a linear calendar day trend was operationalized as the chronological calendar day throughout the seven days of the plan calendar. The linear calendar day trend was centred on the first calendar day: the *first day* (0), the *second day* (1), ..., and the *seventh day* (6). Furthermore, as participants planned for three distinct times of day (i.e., morning, noon/afternoon, and evening), a dummy-coded variable using the morning as reference (0 = *morning*, 1 = *noon/afternoon*, 2 = *evening*) was created.

**Covariates.** The following baseline covariates (T1/day 0) were included: sex, age, BMI, assignment to the intervention condition (i.e., standard vs. enhanced intervention condition) as well as the overall number of plans formed by each person at the intervention session.

**Data Analyses**

Using SPSS Statistics version 25.0 (IBM Corp, 2017), descriptive analyses of the number of plans per person in relation to time variables and plan characteristics were conducted. Subsequently, $\chi^2$ and *t* tests, followed by logistic regressions were performed to examine differences between the subsample ($n = 92$) providing complete plan calendars (retained participants) and participants without (complete) plan calendars who could not be used for present analyses (not retained participants). To test the present hypotheses, a two-level structured dataset with action plans (level 1; within) crossed in participants (level 2; between) was prepared. Two-level univariate logistic models with plan enactment as the within-level outcome were run using the *glmer* function in the *lme4* package (Bates et al., 2015) in RStudio, version 1.1.456 (RStudio Team, 2016). To estimate the percentage of the total between-variance in the outcome (i.e., plan enactment), the intraclass correlation was computed. To test for associations between plan characteristics and plan enactment, separate models for the type of planned behaviour (fruit vs. vegetable plans; Model A) and plan specificity (specific vs. unspecific plans; Models B) were computed. To test for overall effects of fruit plans (vs. vegetable plans; Hypothesis 1), Model A was run with type of planned behaviour as a within-level predictor. To examine Hypothesis 2 (i.e., overall effects of specific vs. unspecific plans), an equivalent model (Model B1) was run with plan specificity as a within-level predictor. Furthermore, Model B2 was run to explore the effects of specificity for distinct times of day (moderation effects, unspecific morning plans as the reference).[2] An additional model (Model C) was specified with times of day as a within-level predictor (morning vs. noon/afternoon, and evening plans) to explore whether overall plan enactment levels differ between times of day. To investigate Hypothesis 3, the linear calendar day trend was included as a within-level predictor in all models. As between-level covariates, age, sex, BMI, intervention condition assignment, and overall number of plans per person were included. All predictor variables were grand-mean centred, except for dichotomous predictors and time variables. The linear calendar day trend was centred at 0 = *day 1* and the times of day variable was centred at 0 = *morning*. Potential random effects of level-1 predictors were tested in equivalent Mplus models (Mplus 7; Muthén & Muthén, 1998-2012), but were modelled as random effects predictors in final R models only when random effect variance was significant and models converged. Missing value analysis had been performed, resulting in Little's missing completely at random (MCAR) test (Little, 1988): $\chi^2$ (3) = 1.42, *p*

[2] Initial analyses showed that fruit plans rarely occurred as noon/afternoon and evening plans, as well as vegetable plans were rarely formed as morning plans. Thus, we refrained from analyzing fruit and vegetable plans for distinct times of day.

= .702, indicating that data are missing completely at random. In all analyses, a full information maximum likelihood procedure accounted for missing data (Larsen, 2011).

## Results

Out of all participants who participated at baseline ($N = 275$), a subsample of $n = 92$ participants returned a photograph or scan of their completed plan calendar and reported the enactment of their plans as instructed. Significant differences between persons who completed the plan calendar (retained participants) and persons without (complete) plan calendars (not retained participants) emerged for BMI only. Participants of the subsample included in the present analyses showed a lower BMI (retained participants: $M = 22.24$, $SD = 2.66$; not retained participants: $M = 23.56$, $SD = 4.44$; $t(203) = 2.50$, $p = .013$). Logistic regression models confirmed unique effects regarding BMI.

### Descriptive Results: Number of Plans per Person and its Relation to Plan Characteristics and Time Variables

Participants formed on average 18.83 ($SD = 3.30$) action plans out of 21 possible plans (for descriptive statistics on number of plans per person see Table 1). Overall, participants generated more vegetable than fruit plans. Interestingly, noon/afternoon and evening plans were more often vegetable than fruit plans, whereas morning plans were more often fruit than vegetable plans (Table 1). Regarding plan specificity, people generated a higher number of specific than unspecific plans. Furthermore, the average number of plans per person showed a decline in absolute levels throughout the seven days of the plan calendar.

**Table 1**

*Descriptive Statistics: Number of Plans per Person for Plan Characteristics across 7 Days and for Different Times of the Day*

| | Times of day | | | |
|---|---|---|---|---|
| Number of plans per person | Morning | Noon/afternoon | Evening | All times of the day |
| | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| All plans | 6.27 (1.58) | 6.40 (1.08) | 6.15 (1.46) | 18.83 (3.30) |
| Type of planned behaviour | | | | |
| Fruit plans | 4.65 (2.56) | 1.22 (1.93) | 1.09 (1.90) | 6.96 (3.62) |
| Vegetable plans | 0.47 (1.15) | 3.80 (2.69) | 3.96 (2.63) | 8.23 (3.94) |
| Level of specificity | | | | |
| Unspecific plans | 1.78 (2.75) | 2.21 (2.74) | 2.47 (2.76) | 6.46 (6.97) |
| Specific plans | 4.49 (2.94) | 4.20 (2.72) | 3.68 (2.71) | 12.37 (7.03) |

| | Plan calendar day | | | | | | |
|---|---|---|---|---|---|---|---|
| Number of plans per person | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 |
| | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| All plans | 2.84 (0.43) | 2.75 (0.60) | 2.75 (0.57) | 2.72 (0.62) | 2.70 (0.61) | 2.60 (0.70) | 2.48 (0.82) |

*Note.* $n$ = 92 participants and $n$ = 1,732 observations. Statistics on type of planned behaviour refer to $n$ = 1,397 observations, that is, plans which included only fruit or only vegetables.

**Plan Enactment: Associations with Time Variables and Plan Characteristics**

On average, participants reported enacting 68.7% (*SD* = 46.4) of their action plans (for descriptive statistics on plan enactment rates see Table 2). The intraclass correlation indicated that 8.71% of the variance was due to level-2 variation (i.e., between). Results from statistical models indicated non-significant plan enactment associations of level-2 covariates: sex, age, BMI, intervention condition assignment, and overall number of plans per person. None of the level-1 (i.e., within) predictors showed significant random variation, except for the type of planned behaviour (nutritional choice). Therefore, only type of planned behaviour was added as a random effects predictor in Model A (i.e., type of planned behaviour as a within-level predictor). Two-level univariate logistic model results showed that fruit plans were more likely being enacted than vegetable plans (Hypothesis 1; Table 3).

Results of Model B1 (i.e., plan specificity as a within-level predictor) revealed that overall plan specificity was unrelated to plan enactment (Hypothesis 2; Table 3). However, a significant interaction between plan specificity and times of day in predicting plan enactment was found (Model B2). The enactment of specific morning plans was more likely compared to enacting unspecific morning plans. Plan enactment levels of specific (vs. unspecific) plans differed between morning and noon/afternoon as well as between morning and evening plans (Figure 2). Further analyses showed that for noon/afternoon as well as for evening plans level of specificity was unrelated to plan enactment.

Regarding overall plan enactment levels for distinct times of day, morning plans had the highest enactment rates as opposed to noon/afternoon and evening plans (Table 2). A simple model (Model C) with times of day as predictor confirmed highest plan enactment rates for morning plans (Table 3). In all models, a negative linear calendar day trend of plan enactment confirmed that plan enactment decreases over the 7-day planning period (Hypothesis 3).

**Table 2**

*Descriptive Statistics among Plan Enactment and Plan Characteristics across 7 Days and for Different Times of the Day*

| | Times of day | | | |
|---|---|---|---|---|
| | Morning | Noon/afternoon | Evening | All times of the day |
| % Plan Enactment | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| All plans | 78.9 (40.8) | 65.2 (47.7) | 61.8 (48.6) | 68.7 (46.4) |
| Type of planned behaviour | | | | |
| Fruit plans | 80.7 (39.5) | 62.5 (48.6) | 78.4 (41.4) | 77.1 (42.0) |
| Vegetable plans | 83.7 (37.4) | 67.7 (46.8) | 58.7 (49.3) | 64.3 (47.9) |
| Level of specificity | | | | |
| Unspecific plans | 71.8 (45.1) | 65.3 (47.7) | 65.5 (47.7) | 67.2 (47.0) |
| Specific plans | 81.7 (38.7) | 65.1 (47.7) | 59.3 (49.2) | 69.5 (46.1) |

| | Plan calendar day | | | | | | |
|---|---|---|---|---|---|---|---|
| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 |
| % Plan Enactment | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* | *M (SD)* |
| All plans | 76.4 (42.6) | 70.1 (45.9) | 67.9 (46.8) | 66.5 (47.3) | 71.7 (45.2) | 61.3 (48.8) | 66.1 (47.5) |
| Type of planned behaviour | | | | | | | |
| Fruit plans | 81.8 (38.8) | 82.1 (38.5) | 82.4 (38.3) | 70.2 (46.0) | 77.0 (42.3) | 73.5 (44.4) | 72.8 (44.8) |
| Vegetable plans | 75.0 (43.5) | 59.6 (49.3) | 63.0 (48.5) | 61.1 (49.0) | 70.8 (45.7) | 53.3 (50.2) | 66.0 (47.6) |
| Level of specificity | | | | | | | |
| Unspecific plans | 76.5 (42.7) | 70.6 (45.8) | 62.5 (48.7) | 61.9 (48.9) | 71.3 (45.5) | 59.0 (49.5) | 67.9 (47.0) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Specific plans | 76.3 (42.6) | 69.9 (46.0) | 70.4 (45.8) | 68.9 (46.4) | 71.9 (45.1) | 62.5 (48.6) | 65.0 (47.9) |

*Note.* $n$ = 92 participants and $n$ = 1,705 observations ($n$ = 1,374 observations for type of planned behaviour) due to missing values of the plan enactment variable.

**Table 3**

*Multilevel Model Estimates regarding Associations of Plan Characteristics and Time Variables with Plan Enactment*

| | Model A: Overall Effects of Type of Planned Behaviour | | | Model B1: Overall Effects of Plan Specificity | | | Model B2: Moderation Effects of Plan Specificity for Distinct Times of Day | | | Model C: Overall Effects of Times of Day | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | *OR* | Est (*SE*) | *p* | *OR* | Est *(SE)* | *p* | *OR* | Est *(SE)* | *p* | *OR* |
| Intercept | 1.09 (0.22) | <.001 | 2.96 | 1.18 (0.22) | <.001 | 3.26 | 1.48 (0.28) | <.001 | 4.40 | 1.84 (0.22) | <.001 | 6.27 |
| Fruit (vs. veg) | 0.87 (0.20) | <.001 | 2.38 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spec (vs. unspec) | -- | -- | -- | 0.12 (0.14) | .401 | 1.12 | 0.51 (0.25) | .041 | 1.67 | -- | -- | -- |
| Noon/a (vs. mng) | -- | -- | -- | -- | -- | -- | -0.28 (0.25) | .255 | 0.75 | -0.70 (.14) | <.001 | 0.50 |
| Evening (vs. mng) | -- | -- | -- | -- | -- | -- | -0.40 (0.25) | .107 | 0.67 | -0.88 (.14) | <.001 | 0.41 |
| Spec × noon/a | -- | -- | -- | -- | -- | -- | -0.61 (0.31) | .049 | 0.55 | -- | -- | -- |
| Spec × evening | -- | -- | -- | -- | -- | -- | -0.72 (0.31) | .019 | 0.48 | -- | -- | -- |
| Plan calendar day | -0.08 (0.03) | .015 | 0.92 | -0.08 (0.03) | .002 | 0.92 | -0.09 (0.03) | .002 | 0.92 | -0.09 (0.03) | .002 | 0.92 |
| Sex[a] | -0.21 (0.21) | .315 | 0.81 | -0.10 (0.19) | .607 | 0.91 | -0.12 (0.19) | .531 | 0.89 | -0.12 (0.19) | .536 | 0.89 |
| Age | -0.01 (0.01) | .483 | 1.00 | 0.01 (0.01) | .840 | 1.00 | 0.01 (0.01) | .880 | 1.00 | 0.01 (0.01) | .945 | 1.00 |
| BMI | 0.03 (0.03) | .375 | 1.03 | 0.03 (0.03) | .414 | 1.03 | 0.03 (0.03) | .378 | 1.03 | 0.03 (0.03) | .332 | 1.03 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Int condition[b] | -0.11 (0.18) | .520 | 0.89 | -0.18 (0.16) | .264 | 0.83 | -0.18 (0.17) | .301 | 0.84 | -0.18 (0.17) | .301 | 0.84 |
| Plans per person | 0.01 (0.03) | .896 | 1.00 | -0.01 (0.03) | .860 | 0.99 | -0.01 (0.03) | .902 | 1.00 | -0.01 (0.03) | .788 | 0.99 |
| Random Effects | Variance | Covariance | | Variance | | | Variance | | | Variance | | |
| Intercept | 0.27 | | | 0.28 | | | 0.31 | | | 0.31 | | |
| Fruit (vs. veg) | 1.24 | -0.49 | | -- | | | -- | | | -- | | |

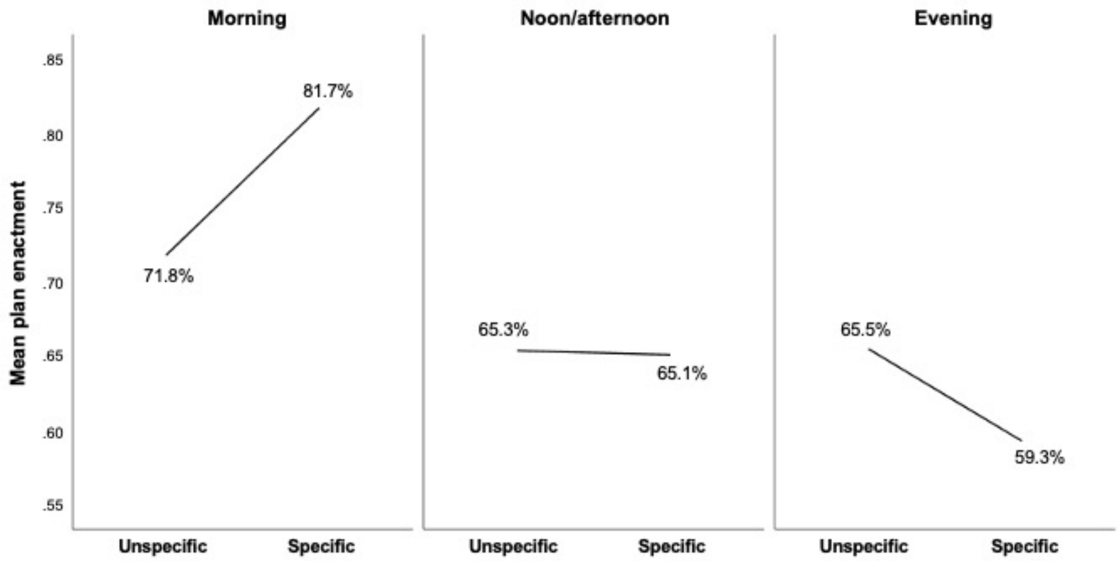
*Note.* Reference group for Model A: vegetable plans, Model B1: unspecific plans, Model B2: unspecific morning plans, Model C: morning plans. Fruit = fruit plans; veg = vegetable plans; spec = specific plans; unspec = unspecific plans; noon/a = noon/afternoon plans; mng = morning plans; evening = evening plans; int condition = intervention condition. Model A: *n* = 88 participants and *n* = 1,330 observations due to missing values. Models B1, B2, and C: *n* = 89 participants and *n* = 1,647 observations due to missing values. Coefficients are unstandardized. Coefficients smaller than |0.005| were rounded to 0.01 or -0.01, respectively. For binomial modelling random residual variance is fixed at 1.

[a] Sex coded as 0 = *male*, 1 = *female*.

[b] Intervention condition coded as 0 = *standard treatment*, 1 = *enhanced treatment*.

**Figure 2**

*Percentage of Plan Enactment for Unspecific and Specific Plans: Illustrating Moderation Effects of Plan Specificity for Distinct Times of Day (n = 92 Participants and n = 1,705 Observations)*




## Discussion

The present study aimed to examine the relationship between two plan characteristics (type of planned behaviour and plan specificity) and the enactment of FV plans formed in a 7-day calendar format. Results showed that chances of plan enactment were higher for fruit than for vegetable plans (supporting Hypothesis 1). Overall plan specificity was unrelated with plan enactment (not in line with Hypothesis 2), but a moderating effect of times of day showed that specific morning plans were more likely being enacted than unspecific morning plans. Noon/afternoon and evening plans did not show any differences for plan specificity-plan enactment associations. Furthermore, overall plan enactment-time variables relationships were found, revealing that morning plans (vs. noon/afternoon, and evening plans) as well as plans of the first day(s) from the plan calendar showed highest plan enactment levels (supporting Hypothesis 3).

**Type of Planned Behaviour: Nutritional Choice**

This study extends previous research by examining plan enactment levels for fruit and vegetable plans separately. The present results suggest that it might be easier to integrate fruit than vegetables into one's daily diet (Mensink et al., 2017b, 2017a). As many types of fruit taste better, i.e., sweet, and, the preparation of vegetables is, in many cases, more time-consuming than it is for fruit, and time constraints are considered as important barriers of healthy nutrition (Pinho et al., 2018), it seems logical that, in order to increase the overall FV consumption, people tend to rather enact fruit plans. Therefore, differences between plan enactment levels of fruit and vegetables should be taken into account in future studies. Furthermore, as descriptive results showed, the intake of fruit vs. vegetables seems to depend on the time of day. Whereas the number of vegetable plans exceeds the number of fruit plans in noon/afternoon and evening plans, morning plans are more often fruit plans. This is in line with the recommendation of eating fruit for breakfast or as a snack compared to vegetables for lunch or dinner (Slavin & Lloyd, 2012).

**Plan Specificity and Times of Day**

In line with study findings by Keller et al. (2017), analyses revealed no overall effect for the plan specificity-plan enactment relationship. However, the present study goes beyond former research by examining moderation effects with times of day revealing a positive relationship between plan specificity and plan enactment only for morning plans. This finding is unique within the plan enactment literature. As people tend to organize their daily life through routines, most people also establish routines in the context of their eating behaviour (eating routines; Jastran et al., 2009). Eating routines in the morning seem to be especially stable (e.g., “having breakfast at home”) which might lead to higher plan enactment for specific plans in the mornings. For instance, morning cues, such as “after getting up” or “for breakfast”, occur (almost) every day and thus cue detection and subsequent plan enactment might be easier.

The strength model of self-control (Baumeister et al., 1998) provides another possible explanation of the highest enactment rates in the morning. Baumeister et al. (1998) assume that self-control is a limited resource which depletes with every action that requires energy (e.g., eating an apple instead of chocolate), leading to a lack of self-control (i.e., *ego depletion*). Baumeister and Heatherton (1996) assumed that individual resources might be more depleted in the evening and, therefore, at the end of the day, self-regulation should be more difficult to maintain. Health behaviour theories suggest that healthy food choices require a high level of self-control (e.g., Hofmann et al., 2008). Therefore, eating healthy might be easiest in the morning which is supported by the present finding that enactment rates are highest in the morning and lowest in the evening. Keeping in mind that the strength model of self-control has been criticized lately (Baumeister et al., 2018), it nevertheless serves as an explanation worth considering.

**The 7-Day Calendar Format**

As a useful planning intervention format to examine time characteristics-plan enactment relationships, the 7-day plan calendar allows an opportunity to investigate a linear day trend of plan enactment rates. Plan enactment was found to decrease throughout the seven days of the plan calendar with the highest plan enactment levels on the first plan calendar day. Findings of a linear calendar day trend might be comparable to plan rank associations which were found to be negative within a setting of formulating up to five action plans on physical activity (Keller et al., 2017). Therefore, plans formulated first might be most promising in a way that participants might plan their favourite type of fruit or vegetable or plan to consume fruit or vegetable that are most accessible. Moreover, circumstances in life change over time and the more time passes the more likely changes happen. This could lead to more difficulties in enacting plans at the end of the 7-day planning period because plans potentially no longer match new circumstances. On the contrary, one might assume that study designs that allow for adjusting plans on a daily basis might lead to an increase in plan enactment as plans get more elaborate over time. However, even within the last days of the plan calendar enactment rates were still high, i.e., more than half of the plans were enacted. All things considered, it can be stated that participants were successful in enacting their plans throughout the seven days of the plan calendar.

**Strengths and Limitations**

The major strength of this study lies in its plan calendar format which allows examining time characteristics (e.g., times of day) of plan enactment and its correlates. Participants were not asked to generate if-then plans which were often used in previous research, but instead entered their plans as morning, noon/afternoon, and evening plans for each day of the subsequent week. Planning for larger periods of time (i.e., for morning, noon/afternoon, or evening) rather than for exact times allows participants to be temporally more flexible in enacting their plans which could lead to higher plan enactment. Similarly, Fleig et al. (2017) showed that planning for broader types of physical activity rather than for very specific exercises allows participants to be more flexible and thus more successful in enacting their plans.

However, some limitations must be acknowledged. Data stem from an intervention study aiming to increase overall FV intake. Therefore, secondary analyses were of correlational nature. Coding of plan characteristics was performed post-hoc and participants were not randomized to different intervention instructions (e.g., planning to eat fruit vs. vegetables) which could be a suggested study design of a future study. Furthermore, analyses were conducted on a restricted subsample of only those participants who completed their plan calendars. Participants without (complete) plan calendars who could not be used for present analyses might have been less successful in enacting their plans. Therefore, future studies should focus on technically more appealing ways of implementing plan calendars. Moreover, previous behaviour, such as eating routines (Jastran et al., 2009), was not measured. Thus, it is impossible to disentangle action plans that display previous behaviour which may be more likely to be enacted from plans that capture newly adopted behaviour and may, therefore, be less likely to be enacted. However, as primary analyses showed an increase of FV consumption over time (Keller et al., 2018), captured behaviour can at least not fully be explained by past behaviour. Regarding situational cues, coding did not take into account different situational cues (e.g., when or with whom). Disentangling which situational cues lead to higher plan enactment could be examined in future research (cf. Fleig et al., 2017; Keller et al., 2017).

**Implications for Practice**

The 7-day calendar format is a promising approach for future planning interventions as it allows to examine time characteristics and resulted in high levels of enactment of FV plans. Moreover, times of day seem to be related to the degree of subsequent plan enactment and therefore should be considered as an important factor in future planning intervention studies. Present results pointed out that it might be easier to integrate fruit rather than vegetables into one's daily diet and, therefore, there might be a greater need for promoting increased vegetable consumption. Furthermore, our findings suggest that future FV planning intervention studies could encourage participants to form highly specific plans for their mornings, whereas no recommendations could be given regarding other times of day.

**Conclusions**

Applying an innovative framework of distinguishing plan characteristics in the context of physical activity (Fleig et al., 2017; Keller et al., 2017) to the nutrition context, type of planned behaviour (fruit vs. vegetable consumption), but not plan specificity (unspecific vs. specific plans) was found as a correlate of plan enactment. It was shown that increasing the consumption of fruit seems to be easier than increasing the consumption of vegetables. The specificity of plans only makes a difference for morning plans when specific plans are more likely to be enacted than unspecific plans. However, underlying psychological mechanisms remain unclear, and further research is needed.

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# Chapter 3

## Plan pursuit in the context of daily fruit and vegetable consumption: The importance of cue detection and the execution of the planned behaviour for overall behaviour change

Domke, A., Keller, J., Knoll, N., Sniehotta, F. F., Heuse, S., & Wiedemann, A. U. (2022). Plan pursuit in the context of daily fruit and vegetable consumption: The importance of cue detection and the execution of the planned behaviour. *British Journal of Health Psychology, 27,* 1172–1187. http://doi.org/10.1111/bjhp.12593

**Abstract**

*Objectives:* In action planning interventions, individuals specify and link cues with behavioural responses to implement behaviour change. To date, not much is known about how and how much the detection of the planned cue (entering and identifying the planned situation) and the execution of the planned behaviour (behavioural response exactly as planned) contribute to overall behavioural changes (changes in target behaviour) achieved by individuals. Using data from an intervention on daily fruit and vegetable (FV) action planning, this study aimed to test whether individuals' cue detection and execution of the planned behaviour are positively related to overall FV intake.

*Design:* Secondary data analyses examined diary data of the intervention condition of a randomized controlled trial. Ninety participants (80% female, aged 19–63 years) formed one FV plan and completed a 13-days post-intervention self-report diary assessing daily FV consumption and situational characteristics of each consumed FV serving. Based on these self-reports and participants' FV plan, day-to-day cue detection and the execution of the planned behaviour were coded.

*Methods:* With two-level models, cue detection and the execution of the planned behaviour were examined as between- and within-person predictors of daily FV intake.

*Results:* Higher between-person execution of the planned behaviour (+1.68 daily servings), higher-than-usual within-person cue detection (+0.46 daily servings), and higher-than-usual within-person execution of the planned behaviour (+0.29 daily servings) were associated with more overall FV intake.

*Conclusions:* Detecting planned cues (within-person) and executing the planned behaviour (between- and within-person) are important for overall FV intake.

*Keywords:* fruit and vegetables, action planning, planning effects, cue detection, execution of the planned behaviour, plan pursuit, intensive longitudinal data

## Introduction

Insufficient fruit and vegetable (FV) consumption is detrimental for health and associated with health risks for several diseases (e.g., hypertension and cardiovascular disease) as well as all-cause mortality (Aune et al., 2017). Although it is recommended by international guidelines to consume at least five daily servings of FV, the global adherence to these recommendations is comparatively low (Hall et al., 2009; Livingstone et al., 2020). As proposed by the behaviour change theories (e.g., Health Action Process Approach, HAPA; Schwarzer, 2008), *action planning* is a frequently used and evidence-based intervention strategy aiding the translation of intentions into actions (Gollwitzer, 1999; Hagger & Luszczynska, 2014). By forming plans, individuals determine *how* to fulfil unconditional goal intentions (e.g., "I want to eat more healthily") by linking situational cues (e.g., *when* and *where*) to goal-directed actions (*what to do*; Sniehotta, 2009). For FV intake, a sample action plan would be: eating an apple (what) at 8 am (when) in the kitchen (where). Linking actions to situational cues and acting when situational conditions arise is the driving mechanism of planning for behaviour change.

To date, most empirical studies focused on unconditional health behaviour outcomes, such as total physical activity (Bélanger-Gravel et al., 2013) or healthy eating (Adriaanse et al., 2011). Sniehotta (2009) argued that when examining the effects of action plans (or implementation intentions; Gollwitzer, 1999) a distinction between conditional and unconditional planning effects should be made. Whereas unconditional effects summarize all goal-directed health behaviours (i.e., overall FV intake), planning leads to *conditional effects* when the planned behaviour (e.g., eating an apple) is performed upon cue detection, that is, under the planned conditions (e.g., at 8 am in the kitchen). The present study investigates plan pursuit mechanisms by examining a persons' *cue detection* and *execution of the planned behaviour* after forming an FV action plan. We aim to examine different types of plan pursuit based on individuals' cue detection and their execution of the planned behaviour for overall behaviour change in the context of day-to-day FV intake.

**Plan Pursuit after Forming Action Plans**

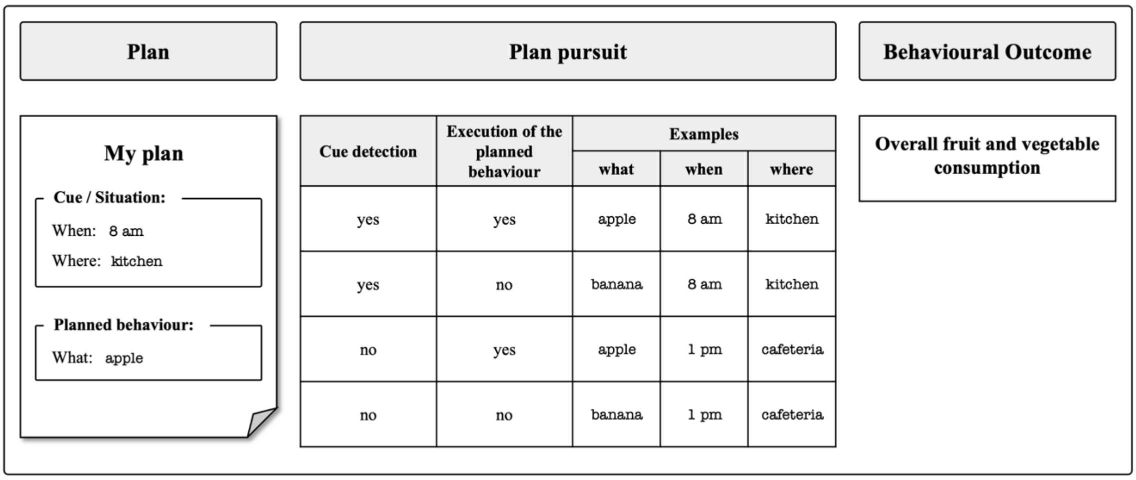
Forming action plans has been found to be an effective health behaviour change strategy (Gollwitzer & Sheeran, 2006), in particular for dietary behaviours (Adriaanse et al., 2011). The success of planning interventions is commonly evaluated by their effects on overall health behaviour outcomes, such as overall FV intake (Adriaanse et al., 2011). However, effects on overall health behaviour outcomes could be the result of regular plan enactment (de Vries et al., 2013), which, as a more proximal outcome, refers to the extent to which individuals execute the behaviour in the situation exactly as planned. For instance, planning to additionally eat an apple each day and successfully executing this "new" behaviour (i.e., regular plan enactment) will increase one's daily FV consumption by one serving (i.e., overall effect). Moreover, earlier research highlighted the need to differentiate between carrying out the planned behaviour in the planned situation (i.e., upon cue detection) versus performing it in a different situation (Orbell et al., 1997; Sniehotta, 2009).

Thus, to further develop the understanding of how action plans from interventions can impact behavioural outcomes, we outline different types of plan pursuit based on individuals' cue detection and execution of the planned behaviour for overall behaviour change (Figure 1). As illustrated by the sample action plan of eating an apple (what) at 8 am (when) in the kitchen (where), we distinguish between (1) opportunities in which individuals are exposed to and detect their planned cue (versus no cue detection) and (2) the execution of the planned behaviour (versus a different goal-directed behaviour). The combination of these two components results in four different types of plan pursuit. These comprise (1) performing the planned behaviour in the planned situation (i.e., *conditional planning effects*; Sniehotta, 2009; e.g., eating the planned apple at 8 am in the kitchen), (2) executing a different goal-directed behaviour in the planned situation (e.g., eating a banana at 8 am in the kitchen), (3) performing the planned behaviour in a different situation (i.e., a different time and/or location; e.g., eating the planned apple at 1 pm in the cafeteria), and (4) executing a different goal-directed behaviour in a different situation (e.g., eating a banana at 1 pm in the cafeteria).

Each of these types of plan pursuit refers to the consumption of at least one serving of fruit and would contribute to a persons' overall FV intake for that day. The question remains how cue detection and the execution of the planned behaviour contribute to a persons' daily overall FV intake. The present study allows for the investigation of different types of plan pursuit on a day-to-day basis as FV intake is an everyday behaviour (Mensink et al., 2017b, 2017a) and individuals show day-to-day variations in following their plan or deviating from it (Wiedemann et al., 2012).

**Figure 1**

*Behavioural Response Matrix after Plan Formation including Different Types of Plan Pursuit*




## The Role of Cue Detection and the Execution of the Planned Behaviour for Health Behaviour Change

In theoretical approaches on implementation intentions and action plans (Gollwitzer, 1999; Hagger & Luszczynska, 2014) it is assumed that identifying a cue and planning to act upon its detection will yield heightened mental accessibility of the cue, making its detection in subsequent situations more likely. Moreover, it is assumed, that the detection of the planned cue is a prerequisite for acting upon it. With repeated cue detection and execution of the planned behaviour, the planned behavioural response is shifted from being consciously controlled by the individual to an automatic elicitation upon encountering the cue (Gollwitzer, 1999). A number of studies have found evidence for the positive relationship between plan enactment and health behaviour change, for instance in the domain of physical activity (Fleig et al., 2017), smoking cessation (de Vries et al., 2013), and healthy nutrition (i.e., fruit consumption; Kasten et al., 2017). These studies focused on broader operationalizations of plan enactment but did not assess differentially whether the action plan-related situation did occur when the planned behaviour was executed, which will be targeted within this study. Similar to evidence from plan enactment studies outlined above, the execution of the planned behaviour should also be a correlate of overall FV intake.

**Aims and Hypotheses**

Extending Sniehotta's (2009) propositions, the present study examines different plan pursuit types derived from data on cue detection and execution of the planned behaviour after forming a daily FV action plan. Based on assumptions from the planning literature that underscore the importance of cue detection for successful plan pursuit (Hagger & Luszczynska, 2014), we hypothesized that frequent cue detection (i.e., at the between-person level) is related to higher overall FV intake [Hypothesis (H)1a]. Such links between cue detection and overall FV intake should also be observable at the within-person level (Inauen et al., 2016). It is further assumed that, on days with higher-than-usual cue detection, individuals are more likely to report higher levels of overall FV intake on that day (H1b). Given that the frequent execution of the planned behaviour should simply lead to an additional FV serving, we assumed that frequent levels of executing the planned FV behaviour should be related to higher overall FV intake (H2a). These between-person assumptions should also be observable at the within-person level, that is, on days when individuals execute their planned behaviour more frequently than usual, higher overall FV intake on that day is more likely (H2b). In addition, it was explored whether the interaction effect between cue detection and the execution of the planned behaviour led to higher levels of overall FV intake.

## Methods

### Design and Procedure

This study reports secondary analyses of an intensive longitudinal two-condition randomized controlled trial (RCT; Domke et al., 2021) aiming to increase FV consumption by a very brief action planning intervention. The RCT was conducted between August 2011 and November 2012 and consisted of a baseline questionnaire (Day −14), a 13-days end-of-day diary (i.e., pre-intervention diary), after which an action planning intervention (for participants assigned to the planning condition; Day 0) was conducted. Subsequently, participants responded to a 13-days post-intervention diary (Days 1–13) as well as follow-up sessions after two (Day 14) and four (Day 28) weeks (study design in Figure B1). Participants were instructed to respond to paper-pencil-based end-of-day diaries. No prompts or reminders were sent to participants. More information regarding the recruitment approach, study design, participant flow, and procedures are provided elsewhere (Domke et al., 2021).

In primary data analyses published elsewhere (Domke et al., 2021), the effects of a brief planning intervention on adults' day-to-day overall FV intake were investigated by comparing the intervention condition (i.e., forming one FV plan) with a waiting-list control condition. Published findings indicated a differential increase of daily overall FV intake from pre- to post-intervention diary, with a discrete change between phases. In the present secondary analyses, only participants assigned to the planning condition (i.e., those who formed a FV action plan), data from the 13-days post-intervention diary, and baseline covariates were used.

**Sample and Recruitment**

Eligible participants were at least 18 years old, had no self-reported medical conditions conflicting with health recommendations for dietary behaviour, and did not participate in weight loss or nutrition programs. Individuals were recruited in physical education classes (e.g., yoga, spinal exercises; no diet or weight loss programs) and university classes between August 2011 and November 2012. As an incentive for complete study participation, participants had the choice to either enter a lottery for health-related products or to receive course credit. At Day 0, $N = 206$ participants were randomly assigned to either the action planning condition ($n = 106$) or the waiting-list control condition ($n = 100$). Ninety participants from the planning condition (out of $n = 106$: 85%) returned the post-intervention diary and provided at least one daily report on their FV plan throughout the post-intervention diary.

Data of present analyses comprised the intervention arm subsample of $n = 90$ participants (80% female; mean age = 32.26 years, $SD = 12.55$ years, range = 19–63 years; mean body mass index (BMI) = 22.47, $SD = 3.00$, range = 18.00–32.77). Throughout the 13-days post-intervention diary, 1,034 daily reports on participants' FV action plans were provided (i.e., 88% out of 1,170 possible daily reports). On average, participants provided information about their plan on 11.80 days ($SD = 2.24$, range = 3–13).

The ethics committee of the German Psychological Society granted approval for this study.

**Intervention Session**

Participants from the planning condition received a brief action planning intervention in which they were instructed to form an action plan for consuming one additional FV serving from the next day on. The action plan should be entered in three blank fields (*when, where*, and *what kind*) below an example action plan, that is, when? "in the evening, 8 pm", where? "in front of the television", what kind? "1 sliced apple". Participants were asked to memorize their plan and to visualize how they would consume the planned serving of FV in the planned situation. The behaviour change techniques (BCTs; Michie et al., 2013) BCT 1.4 ("action planning") and BCT 15.2 ("mental rehearsal of successful performance") were applied (Domke et al., 2021).

**Measures**

**Daily FV intake.** Participants' daily overall FV consumption was measured using a 24-hour recall food frequency questionnaire (Pérez Rodrigo et al., 2015). A table with seven rows ("first serving", "second serving", ..., and "seventh serving") and four blank columns ("when?", "where?", "what kind?", and "how?") was headed with the instruction "At which occasions did you consume fruit or vegetables today? Please be as precise as possible and use one row per serving". One example plan was provided: when? "at lunch-time, 12.30 pm", where? "cafeteria", what kind? "carrots", and how? "raw". One serving was explained as one handful of fruit or vegetables. Rice and potatoes did not count as FV.

**Daily cue detection and execution of the planned behaviour.** Cue detection and execution of the planned behaviour were operationalized as coded variables based on a comparison of the participants' FV plan with the self-reported daily FV servings for each diary day. As described above, each day, participants were asked to indicate where and when (time of day) they ate which kinds of and how much fruit and vegetables (Table B1).

*Coding procedures.* Two trained independent raters compared participants' daily self-reported FV intake with participants' daily reports on their FV plans by comparing plan components (cue detection: time, location; behaviour: type of FV) with components of all FV entries for each day. Matching entries were coded as 1, mismatching entries as 0, resulting in three dichotomous coding categories (time, location, and type of FV).[3] In case of differences

[3] Small deviations between entries were tolerated. That is, variables were coded as 1 when (time) there was a deviation of a maximum of two hours (vs. more than 2 hours), (location) a connection between places was conceivable (vs. not conceivable), and (type of FV) consumed FV included the planned one (vs. different FV consumed).

in coding, discussions between both raters were conducted to reach a consensus, which was then used as the final coding. Pre-consensus inter-rater reliability (Cohen's kappa; calculated across all daily FV servings) was $\kappa = .97$ for type of FV, $\kappa = .98$ for location, and $\kappa = .87$ for time. Of the one to seven daily ratings per person, the FV serving which was most similar to the daily plan was selected (starting with the most similar cue), resulting in a total of 1,034 selected FV consumption entries (referring to 1,034 daily plan reports). The coding scheme is depicted in Table 1.

*Cue detection.* Subsequently, daily levels of reported cue detection were coded (i.e., same time and location in plan as in the 24-hour recall food frequency table) to derive a dummy-coded cue detection variable (1 = *cue detection*; 0 = *no cue detection*) for each day of the 13-days post-intervention diary.

*Execution of the planned behaviour.* For each diary day of the post-intervention diary, another dummy-coded variable was coded with 1 = *execution of the planned behaviour* and 0 = *execution of a different behaviour*, based on whether the planned behaviour (i.e., the same behaviour in plan as in the 24-hour recall food frequency table) was executed or not.

*Plan pursuit.* The combinations for cue detection and the execution of the planned behaviour were summarized in a four-field matrix of four types of plan pursuit (Table 2).

**Table 1**

*Coding Scheme of Plan Pursuit after Forming an Action Plan*

| **Cue detection** | | | | | | **No cue detection** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cue detection, planned behaviour | | | Cue detection, different behaviour | | | No cue detection, planned behaviour | | | No cue detection, different behaviour | | |
| *What* | *When* | *Where* | *What* | *When* | *Where* | *What* | *When* | *Where* | *What* | *When* | *Where* |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| | | | | | | 1 | 1 | 0 | 0 | 0 | 1 |
| | | | | | | 1 | 0 | 0 | 0 | 1 | 0 |

*Note.* Coding of types of plan pursuit: 1 = *match*, 0 = *mismatch*.

**Table 2**

*Four-field Matrix of Different Types of Plan Pursuit after Forming an Action Plan*

| | | Cue detection | | |
|---|---|---|---|---|
| | | yes | no | all |
| Planned behaviour | yes | 515 | 201 | 716 (69%) |
| | no | 137 | 181 | 318 (31%) |
| | all | 652 (63%) | 382 (37%) | 1,034 |

*Note.* Data refers to absolute numbers of daily plan reports.

**Covariates.** Covariates included participants' sex (0 = *male*, 1 = *female*), their age, BMI, the number of daily reports per person, and their past behaviour (grand mean-centred, respectively). Past behaviour was assessed at the baseline questionnaire (Day −14) by the item "Last week, how many daily FV servings did you consume on average?" As goal intentions are proposed as important prerequisites for health behaviour change (e.g., Gollwitzer, 1999), they served as between- and within-person covariates. At the post-intervention diary, the intention was assessed using a six-point scale ranging from *completely disagree* (1) to *completely agree* (6) by the item "I intend to consume five servings of fruit or vegetables today."

## Data Analyses

**Attrition analysis.** Differences in baseline variables between the subsample used for present analyses ($n$ = 90 retained participants) and the remainder ($n$ = 16 non-retained participants) were examined using a dichotomous retainer variable and conducting $\chi^2$- and $t$-tests, followed by logistic regressions.

**Day-to-day associations of cue detection and execution of the planned behaviour with overall FV intake.** A two-level structured dataset with time (within; level-1) nested in participants (between; level-2) was prepared. Two-level models with FV consumption as the within-person outcome were run by applying the *lmer* function in the *lme4* package (Bates et al., 2015) in RStudio, version 1.3.1093 (RStudio Team, 2020) using restricted maximum likelihood estimation. To test for associations between types of plan pursuit and daily FV intake, three separate models were run: Model 1 tested effects of cue detection, Model 2 tested effects of the execution of the planned behaviour, and Model 3 tested the additional within-person cue detection-planned behaviour interaction.

In all models, both the between-person effect (i.e., throughout the diary) and the within-person effect (i.e., on a particular day) of study variables were included. Between-person predictors were grand mean-centred and within-person predictors were person mean-centred, respectively. To control for time effects, a linear day trend was included as a within-person predictor in all models, centred at the first day of the post-intervention diary (0–12; 0 = *Day 1*). To apply a maximal random effects structure, random effects of within-person predictors were added stepwise and retained in the final model when models converged (Barr et al., 2013). For sensitivity analyses (Tables B2 and B3), covariates were added to the final two-level models.

## Results

### Attrition Analysis

Participants who provided at least one daily report on their FV plan throughout the post-intervention diary ($n$ = 90) showed no differences on any of the baseline variables when compared with data from participants who were not retained in present analyses ($n$ = 16).

### Descriptive Results

Participants consumed on average 4.02 daily FV servings ($SD$ = 1.77; range: 0–9) throughout the 13-days post-intervention diary. Out of 1,034 daily reports, cue detection was coded in 652 daily reports (63%), whereas no cue detection occurred in 382 daily reports (37%). The execution of the planned behaviour was coded for 716 daily reports (69%) whereas different FV behaviour was performed in 318 daily reports (31%). When combined, participants reported cue detection and the consumption of the planned FV in 515 daily reports, corresponding to 50% of all daily reports, 79% out of 652 daily reports with reported cue detection, and 72% out of 716 daily reports with the execution of the planned behaviour. Note that on days with reported cue detection, participants might have additionally consumed the planned or a different FV in different situations, that is, without cue detection. Deviations from the plan (i.e., no cue detection and/or consuming another fruit or vegetable than planned) were found in the remaining 50% (i.e., 519 out of 1,034 daily observations) after forming the FV action plan.

**Day-to-Day Associations of Cue Detection and Execution of the Planned Behaviour with Overall FV Intake**

Results of unstandardized coefficients derived from Models 1, 2, and 3 are displayed in Table 3. At the between-person level, a significant positive link between cue detection and overall FV intake ($b$ = 1.72 servings/day; $SE$ = 0.41, $p < .001$) was found. At the within-person level, a significantly higher daily overall FV intake (higher by 0.46 servings) was estimated for days when cue detection was higher than usual ($SE$ = 0.11, $p < .001$).

Regarding execution of the planned behaviour, a significant between-person relationship with overall FV intake was observed ($b$ = 1.68 servings/day; $SE$ = 0.44, $p < .001$). At the within-person level, daily overall FV intake was significantly higher by 0.29 servings for days when participants reported higher-than-usual execution of the planned behaviour ($SE$ = 0.10, $p = .003$).

In Model 3, the pattern of results found in Models 1and 2 did not change. No significant interaction effect between cue detection and the execution of the planned behaviour was found.

In all models, the linear day trend was unrelated to daily FV intake. Sensitivity analyses revealed that the pattern of results found in all models remained the same when covariates besides intention were added as further predictors (analogous Models 1a, 2a, and 3a in Table B2). However, when all covariates were added to the models, significant between-person effects for cue detection diminished (analogous Models 1b, 2b, and 3b in Table B3). Analogous models 1c, 2c, and 3c with standardized coefficients are listed in Table B4.

**Table 3**

*Multilevel Model Estimates Predicting Daily Fruit and Vegetable Consumption, with Cue Detection and No Cue Detection (Model 1), Planned and Different Behaviour (Model 2) as Predictors, as well as Interaction Effects of Cue Detection and Planned Behaviour (Model 3)*

| | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 4.12 (0.15) | **<.001** | [3.82, 4.41] | 4.11 (0.15) | **<.001** | [3.81, 4.41] | 4.12 (0.15) | **<.001** | [3.83, 4.41] |
| Between-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 1.72 (0.41) | **<.001** | [0.91, 2.53] | - | - | - | 1.17 (0.48) | **.017** | [0.24, 2.11] |
| Planned vs. different behaviour | - | - | - | 1.68 (0.44) | **<.001** | [0.82, 2.54] | 1.06 (0.50) | **.037** | [0.08, 2.04] |
| Within-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 0.46 (0.11) | **<.001** | [0.24, 0.67] | - | - | - | 0.43 (0.11) | **<.001** | [0.22, 0.65] |
| Planned vs. different behaviour | - | - | - | 0.29 (0.10) | **.003** | [0.10, 0.48] | 0.23 (0.10) | **.018** | [0.04, 0.43] |
| Cue detection x Planned behaviour | - | - | - | - | - | - | -0.23 (0.25) | .345 | [-0.72, 0.25] |
| Linear day trend | -0.01 (0.01) | .556 | [-0.03, 0.01] | -0.01 (0.01) | .738 | [-0.03, 0.02] | -0.01 (0.01) | .644 | [-0.03, 0.02] |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 1.62 | | [1.10, 2.31] | 1.71 | | [1.16, 2.42] | 1.59 | | [1.06, 2.25] |
| Cue detection vs. no cue detection (within-person level) | 0.23 | | [0.01, 0.58] | - | | - | 0.24 | | [0.01, 0.58] |
| Linear day trend | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Residual | 1.21 | [0.01, 1.33] | 1.25 | [1.14, 1.38] | 1.20 | [0.01, Inf] |

*Note.* CI = Confidence interval. Bold *p*-values indicate statistical significance at $p < .05$. Models are based on data from $n = 90$ participants and $n =$ 1,034 observations. Intraclass correlation (ICC) for daily FV intake: 0.52 ([0.44, 0.61]), cue detection: 0.33 ([0.26, 0.42]), and planned behaviour: 0.33 ([0.25, 0.41]). The variance inflation factor (VIF) of all predictors was < 2. Coefficients are unstandardized. Coefficients smaller than |0.005| were rounded to 0.01 or -0.01, respectively.

## Discussion

As secondary analyses of the intervention condition from an RCT, this study aimed at examining different types of plan pursuit based on individuals' daily cue detection and their execution of the planned behaviour for overall FV intake after forming an FV action plan. When participants pursued their FV action plan, cue detection (63%) or the execution of the planned behaviour (69%) were present for the majority of daily reports. When combined, joint cue detection and the execution of the planned behaviour were coded for half (50%) of all daily reports. In line with present hypotheses, significant relationships with overall FV intake were found for between-person and within-person cue detection as well as for between-person and within-person execution of the planned behaviour. Note that between-person effects for cue detection diminished when adding intention as a covariate to the model (sensitivity analyses). However, no significant effect for the interaction of cue detection with the execution of the planned behaviour predicting daily overall FV intake was found. This indicates that joint cue detection and execution of the planned behaviour had no impact on daily overall FV intake beyond each predictor's main effect.

### Frequency of Types of Plan Pursuit

The present study outlines different plan pursuit types for behaviour change after forming an action plan. Types of plan pursuit have been included as operationalizations of plan enactment in earlier studies. For instance, Domke et al. (2019) used self-reports entered in a 7-day FV planning calendar as a plan enactment measure, which led to average plan enactment levels of 68.7%. Their operationalization and average rates of plan enactment are similar to the present study's operationalization of execution of the planned behaviour (average rate: 69%). In the context of physical activity, Fleig et al. (2017) assessed plan enactment as joint cue detection and execution of the planned behaviour by participants' ratings on a scale from 0% (not enacted as planned) to 100% (completely enacted as planned). Plan enactment scores ranged from 53.7% to 56.3% (Fleig et al., 2017), which are similar to our finding of joint cue detection and execution of the planned behaviour in 50% of daily observations.

In the present study, deviations from the plan (i.e., no cue detection and/or consuming another fruit or vegetable than planned) were found for the remaining 50% of daily observations. To tackle the issue that a certain degree of plan deviation, that is, either from cue detection or executing the planned behaviour, can occur in persons' daily life, coping plans could be formed (Spruijt-Metz & Nilsen, 2014). These would increase the likelihood of FV intake on a specific day by either specifying cues that fit better in the daily routine (e.g., "If I am in a hurry at 8 am, I will eat an apple at 1 pm in the cafeteria.") or by replacing the initially planned FV with one that is more accessible in the specific situation (e.g., "If I do not have an apple at home, I will eat a banana instead.").

**The Role of Cue Detection for Daily FV Intake**

Daily overall FV intake was higher for participants with higher average cue detection (i.e., +1.72 servings; between-person level) and on days when participants reported higher-than-usual cue detection (i.e., +0.46 servings; within-person level). However, when the intention was added as a covariate (Table B3), between-person effects of cue detection diminished. Even for volitional processes during plan pursuit, persons' intentions to consume more FV remain a key correlate of overall FV intake (Gollwitzer & Sheeran, 2006). At the within-person level, findings support assumptions from the planning literature regarding the importance of cue detection for successful plan pursuit (Gollwitzer, 1999; Hagger & Luszczynska, 2014) and highlight the importance to differentiate between between-person and within-person relationships.

According to Gollwitzer (1999), repeated cue detection and acting upon it should facilitate the maintenance of health behaviour change by strengthening cue-response associations between the situational cue and the planned behaviour and might save resources, which can be used for self-regulatory attempts to add further FV servings on that specific day.

In line with the proposal of strengthened cue-response associations, action plans are an integral part of many habit formation interventions (Kwasnicka et al., 2019). In the present study, it is possible that repeated plan enactment upon cue detection may have initiated habit formation, which, when habits are formed, could have led to automaticity in enacting the planned behaviour (Gardner, 2015). Moreover, based on the literature on habit formation, the type of cue is important for repeated plan enactment (Judah et al., 2013). Cues should be encountered often and consistently to increase the likelihood of cue detection and, subsequently, plan enactment (Gardner & Lally, 2018). The cues used in participants' action plans in the present study were location- and time-based cues (e.g., "at 8 am" and "in the kitchen"). As another possibility, cues could be routine-based such as "after having breakfast". For routine-based cues, cue detection might be easier as they allow for more flexibility and need less active monitoring (e.g., "after having breakfast" can be easier detected than checking when the clock ticks "9 am"; Judah et al., 2013; Keller et al., 2021). Future research could encourage participants to link their planned behaviour to a routine of their daily life and subsequently examine different types of plan pursuit.

**The Role of Executing the Planned Behaviour for Daily FV Intake**

Regarding the execution of the planned behaviour, daily FV intake was higher for participants with higher average execution of the planned behaviour (i.e., +1.68 servings; between-person level) and on days when participants reported higher-than-usual execution of the planned behaviour (i.e., +0.29 servings; within-person level). Results indicated that the execution of the planned behaviour plays a crucial role in unconditional health behaviour change after forming an action plan. It can be assumed that a person who executes the planned behaviour perceives successful mastery which can lead to higher levels of self-efficacy (Bandura, 1997; Warner et al., 2018). This, in turn, could enable persons to consume further servings of FV. To gain a better understanding of these mechanisms, links with mastery experience and self-efficacy should be examined in future research (cf. Warner et al., 2018).

**Synergistic Effects of Cue Detection and Execution of the Planned Behaviour?**

Even though both cue detection and the execution of the planned behaviour were positively linked with higher overall FV intake, there was no interaction effect. That is, joint cue detection and execution of the planned behaviour (e.g., eating an apple at 8 am in the kitchen) was not superior for daily FV intake when compared to either cue detection (e.g., eating a banana at 8 am in the kitchen) or the execution of the planned behaviour (e.g., eating an apple at 1 pm in the cafeteria). This non-finding contradicts the theoretical assumption that the driving mechanism of action planning for health behaviour change is the automatically elicited goal-directed behavioural response upon cue detection (Gollwitzer, 1999). However, the present findings indicate that substantial increases in FV intake can also take place when the planned behaviour was performed independent of the detection of the situational cue. Thus, when discussing the mechanisms of behaviour change by action planning, the importance of the execution of the planned behaviour should not be underestimated. However, mechanisms might be different for other contexts where behaviour change is more complex and difficult (e.g., smoking cessation; Scholz et al., 2009) or for more elaborated action plans. For instance, using more specific cues (e.g., routine- *and* time-based: “after the morning show at 8 am”) and/or FV behaviours (e.g., “yoghurt with one sliced apple”) could lead to stronger cue-response associations that unfold its effects differently. That is why, in future research, the differentiation between cue detection and the execution of the planned behaviour should be examined further.

**Strengths and Limitations**

One of the strengths of the present study is its approach in examining different types of plan pursuit based on individuals’ cue detection and their execution of the planned behaviour in the context of FV planning. Cue detection, however, is crucial also for other behavioural contexts such as handwashing behaviours, in which cue-contingent behavioural performance is important for health outcomes (e.g., infection transmission is less likely when washing hands in risky situations; Little et al., 2015). The study design comprised of intensive longitudinal assessments, which enabled the investigation of day-to-day processes of persons' daily plan pursuit and allowed to disentangle between- and within-person predictions of characteristics of persons' plan pursuit. Regarding clinical relevance, the within-person increases of overall FV intake on days when participants showed cue detection (by about half an FV portion) or executed their planned behaviour (by about a quarter FV portion) indicated that both predictors accounted for an extra ¾ daily FV servings towards the 5 FV servings goal.

The present study also has limitations. First, a selective sample (e.g., 80% female participants) was examined which does not represent the general population. Second, the present analyses were of correlational nature, thus, no conclusions about causal relations can be drawn. Third, as the operationalization of cue detection measured only reported cue detection, participants may have detected their cue more frequently than reported (i.e., without consuming any FV). However, it can be discussed whether the conscious perception of the cue (i.e., cue detection) is needed for executing the planned behaviour or if cue exposure, even unconsciously, is sufficient. This aspect should be considered in future research. Fourth, FV intake was assessed using self-reports that are likely to be linked to methodological issues such as plan recall and social desirability bias. Objective assessments through meal photographs could complement self-reports in future studies. Finally, future studies should in general focus on technical ways of capturing intensive longitudinal data such as smartphone-based assessments and a reminder system.

**Conclusion**

The present study extends present conceptualizations and operationalizations of examining plan pursuit after an action planning intervention by outlining different types of plan pursuit based on individuals' cue detection and their execution of the planned behaviour for overall behaviour change (i.e., FV intake). Our findings show that cue detection, the execution of the planned behaviour as well as executing the planned behaviour in the planned situation occur frequently in the context of planning one's FV intake. Whereas within-person cue detection and between- and within-person execution of the planned behaviour were positively linked with higher FV intake, joint cue detection and execution of the planned behaviour was not superior in predicting same-day FV intake beyond each predictor's main effects.

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# Chapter 4

## Immediate effects of a very brief planning intervention on fruit and vegetable consumption: A randomized controlled trial

Domke, A., Keller, J., Heuse, S., Wiedemann, A. U., Lorbeer, N., & Knoll, N. (2021). Immediate effects of a very brief planning intervention on fruit and vegetable consumption: A randomized controlled trial. *Applied Psychology: Health and Well-Being*, *13*(2), 377–393. https://doi.org/10.1111/aphw.12254

**Abstract**

Action planning interventions can effectively promote fruit and vegetable (FV) consumption, but not much is known about the day-to-day translation of intervention planning into action. In this randomized controlled trial, immediate intervention effects of a very brief planning intervention on FV consumption during the following 13 days were investigated. After a 13-day pre-intervention diary, *N* = 206 participants (aged 19–66 years) were randomly allocated to a waiting-list control condition or a planning condition, where they formed one FV plan. Participants from both conditions completed a 13-day post-intervention diary. Self-reported daily FV consumption, FV-specific self-efficacy, and action control were assessed. Segmented linear mixed models estimating a discrete change (i.e., "jump") between diary phases showed a positive "jump" of FV intake and self-efficacy in the planning condition when compared to the control condition. For action control, such effects were not observed. Changes in study variables throughout the post-intervention phase did not differ between both conditions. Present findings extend previous evidence on action planning interventions by showing that increases in self-regulatory (i.e., self-efficacy) and behavioural (i.e., FV intake) outcomes can occur very rapidly and already on the first day for which behavioural increases were planned.

*Keywords:* action planning, ecological momentary assessment, fruit and vegetables, nutrition, randomized controlled trial

## Introduction

Sufficient fruit and vegetable (FV) consumption decreases the risk for all-cause mortality and several diseases such as cardiovascular disease, cancer, and hypertension (Aune et al., 2017). International guidelines recommend the consumption of at least five servings of FV per day; however, globally, adherence to these recommendations remains comparatively low (Hall et al., 2009). Individuals frequently fail to translate their good intentions into action (Godin & Conner, 2008; Inauen et al., 2016), a phenomenon which is known as the "intention-behaviour gap". As proposed by behaviour change theories (e.g., Health Action Process Approach, HAPA; Schwarzer, 2008), volitional self-regulatory factors such as action planning, self-efficacy, and action control are important factors that might close the intention-behaviour gap by helping to initiate behaviour changes (Zhang et al., 2019).

Action planning is suggested to change health behaviour by mediating the intention-behaviour relationship (Gollwitzer, 1999; Schwarzer, 2008). That is, people with good intentions to eat healthily could form a plan on when, where, and how they perform a desired nutrition behaviour such as "I will eat an apple for breakfast at 8 am in the kitchen." With such an action plan, a mental link between situational cues (when and where) and the behavioural response (how) is created, which makes the behavioural performance more likely when individuals encounter the planned situation (Hagger & Luszczynska, 2014). Evidence from a meta-analysis on planning interventions on healthy nutrition revealed medium effect sizes for improvements in nutrition behaviour (Adriaanse et al., 2011).

To evaluate the effectiveness of the intervention, many intervention studies use only a limited number of assessments, often relying on participants' retrospective reports on eating behaviour over specified amounts of time, such as over the past seven days (cf. Adriaanse et al., 2011). However, day- to-day measurements of behaviour change right after an action planning intervention would provide insights about the time point when the intervention unfolds its effects. In this context, Scholz (2019) emphasized the importance of investigating temporal dynamics in health behaviour change and its processes, specifically taking a closer look at the starting point and the duration of intervention effects is highly relevant for a better understanding of the intervention. This also includes an investigation of day-to-day changes of self-regulatory factors, that is, self-efficacy and action control, that underlie behaviour change following an action planning intervention (Sniehotta et al., 2005).

**Self-Efficacy and Action Control Following Action Planning**

*Self-efficacy* describes individuals' beliefs in their capabilities to master a specific task that is needed to achieve a desired goal (Bandura, 1997). In the context of nutrition, self-efficacy refers to beliefs in capabilities to stick to a healthy diet and is an essential factor enabling individuals to initiate and maintain their healthy nutrition. According to social cognitive theory (Bandura, 1997), mastery experiences, that is, the experience of having performed a desired behaviour, are the strongest determinant of self-efficacy. The interrelation of self-efficacy and mastery experiences is proposed to be of reciprocal nature (Bandura, 1997). A study by Warner et al. (2018) found that, during a smoking quit attempt, day-to-day mastery experiences and self-efficacy seemed to be reinforcing each other. In the context of pursuing an action plan, it can be assumed that a person who enacts an action plan perceives successful mastery of the planned behaviour, which, in turn, increases the person's self-efficacy. When plans are supposed to be enacted daily, already the first enactment of the plan could lead to mastery experiences and, thus, to an enhancement of self-efficacy. For physical activity as the health behaviour, results from meta-analyses revealed that self-efficacy increases after action planning interventions (e.g., Williams & French, 2011).

*Action control* is another self-regulatory factor that promotes behavioural adoption and maintenance (Sniehotta et al., 2005) and consists of three facets: *awareness of behavioural standards* (i.e., the constant awareness of one's behavioural plans), *self-monitoring* (i.e., observing actual behaviour and comparing it with one's standards), and investing *self-regulatory effort* to reach the behavioural standard (i.e., reducing discrepancies between actual behaviour and standards; (Carver & Scheier, 1998; Sniehotta et al., 2006). While self-efficacy and action planning are prospective, action control operates at the situational level or even retrospectively (Sniehotta et al., 2005). Based on the HAPA, behavioural effects of action planning are proposed to be mediated by action control (Schwarzer, 2008; Sniehotta et al., 2005). The facets of action control are addressed through an action planning intervention by, for instance, setting the behavioural standard through forming an action plan and making self-monitoring more likely by specifying situational cues of future situations to facilitate the monitoring of behavioural enactment (Sniehotta et al., 2005). Planning interventions should therefore also have effects on action control as an underlying mechanism. Daily nutrition behaviours such as FV consumption might be particularly linked with action control as this behavioural context provides frequent opportunities for behaviour change.

**Immediate Day-to-Day Effects of an Action Planning Intervention**

The effectiveness of action planning interventions on nutrition outcomes is mostly evaluated by aggregating behavioural measures over a certain time period (Adriaanse et al., 2011). As examining processes of behaviour change at a high temporal resolution allows to gain a better understanding of such processes in daily life (Scholz, 2019), the present study focuses on day-to-day changes of FV consumption right before and after an action planning intervention. Nutrition-related ecological momentary assessment (EMA; Stone & Shiffman, 1994) studies with food diaries can be applied where participants monitor their nutrition behaviour at a high temporal resolution (Inauen et al., 2017). For instance, Brookie et al. (2017) conducted a diary-based EMA study evaluating the effects of a 13-day text messaging intervention. After aggregating daily FV measures across 2 weeks, they found increases in FV consumption over time (Brookie et al., 2017). Daily diary EMAs following an action planning intervention were used in the studies by Gratton et al. (2007) and Verplanken and Faes (1999). Both studies found increases in healthy eating for outcome aggregations across different time periods: between the 1st and 5th day (Verplanken & Faes, 1999) and between the 8th and 14th day (Gratton et al., 2007) following the intervention. Thus, first evidence on immediate intervention effects of action planning interventions exists; however, due to outcome aggregations over certain time periods, it remains an open question when exactly (i.e., at which day) the behaviour was taken up or changed.

**Aims and Hypotheses**

The present study aims to investigate the day-to-day temporal development of FV consumption, self-efficacy, and action control in adults forming one FV action plan (planning condition) compared to adults from a waiting-list control condition. The present study design includes a 13-day pre-intervention and a 13-day post-intervention daily diary. Similar to analytical approaches reported by Berli et al. (2016) and Inauen et al. (2017), day-to-day effects on study outcomes prior to (pre-intervention phase) versus following (post-intervention phase) the action planning intervention as well as between both phases (i.e., immediate effect for the first day following the intervention) were examined.

Based on meta-analytic evidence on the effectiveness of planning interventions for FV intake (Adriaanse et al., 2011), we hypothesized that the action planning condition (vs. control condition) would be related (1) to higher FV intake by showing an adoption of FV intake immediately after the intervention (immediate intervention effect; Hypothesis 1a), which is maintained throughout the post-intervention phase (behavioural maintenance; Hypothesis 1b). Second, as action planning increases the likelihood of mastery experiences, a positive correlate of self-efficacy (Warner et al., 2018), we assumed for the action planning condition (vs. control condition) that (2) self-efficacy is immediately increasing following the intervention (immediate intervention effect; Hypothesis 2a) and this increase is maintained throughout the post-intervention phase (behavioural maintenance; Hypothesis 2b). Third, based on Sniehotta et al.'s (2005) suggestion that action planning is a determinant of action control, we hypothesized for the action planning condition (vs. control condition) that (3) action control is immediately increasing after the intervention (immediate intervention effect;

Hypothesis 3a). This increase is assumed to be maintained throughout the post-intervention phase (behavioural maintenance; Hypothesis 3b).

## Methods

### Design and Procedure

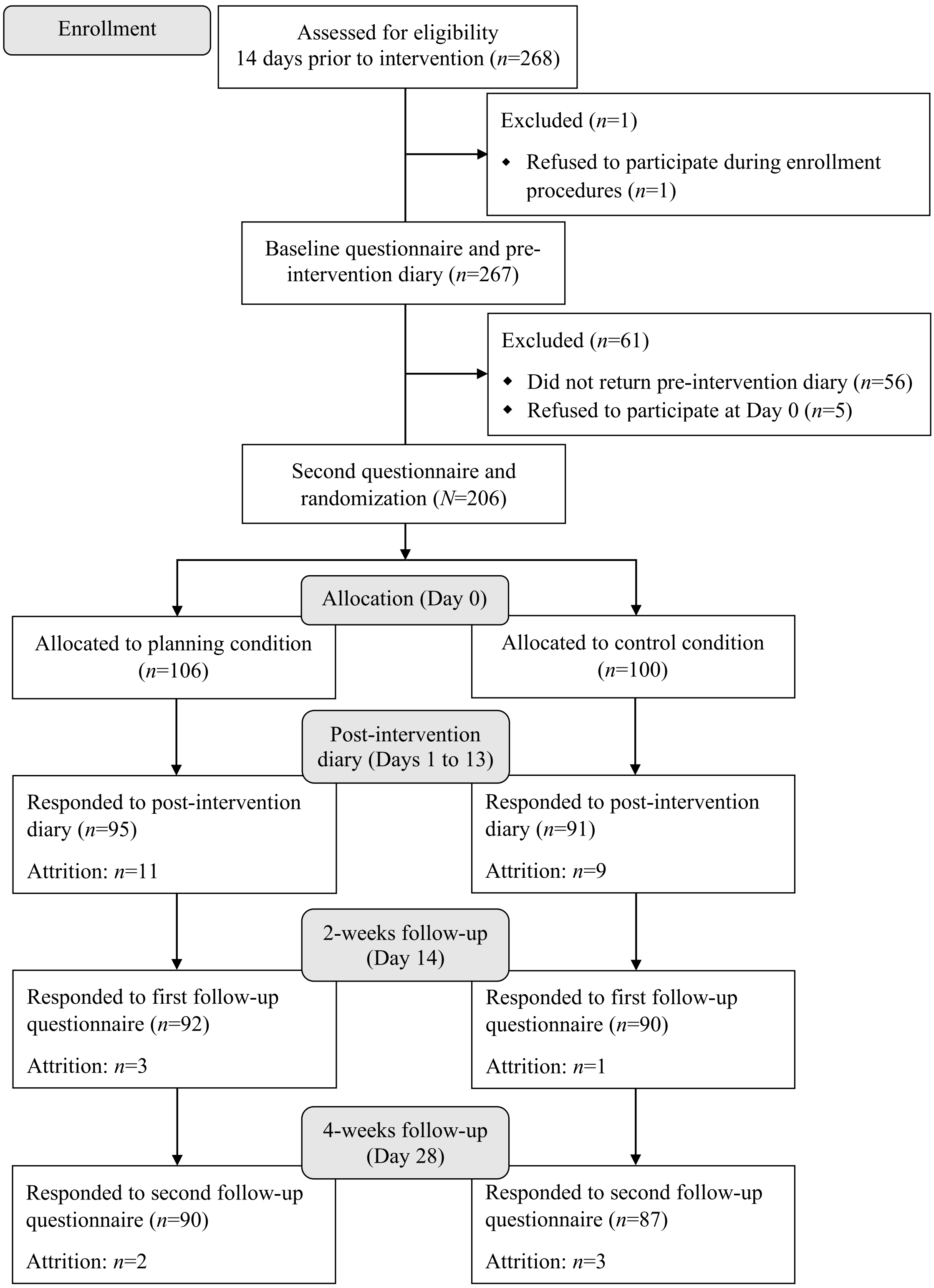
The present study reports primary analyses from an intensive longitudinal two-condition randomized controlled trial (RCT) on the effects of a very brief planning intervention on adults' day-to-day FV consumption. Following informed consent, participants responded to the baseline questionnaire (14 days prior to the intervention; Day −14) and were handed a 13-day diary (henceforth called *pre-intervention diary*; Day −13 to Day −1) to complete at their homes. At Day 0, participants were asked to respond to a second questionnaire, followed by randomization procedures. For participants assigned to the planning condition only, the intervention was conducted after the second questionnaire at Day 0. Subsequently, all participants were asked to respond to another 13-day diary at their homes (henceforth called *post-intervention diary*; Day 1 to Day 13). Participants were instructed to respond to daily questionnaires each night before going to bed. No reminders were sent when participants did not respond to a daily questionnaire. Follow-up questionnaires were conducted at a 2- and 4-week follow-up but were not further considered in this report (the full study design can be found in Figure C1). All study materials were paper-pencil-based. Ethical approval was granted by the ethics committee of the German Psychological Society. The data sets generated during this study are not publicly available as we do not have permission from study participants. Group-level information about the data is available from the corresponding author on reasonable request.

### Sample and Recruitment

Eligible participants were at least 18 years old, had no self-reported medical conditions conflicting with health recommendations for dietary behaviour, and did not participate in weight loss or nutrition programs. Individuals were recruited and surveyed in physical education classes (e.g., yoga, spinal exercises; no diet or weight loss programs) and university classes between August 2011 and November 2012. As incentives following complete study participation, participants had the choice to either enter a lottery for health-related products or to receive course credits. A total of $N = 206$ participants (out of a sample of 268 eligible participants; see Figure 1 for participant flow) were randomly assigned to the action planning condition (henceforth called *planning condition;* $n = 106$) or the waiting-list control condition (henceforth called *control condition*; $n = 100$) using a web-based randomization tool. Based on baseline self-reports, participants from the planning condition were on average 32.80 years old ($SD = 12.25$; range: 19–63), had a mean body mass index (BMI) of 22.72 ($SD = 3.13$; range: 18.00– 32.77), 72% of them were employed ($n = 76$), and 78% of them were women ($n = 83$). Participants from the control condition were on average 30.59 years old ($SD = 10.06$; range: 20–66), had a mean BMI of 22.25 ($SD = 3.23$, range: 16.80–32.85), 58% of them were employed ($n = 57$), and 75% of them were women ($n = 75$). Detailed information on baseline sample characteristics is displayed in Table C1. A total of $n = 186$ participants (out of $N = 206$: 90%; $n = 95$ participants from the planning condition and $n = 91$ participants from the control condition) returned the post-intervention diary.

**Figure 1**

*Flow Diagram showing Participant Attrition*



**Experimental Conditions**

The intervention embedded in this study was a very brief FV-specific action planning intervention administered in the planning condition only. Participants randomly allocated to the planning condition were asked to generate an action plan for *one additional FV serving* that should be consumed daily from the next day on. Participants entered their action plan in three blank fields: *when*, *where*, and *what kind*. A sample FV action plan was provided to facilitate comprehension, that is, when? “in the evening, 8 pm”, where? “in front of the television”, and what kind? “one sliced apple”. Subsequently, participants were asked to memorize their plan and to visualize themselves with closed eyes consuming the planned serving of FV in the planned situation. Similar planning interventions have been proven effective for increasing FV consumption before (e.g., Wiedemann et al., 2012). In addition, participants from the planning condition had the possibility to adjust their FV plan throughout the following 13 days of the post-intervention diary. At the beginning of each daily questionnaire, participants were asked to report whether they had adjusted their plan by writing down either their original or their new plan (i.e., *when*, *where*, and *what kind*). In the intervention, the following behaviour change techniques (BCTs; Michie et al., 2013) were applied: BCT 1.4 (“action planning”) and BCT 15.2 (“mental rehearsal of successful performance”).

Participants from the control condition did not receive a planning intervention.

**Measures**

**Fruit and vegetable consumption.** As the primary outcome of the present study, participants’ daily FV consumption was measured by the pre- and post-intervention diaries using a 24-hr recall food frequency questionnaire (for an overview, see Pérez Rodrigo et al., 2015). The general question “At which occasions did you consume fruit or vegetables today?” was followed by the instruction: “Please be as precise as possible and use one row per serving.” Participants were then asked to enter their daily FV consumption, serving by serving, in a table with seven rows labelled “first serving”, “second serving”, ..., and “seventh serving”. Other than in conventional food frequency questionnaires, additional columns on the FV opportunity were added. For each FV serving, participants entered information on “when?”, “where?”, and “how?” they consumed the fruit or vegetable. An example for one FV serving was provided: when? “at lunch-time, 12.30 pm”, where? “cafeteria”, what kind? “carrots”, and how? “raw”. One serving was explained as a handful of FV, for example “a handful of grapes or salad”. Rice and potatoes did not count as FV.

**Self-efficacy and action control.** Adapting items from previous studies, daily FV-specific *self-efficacy* (Schwarzer et al., 2017) and *action control* (Sniehotta et al., 2005) were assessed by the pre- and post-intervention diaries using six-point scales ranging from *completely disagree* (1) to *completely agree* (6). Self-efficacy was measured by the item “Today, I was certain that I can manage to consume five servings of fruit or vegetables.” Action control was assessed by its three facets: awareness of standards (“Today, I have always made myself aware of my fruit and vegetable intake.”), self-monitoring (“Today, I have focused my attention on consuming five servings of fruit or vegetables.”), and self-regulatory effort (“Today, I have tried very hard to consume five servings of fruit or vegetables.”). Within- and between-person reliabilities for daily action control measures were calculated (Scott et al., 2018). The within-person reliability of 0.61 (planning condition) and 0.52 (control condition) indicates medium reliability to detect within-person fluctuations in action control across daily measurements. Between-person reliability was approximately 1 for both conditions.

**Action planning.** As a relevant measure for manipulation check analyses (see below), FV-specific *action planning* was assessed daily by using six-point scales ranging from *completely disagree* (1) to *completely agree* (6). Every item of the 3-item scale started with the item stem “For today, I have planned ...”, and was complemented by “...when I will consume fruit and vegetables”, “...where I will consume fruit and vegetables”, and “...what kind of fruit and vegetables I will consume". Within-person reliability of 0.85 (planning condition) and 0.80 (control condition) reflects high reliability to detect within-person fluctuations in action planning throughout daily measurements (Scott et al., 2018). Again, between-person reliability was approximately 1 for both conditions.

**Covariates.** Covariates included participants' baseline age, BMI (grand-mean centred, respectively), and sex (0 = *male*, 1 = *female*). Based on results from dropout analyses and randomization checks (see below), subsequent data analyses also included employment status (0 = *unemployed*; 1 = *employed*) as a covariate.

**Data Analysis**

**Dropout analyses and randomization checks.** To examine attrition mechanisms in the full sample ($N$ = 206 participants), chi-square and $t$-tests, followed up by logistic regressions, were performed for baseline variables. A dichotomous variable (0 = *noncompliers*; 1 = *compliers*) was coded; that is, participants who returned the post-intervention diary were coded as compliers ($n$ = 186), and participants who did not return the post-intervention diary were coded as noncompliers ($n$ = 20). For randomization checks, chi-square, $t$-tests, and logistic regressions were performed, using an experimental condition variable (0 = *control condition*; 1 = *planning condition*) as outcome.

**Manipulation check.** To examine whether the intervention was associated with increases in the active ingredient of the intervention, action planning, a manipulation check was performed applying analogous two-level models used for the analysis of intervention effects (described below).

**Intervention effects.** Intent-to-treat analyses used data from $N$ = 206 randomly assigned participants (planning condition: $n$ = 106; control condition: $n$ = 100). Based on Shrout et al. (2018), first-day (Day −13) and second-day (Day −12) assessments of the pre-intervention diary were excluded from the present analyses as visual inspection indicated an initial elevation bias for study variables. Subsequently, a two-level structured dataset with time (level 1; within) nested in participants (level 2; between) was prepared. Three separate two-level models were used to test for intervention effects on the study outcomes FV consumption (Model 1a), self-efficacy (Model 2a), and action control (Model 3a) by applying the *lmer* function in the *lme4* package (Bates et al., 2015) in RStudio, version 1.2.5042 (RStudio Team, 2020). To model different time slopes for the pre- and post-intervention phase (see Inauen et al., 2017) and to test for intervention effects in terms of a discrete change (i.e., "jump") for the first day of the post-intervention phase, segmented linear mixed models (i.e., spline models; Saeed et al., 2018) were fit. These models were defined by the following equation:

$$Y_{it} = b_0 + b_1 I + b_2 T_t + b_3 P + b_4 IT_t + b_5 IP + b_6 T_t P + b_7 IT_t P + u_{0t} + u_{2t} + u_{3t} + u_{6t} + e_{it} \qquad (1)$$

Here, $Y_{it}$ refers to person *i*'s outcome on day *t*; *I* reflects the experimental condition variable (0 = *control condition*, 1 = *planning condition*); $T_t$ represents the *linear day trend,* centred to the first day of the pre-intervention diary (0 = Day −11), that is, with 0–10 reflecting the pre-intervention diary days (Days −11 to −1), with a missing value for Day 0 when the intervention was conducted, and with 12–24 reflecting the post-intervention diary days (Days 1 to 13); and *P* reflects the intervention phase variable (0 = *pre-intervention diary*, 1 = *post-intervention diary*). The interpretation of regression coefficients as represented in the model (Equation 1) is as follows: $b_0$ represents the mean outcome level for the control condition at Day −11 (i.e., intercept); $b_1$ represents intercept differences between conditions at Day −11; $b_2$ represents the linear day trend of the outcome (i.e., slope) throughout the pre-intervention diary in the control condition; $b_3$ represents a discrete change in the outcome between pre- and post-intervention diary (i.e., "jump"; Saeed et al., 2018) in the control condition; $b_4$ represents slope differences between conditions in the pre-intervention diary; $b_5$ represents "jump" differences between conditions; $b_6$ represents the slope throughout the post-intervention diary in the control condition; $b_7$ represents slope differences between conditions in the post-intervention diary.

To identify the maximal random effects structure (Barr et al., 2013), the random effects of predictors were added stepwise and only maintained in the final model when models converged. Final models included random effects for the linear day trend ($u_{2t}$), the phase effect ($u_{3t}$), the linear day trend × phase effect interaction ($u_{6t}$), the intercept ($u_{0t}$), and residuals ($e_{it}$). For sensitivity analyses, covariates were added to the final two-level models.

## Results

### Dropout Analyses and Randomization Checks

Participants who did not return the post-intervention diary ($n$ = 20 noncompliers) showed no differences in any baseline variables when compared with those who returned the post-intervention diary ($n$ = 186 compliers). Randomization checks indicated no differences in baseline variables between the experimental conditions, except for employment status. Participants from the planning condition were more likely to be employed ($\chi^2(1) = 4.92$, $p$ = .027); thus, employment status was added to the set of covariates.

### Manipulation Check

The manipulation check revealed no significant between-condition differences in action planning throughout the pre- and post-intervention phases (Table C2). Day-to-day temporal development of action planning across pre- and post-intervention diaries is displayed in Figure C2.

### Descriptive Results

In both intervention conditions, participants provided data on their daily FV consumption on most days (i.e., a mean response rate of 21.95 out of 24 days, $SD$ = 4.49). Throughout the pre-intervention diary, participants consumed on average 3.51 ($SD$ = 1.19) servings of FV per day. Across the post-intervention diary, participants from the planning condition had a mean FV consumption of 3.99 servings ($SD$ = 1.38), whereas participants from the control condition reported a mean FV intake of 3.68 servings (*SD* = 1.20). The development of mean FV consumption over time including developments of randomly chosen *n* = 10 participants from each condition is depicted in Figure C3. Descriptive statistics on action planning, self-efficacy, and action control are displayed in Table 1.

Regarding intervention fidelity, *n* = 95 participants (out of *n* = 106; 90%) from the planning condition adhered to the instructions and formed a complete “when-where-what kind” action plan in the intervention session.

**Table 1**

*Descriptive Statistics for Mean Levels of Daily Fruit and Vegetable Consumption, Action Planning, Self-efficacy, and Action Control*

| | Pre-intervention diary | | | | | | Post-intervention diary | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Planning condition (*n* = 106) | | Control condition (*n* = 99) | | All (*n* = 205) | | Planning condition (*n* = 95) | | Control condition (*n* = 91) | | All (*n* = 186) | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| FV consumption | 3.46 | 1.14 | 3.56 | 1.23 | 3.51 | 1.19 | 3.99 | 1.38 | 3.68 | 1.20 | 3.84 | 1.30 |
| Action planning | 2.76 | 0.94 | 2.72 | 0.95 | 2.74 | 0.95 | 2.96 | 1.06 | 2.69 | 1.01 | 2.82 | 1.04 |
| Self-efficacy | 2.78 | 1.13 | 2.88 | 1.16 | 2.83 | 1.14 | 3.24 | 1.25 | 2.97 | 1.24 | 3.11 | 1.25 |
| Action control | 2.76 | 0.92 | 2.76 | 0.98 | 2.76 | 0.95 | 2.98 | 0.99 | 2.75 | 0.98 | 2.86 | 0.99 |

*Note.* FV = Fruit and vegetable. The number of participants listed for the pre-intervention diary (*n* = 205) differs from the number displayed in Figure 1 because one participant from the control condition did show missing values on all study outcomes.

**Intervention Effects on FV Intake, Self-Efficacy, and Action Control**

Results of unstandardized coefficients derived from Model 1a, 2a, and 3a are displayed in Table 2 and Figure 2. Regarding Model 1a with *FV intake* as the outcome, results indicated that FV consumption in the control condition started at 3.62 servings at Day −11, which did not differ between conditions. Throughout the pre-intervention diary phase, the control condition showed a nonsignificant linear day trend, which was similar in the planning condition (i.e., nonsignificant between-condition effect of the pre-intervention day trend). FV consumption in the control condition did not show a "jump" between both diary phases (i.e., phase effect control condition in Table 2). However, significant between-condition differences of the phase effect were found, indicating that participants from the planning condition (vs. control condition) showed an enhanced FV consumption immediately following the intervention (i.e., a "jump"; see Figure 2). Regarding the day trend in the post-intervention diary, the control condition showed an increase over time. The nonsignificant post-intervention day trend × planning condition interaction indicated that there were no between-condition differences in FV consumption changes following the intervention. Post hoc analyses using an analogous model with a recoded condition variable (0 = *planning condition*, 1 = *control condition*) revealed that participants from the planning condition maintained their FV intake throughout the post-intervention diary ($B$ = .01, $SE$ = .02, $p$ = .877).

Regarding *self-efficacy,* Model 2a revealed a similar pattern of results when compared to Model 1a (Table 2). Self-efficacy levels in the control condition at Day −11 started at 2.90, which did not differ from the planning condition. For the pre-intervention diary phase, there was a nonsignificant linear day trend in the control condition, which was similar in the planning condition. Moreover, the control condition did not show a "jump" in self-efficacy between pre- and post-intervention diary, but significant between-condition differences of the phase effect were found (i.e., a "jump" in the planning condition). For the post-intervention diary phase, analyses did not show any changes in self-efficacy in the control condition, which was similar in the planning condition.

Regarding *action control* (Model 3a), levels in the control condition at Day −11 started at 2.69, which did not differ between conditions. No significant effects were observed for control participants' changes throughout the pre- and post-intervention phase as well as between both phases (Table 2). Moreover, effects did not vary between conditions.

Sensitivity analyses across the three study outcomes revealed that the pattern of results found in Models 1a, 2a, and 3a remained the same when covariates were added as further predictors (results of Models 1b, 2b, and 3b are shown in Table C3). Further analyses of Models 1a, 2a, and 3a with the linear day trend centred on the last day of the post-intervention diary (Day 13) revealed no between-condition differences in FV consumption, self-efficacy, and action control at Day 13. Models 1c, 2c, and 3c with standardized coefficients can be derived from Table C4.

**Table 2**

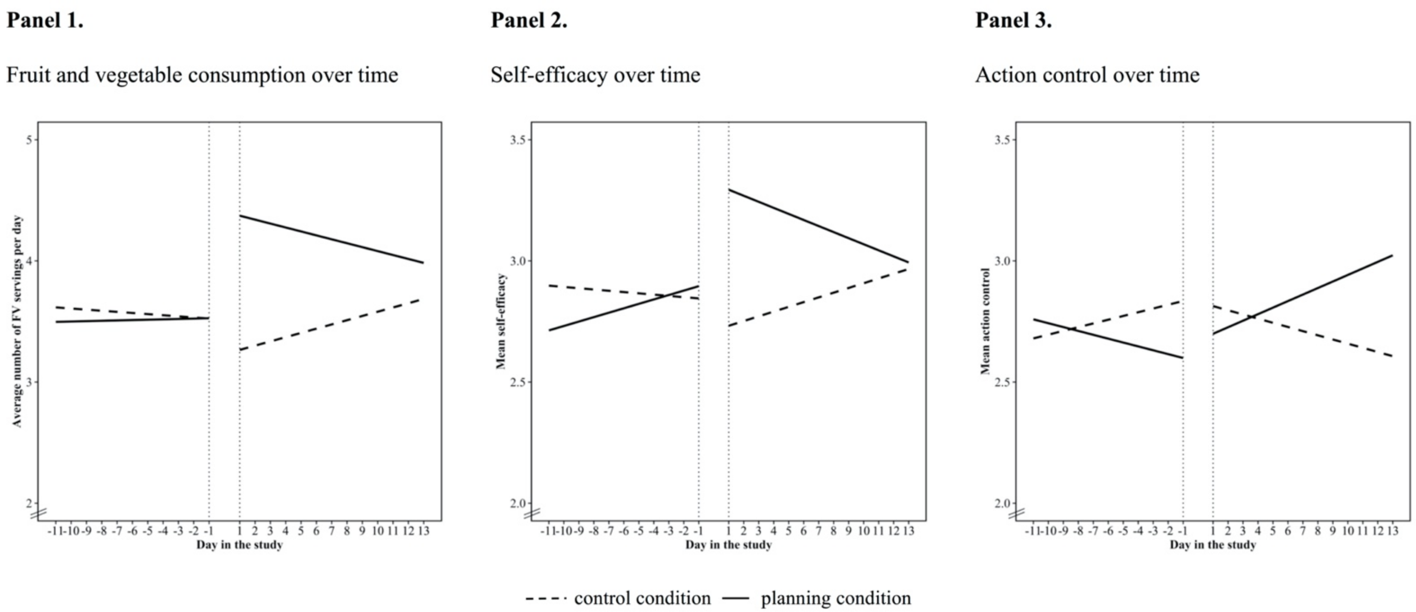
*Multilevel Model Estimates Predicting Fruit and Vegetable Consumption, Self-Efficacy, and Action Control, Using the Control Condition at Day -11 as the Reference*

| | Model 1a: FV consumption | | | Model 2a: Self-efficacy | | | Model 3a: Action control | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 3.62 (0.13) | **<.001** | [3.36, 3.88] | 2.90 (0.13) | **<.001** | [2.64, 3.16] | 2.68 (0.10) | **<.001** | [2.48, 2.88] |
| Interv. effect Day -11 | -0.12 (0.18) | .519 | [-0.48, 0.24] | -0.18 (0.18) | .314 | [-0.54, 0.17] | 0.08 (0.14) | .585 | [-0.20, 0.36] |
| Pre-interv. day trend CC | -0.01 (0.01) | .479 | [-0.03, 0.02] | -0.01 (0.01) | .677 | [-0.03, 0.02] | 0.02 (0.01) | .156 | [-0.01, 0.04] |
| Pre-interv. day trend x PC | 0.01 (0.02) | .870 | [-0.03, 0.04] | 0.02 (0.02) | .303 | [-0.02, 0.05] | -0.02 (0.02) | .294 | [-0.05, 0.01] |
| Phase effect CC | -0.35 (0.21) | .096 | [-0.76, 0.06] | -0.16 (0.19) | .419 | [-0.54, 0.21] | 0.14 (0.15) | .366 | [-0.17, 0.43] |
| Phase effect x PC | 0.88 (0.30) | **.003** | [0.30, 1.46] | 0.57 (0.27) | **.037** | [0.05, 1.11] | -0.06 (0.21) | .769 | [-0.48, 0.36] |
| Post-interv. day trend CC | 0.04 (0.02) | **.038** | [0.01, 0.07] | 0.02 (0.02) | .243 | [-0.01, 0.05] | -0.02 (0.01) | .182 | [-0.04, 0.01] |
| Post-interv. day trend x PC | -0.03 (0.02) | .168 | [-0.08, 0.01] | -0.02 (0.02) | .284 | [-0.07, 0.02] | 0.03 (0.02) | .140 | [-0.01, 0.06] |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 1.25 | | [0.94, 1.62] | 1.45 | | [1.14, 1.74] | 0.90 | | [0.71, 1.12] |
| Pre-interv. day trend CC | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] |
| Phase effect CC | 0.56 | | [0.08, 1.46] | 1.59 | | [0.92, 2.37] | 1.02 | | [0.62, 1.51] |
| Post-interv. day trend CC | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] |
| Residual | 1.54 | | [1.48, 1.62] | 0.81 | | [0.77, 0.85] | 0.48 | | [0.46, 0.50] |

*Note.* FV = Fruit and vegetable; Est = Estimate; Interv. = Intervention; CC = Control condition; PC = Planning condition; CI = Confidence interval. Bold *p*-values indicate statistical significance at $p < .05$. Intercept indicates the mean of the control condition at Day -11. Models are based on data from $n = 205$ participants and $4{,}450 \leq n \leq 4{,}522$ observations due to missing values. Intraclass correlation (ICC) for FV intake (Model 1a): 0.43 ([0.39, 0.49]). ICC for self-efficacy (Model 2a): 0.55 ([0.50, 0.60)]. ICC for action control (Model 3a): 0.58 ([0.53, 0.63)]. Coefficients are unstandardized. Coefficients smaller than |0.005| were rounded to 0.01 or -0.01, respectively.

**Figure 2**

*Day-to-Day Temporal Development of Fruit and Vegetable Consumption (Panel 1), Self-Efficacy (Panel 2), and Action Control (Panel 3)*



## Discussion

This intensive longitudinal two-condition RCT examined whether a very brief FV action planning intervention can lead to increased FV consumption, self-efficacy, and action control by particularly focusing on immediate intervention effects. The present results indicate that the planning condition, as opposed to the control condition, led to increases in FV intake and self-efficacy immediately following the intervention (supporting Hypotheses 1a and 2a). Enhanced levels of FV intake and self-efficacy were subsequently maintained throughout the 13-day post-intervention diary phase (supporting Hypotheses 1b and 2b). Regarding action control and not in line with present assumptions (Hypothesis 3a and 3b), effects did not reach significance at $p < .05$. Moreover, no differences between the planning condition and the control condition were found for FV intake, self-efficacy, and action control at the end of the diary phase (i.e., 13th day following the intervention).

### Time Proximity of Effects from Action Planning Interventions

Evidence from a meta-analysis revealed positive medium- and long-term effects of action planning interventions on FV consumption (Adriaanse et al., 2011). However, as the dynamics of short-term intervention effects have rarely been studied, this study provides insights into the question of *when exactly* an action planning intervention becomes beneficial for FV consumption (Scholz, 2019). Whereas previous studies on planning interventions reported the use of daily nutrition-related measures but aggregated respective outcomes across different time periods (e.g., Verplanken & Faes, 1999), the present study assessed and analysed daily EMA data at this high temporal resolution. This facilitates the investigation of temporal dynamics in study outcomes following an intervention, that is, *when* does an intervention effect start and *how* does an effect evolve over time (Scholz, 2019). The analytical approach of modelling a discrete change following an intervention, that is, a "jump", has rarely been used in previous studies on health behaviour change (see Berli et al., 2016 and Inauen et al., 2017 for exceptions). For instance, results from Inauen et al. (2017)

yielded that a social support intervention led to a gradual increase in healthy eating, but no discrete change between study phases was found. The present study evaluating the effects of an action planning intervention revealed a different pattern: a discrete change in FV consumption (and self-efficacy) for the first post-intervention day and maintained levels for subsequent days. Possibly, different active ingredients of interventions might lead to different change dynamics in nutrition outcomes. The effects of social support seemed to need some time to unfold (Inauen et al., 2017), whereas effects of an action planning intervention (i.e., persons forming one plan for the next day) may occur very quickly but without leading to further FV increases in the longer run. Integrating evidence from Inauen et al. (2017) and the present study, nutrition-related interventions consisting of a combination of social support and action planning (cf. Prestwich et al., 2014) appear promising for intervention developers and should be followed up by future studies capturing immediate intervention effects as well as longer-term effects.

**Effects on FV Intake after Forming one FV Plan**

After forming one plan in the planning condition, elevated levels of FV intake at post-intervention Day 1 remained unchanged (on average) throughout the following 13 days. Thus, intervention instructions on forming a plan for consuming one additional FV serving seemed to lead to an immediate increase but no subsequent increases in FV consumption. To increase one's FV consumption by one serving might therefore be a behaviour that can be easily performed from one day to the next and embedded in one's daily routines. One-plan action planning might therefore be a promising active ingredient of interventions aiming at immediate effects. However, forming only one action plan might not be enough to achieve a further increase in FV levels. In the randomized controlled trial by Wiedemann et al. (2012), the number of FV plans was experimentally manipulated using six conditions (i.e., control condition, one plan, two plans, ..., five plans). Their findings indicated that FV planning interventions consisting of at least four plans revealed at least small-sized intervention effects on FV intake at a one-week follow-up when compared to a waiting-list control condition (Wiedemann et al., 2012). The planning intervention condition consisting of only one plan was linked with overall increases in FV intake, but this effect did not differ from changes found in the control condition (Wiedemann et al., 2012), which was also observed in the present study. Hence, instructing participants to increase their FV behaviour by more than one serving, for instance, by adding multiple action plans to the planning intervention, might increase the likelihood of further increases in FV intake levels. Based on meta-analytical findings on small-to-medium effect sizes across studies, where multiple plans were formed (Adriaanse et al., 2011), we believe that multiple plans might also be beneficial for higher immediate intervention effects on FV levels. However, it has to be considered that recruitment procedures in such studies often lead to the enrolment of motivated participants with higher FV baseline levels such as in the present study ($M = 3.51$ FV servings per day throughout the pre-intervention diary). Persons who start with lower FV levels may find it more difficult to form and enact multiple plans. Future research could examine for whom single versus multiple plans might be more effective.

Moreover, participants from the control condition showed post-intervention increases in FV consumption. This unexpected effect might be caused by daily measurements of FV intake as the measurements might, independent of intervention conditions, raise awareness about one's own FV consumption and increase the likelihood of performing the actual behaviour, a phenomenon called *measurement reactivity* (for a review, see French & Sutton, 2010).

**Effects on Self-Efficacy and Action Control**

For self-efficacy, results support prior findings of self-efficacy enhancements after planning interventions in various health behaviour change domains (Zhang et al., 2019). For instance, in the physical activity domain, the meta-analysis by Williams and French (2011) found larger effect sizes for longer-term follow-ups after action planning interventions than after interventions using other active ingredients. The present finding of effects for immediate self-efficacy increases provides insights into the role of action planning in the nutrition context. As a potential explanation for immediate self-efficacy increases, the mastery of a single and personalized FV plan seems more feasible than the mastery of a general intention toward FV and would thus support higher self-efficacy beliefs about one's FV intake (Keller et al., 2016). Moreover, once the behaviour was successfully carried out, a personalized FV plan might facilitate internal attribution processes and result in further increases of self-efficacy (Bandura, 1997). However, as there were nonsignificant post-intervention day trends in both intervention conditions, the latter was not found in the present analyses. To facilitate subsequent mastery experiences and hence to elicit further increases in self-efficacy throughout the post-intervention diary, it might be beneficial to form multiple plans (as discussed above). Moreover, present findings extend the unidirectional link from self-efficacy to action planning, as proposed by the HAPA model, which was already shown for the physical activity domain (Keller et al., 2016). In this regard, a positive feedback loop might be initiated with higher levels of action planning leading to higher levels of self-efficacy, which, in turn, could further increase action planning and so forth. Temporal developments of self-efficacy-action planning links should be tested in future EMA studies.

Regarding action control, present results indicated no group-differential intervention effects, indicating that forming one FV plan had no short-term impact on action control in the present study design. Similar to the discussion above, forming multiple plans would potentially increase the likelihood to observe increases in action control (Adriaanse et al., 2011; Sniehotta et al., 2006). When comparing short-term intervention effects on action control with effects on FV intake and self-efficacy, our findings suggest that courses over time can differ between different factors of FV-related self-regulation (see also Figure 2).

**Strengths and Limitations**

The present study has several strengths. The study design included an experimental manipulation within two intensive longitudinal assessment periods, which enabled the analysis of change in study outcomes before and after the manipulation. This procedure opens new insights into the temporal development of outcomes addressed by the intervention. Next to FV intake as the primary outcome, this study also focuses on two self-regulatory factors (i.e., self-efficacy and action control), which are important correlates of FV intake.

However, some limitations must be acknowledged. First, although participants from the planning condition reported more planning in the post-intervention phase, this difference was not significantly different from control condition participants' reports in full multilevel models. Thus, it may require more than one action plan to enhance self-reported action planning levels, which was shown in a study by Lhakhang et al. (2014) revealing increases in participants' action planning after forming two FV action plans. Moreover, the primary study outcome (i.e., FV consumption) was assessed using self-reports. Future studies could, additionally, use objective data such as meal photographs to validate the accuracy of self-reports. Moreover, this study was conducted using paper-pencil-based diaries, which goes along with lower controllability of study protocol adherence in terms of actual time points when the daily questionnaires are completed by participants. Applying mobile-based assessments would allow for better timing of the provision of study materials and provide time stamps of assessments (Villinger et al., 2019). Moreover, a digital reminder system could be used in future studies to improve study protocol adherence. As daily questionnaires were completed each evening, present findings underlie the assumption that participants can remember their present-day FV consumption. However, a potential recall bias cannot be ruled out. Possibly due to reactive recruitment strategies, which took place in physical education and university classes, present findings refer to a sample with higher education and higher levels of FV consumption, which may not generalize to the general German population (Mensink et al., 2013).

**Conclusion**

The present study showed that a brief action planning intervention can elicit immediate increases in self-regulatory (i.e., self-efficacy) as well as behavioural (i.e., FV intake) outcomes. Thus, this study extends the literature on nutrition-related action planning interventions by also examining the temporal proximity of short-term intervention effects. To not only facilitate immediate but also longer-term effects of planning interventions, future studies should focus on, for instance, forming multiple plans or adding other active ingredients to the intervention, such as social support.

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# Chapter 5

# General Discussion

## General Discussion

Though action planning interventions have been studied intensely in the past decades in health psychology research (Hagger & Luszczynska, 2014), previous studies mainly focused on distal constructs and conceptualizations (e.g., overall health behaviour change, aggregated outcome measures), framing a bigger picture of the effects of action planning interventions. Thus, the primary goal of this thesis was to shed light on specific mechanisms of action planning interventions in the context of FV intake at a high resolution, providing insights into the question of when and how an action planning intervention unfolds its effects. More precisely, this thesis aimed at investigating (1) the frequency of plan enactment and its links to plan characteristics (i.e., plan specificity and type of the planned behaviour) and time variables (i.e., times of day and plan calendar day; Chapter 2), (2) the frequency of cue detection and the execution of the planned behaviour and their between- and within-person links to overall FV intake (Chapter 3), and (3) the short-term effects of an action planning intervention on FV intake and volitional self-regulatory outcome variables (i.e., self-efficacy and action control; Chapter 4). A summary of findings from empirical chapters is provided in Table 1.

**Table 1**

*Summary of the Findings (Chapters 2 to 4)*

| Ch. | Aims | Findings | Conclusions |
|---|---|---|---|
| **2** | Examining the frequency and temporal development of plan enactment and its relationship to plan characteristics and time variables | FV plans were enacted in the majority of cases. Fruit plans were more likely being enacted than vegetable plans. Plan specificity was unrelated to plan enactment; specific morning plans were more likely being enacted than unspecific morning plans. Plan enactment rates decreased over the day and over the 7-day planning period. | People were successful in enacting their FV plans throughout the 7-day planning period. It was easier to enact fruit than vegetable plans and, in the morning, specific than unspecific plans. Plan enactment was easier in the morning than during the rest of the day and on the first rather than the last days of the planning period. |
| **3** | Investigating the frequency of cue detection and the execution of the planned behaviour as well as their links to overall FV intake at the between- and within-person level | Cue detection and the execution of the planned behaviour were shown in the majority of cases. Within-person cue detection and between- and within-person execution of the planned behaviour were positively associated with FV intake, but there was no additional effect of joint cue detection and the execution of the planned behaviour beyond each predictor's main effect. | People were successful in both detecting the planned cue and executing the planned behaviour. Cue detection and the execution of the planned behaviour seem to play a crucial role in unconditional health behaviour change after forming an FV action plan. |
| **4** | Analysing the day-to-day temporal development of FV intake, self-efficacy, and action control immediately following an action planning intervention | FV intake and self-efficacy showed an immediate increase after the intervention and maintenance of heightened levels. For action control, no significant effects were found. | The present action planning intervention unfolded its effects on FV intake and self-efficacy immediately after the intervention but without leading to subsequent increases. |

*Notes.* Ch. = Chapter. FV = Fruit and vegetable.

## Summarizing and Integrating the Findings into the Literature

In the following sections, a summary and integration of the main findings of the empirical chapters (Chapters 2 to 4) into the literature are provided.

**Plan enactment: Its frequency and relationship to plan characteristics and time variables (Chapter 2).** In Chapter 2, plan enactment was investigated in the context of a 7-day plan calendar format (Happy 5 project), leading to the following results and implications regarding the frequency of plan enactment and its relationship to plan characteristics and time variables:

Descriptive results revealed an overall plan enactment rate of 68.7%. To integrate this finding into the literature, one must consider the heterogeneity of plan enactment operationalizations. In this specific context, plan enactment was operationalized by dichotomous scores that stem from participants’ reports on whether they had enacted their action plans or not. This operationalization allows accounting for whether the planned behaviour was performed (i.e., consumption of the planned fruit or vegetable) but does not control explicitly whether the planned situation did occur. In different health behaviour domains, plan enactment scores varied highly, which might be explainable by their heterogenous operationalizations (i.e., various scales and coding procedures). However, the high plan enactment rates found in Chapter 2 and in another study on healthy eating (50.0% to 69.4%; Kasten et al., 2017) showed that people are generally successful in enacting their FV plans.

Results showed that fruit plans were more likely being enacted than vegetable plans. This finding reflects that, in Germany, people generally consume more fruit than vegetables (Mensink et al., 2017b, 2017a). This might be due to an overall preference for the sweet taste of fruit (Slavin & Lloyd, 2012) and the mostly more time-consuming preparation of vegetables (cf. barriers of eating healthy; Pinho et al., 2018). Not in line with Gollwitzer's (1999) assumptions that highly specific plans lead to higher levels of plan enactment, overall plan specificity was found to be unrelated to plan enactment, which is comparable with study findings by Keller et al. (2017). However, specific morning plans were more likely being enacted than unspecific morning plans, whereas no such relation was found for noon/afternoon and evening plans. This might be due to especially stable morning routines (Jastran et al., 2009), which would make the formulation and enactment of highly specific FV plans easier in the morning. At later times of the day (i.e., noon/afternoon and evening), circumstances might be less predictable than in the morning. Thus, planning highly specifically for these times of the day might be more difficult and, due to a probably higher load of varying tasks, the enactment of specific plans did not have an advantage over the enactment of unspecific plans.

Considering time effects for overall plan enactment levels, the highest enactment rates were found for (1) morning plans as opposed to noon/afternoon and evening plans and (2) plans of the first day(s) when compared to plans of the last day(s) of the plan calendar, indicating a decline (1) over the day and (2) over the 7-day planning period. (1) The decline over the day can be explained by the strength model of self-control (Baumeister et al., 1998), which supports the present finding of the highest enactment rates for morning plans by the assumption that healthy food choices are easiest in the morning (cf. *ego depletion*). However, this explanation should be taken with caution as replication failures provoked questioning about whether the ego depletion effect is real or solely a result of publication bias and *p*-hacking (Friese et al., 2019). Thus, another explanation is possible: Inauen et al. (2016) found strong intention-behaviour associations between participants' intention to avoid unhealthy snacking and the consumption of unhealthy snacks. Intentions to avoid unhealthy snacking seemed to be stronger in the morning than in the evening (Inauen et al., 2016). When transferred to the domain of healthy eating, it might be conceivable that intentions to eat healthily decline throughout the day, which may lead to a simultaneous decline in plan enactment. (2) When comparing the decline of plan enactment rates over the 7-day planning period to plan rank associations, a similar decline was found by Keller et al. (2017) when formulating up to five action plans in the context of physical activity. As circumstances change over time, participants' action plans formulated for the end of the planning period might no longer fit into their daily life, which could impede successful plan enactment.

**Frequency and links of cue detection and the execution of the planned behaviour with overall FV intake (Chapter 3).** In Chapter 3, secondary analyses investigated plan pursuit after forming one FV action plan (BiBo project). The following results and implications on the frequency of cue detection and the execution of the planned behaviour as well as between- and within-person links with overall FV intake could be derived:

Cue detection and the execution of the planned behaviour were present for the majority (i.e., 63% or 69%, respectively) of daily reports. Joint cue detection and the execution of the planned behaviour were found for half (50%) of all daily reports. When comparing these findings to evidence from prior studies, one must refer to different operationalizations of plan enactment. Thus, the finding of 69% reported execution of the planned behaviour can be compared to findings from Chapter 2, in which plan enactment was operationalized by self-reported statements on whether participants had consumed the planned FV serving or not (plan enactment rate of 68.7%). For joint cue detection and execution of the planned behaviour, a comparable operationalization can be found in a study on physical activity: Fleig et al. (2017) assessed plan enactment through participants' ratings on a scale from 0% (not enacted as planned) to 100% (completely enacted as planned), resulting in plan enactment scores ranging from 53.7% to 56.3% (Fleig et al., 2017). Thus, the conclusion derived from Chapter 2 can be supported as participants seem to be generally successful in enacting their FV plans. Moreover, high enactment rates were found for unique cue detection and execution of the planned behaviour, indicating that participants were even more successful in enacting unique components of their plan.

Within-person cue detection and within- and between-person execution of the planned behaviour were found to be positively related to overall FV intake. For cue detection, findings support Gollwitzer's (1999) assumption that detecting the planned cue is an important predictor for successful plan pursuit from day to day. It is proposed that repeated cue detection creates strengthened cue-response associations, which facilitate automatically performing the planned behaviour and in turn, lead to increases in the overall health behaviour (Gollwitzer, 1999). It is important to note that the behavioural response evoked by cue detection, as operationalized in this context, is not restricted to executing the behaviour that was initially planned but includes any goal-directed behavioural response. This would extend Gollwitzer's (1999) assumption by suspecting that cue-response associations might not necessarily be linked to the exact planned behavioural response but to any goal-directed behaviour that is performed after detecting the planned cue. These considerations, however, are rather new and should be validated by replicating present results in an experimental design that allows for drawing causal conclusions.

Regarding the execution of the planned behaviour, results point to its crucial role in health behaviour change after an action planning intervention from day to day as well as between persons. Here again, it should be emphasized that executing the planned behaviour was not necessarily linked to successful cue detection. Thus, the execution of the planned behaviour itself seems to provoke the consumption of further FV servings (e.g., through experiencing successful mastery; Bandura, 1997; Warner et al., 2018), which goes beyond theoretical assumptions and should be replicated and further explored in future research.

The nonsignificant cue detection x execution of the planned behaviour interaction effect on FV intake indicates that joint cue detection and execution of the planned behaviour had no additional impact on daily overall FV intake beyond each predictor’s main effect. This further supports the assumptions that (1) cue-response associations might be formed between the planned situational cue and any goal-directed behaviour and (2) the successful execution of the planned behaviour might be associated with increases in FV intake independent of whether the planned cue was detected or not. To summarize, the findings of Chapter 3 suggest that cue detection and the execution of the planned behaviour may have unique roles in predicting overall FV intake. However, for a deeper understanding of these associations, the present results need to be replicated in an experimental design that allows for causal conclusions.

**Immediate effects on FV intake, self-efficacy, and action control (Chapter 4).** In Chapter 4, the following results and implications were drawn from primary data analyses of an intensive longitudinal RCT (BiBo project) on immediate intervention effects on FV consumption, self-efficacy, and action control:

For FV intake, an immediate increase following the intervention was found in the planning condition but not in the control condition. Subsequently, enhanced levels of FV intake were maintained. Thus, the effects of action planning interventions on FV intake can unfold immediately (i.e., one day) after the intervention. For a social support intervention on healthy eating (Inauen et al., 2017), a different picture emerged, showing a gradual increase in healthy eating but no discrete change between study phases. Thus, different active intervention ingredients seem to result in different patterns of change over time. This emphasizes the importance of investigating temporal dynamics in health psychology (Scholz, 2019). With the present action planning intervention on FV intake, scarce evidence on short-term intervention effects (Verplanken & Faes, 1999) was supported and extended as prior studies used aggregated outcome measures that do not allow to capture day-to-day changes.

Regarding volitional outcome variables, for self-efficacy, the same pattern of results was found (i.e., an immediate increase following the intervention in the planning condition and subsequent maintenance of heightened levels). This finding is in line with prior studies in various health behaviour domains, showing self-efficacy enhancements after action planning interventions (for a meta-analysis see Zhang et al., 2019) and underlines the importance of self-efficacy in predicting health behaviour changes. Moreover, present results indicate that the proposed unidirectional link from self-efficacy to action planning (HAPA; Schwarzer, 2008) might be extended by an additional reversed link from action planning to self-efficacy. For action control, no significant effects emerged (i.e., no changes throughout the diary phases and between both phases), indicating that the present action planning intervention of forming one FV plan had no short-term effects on action control. Thus, the temporal development of different volitional self-regulatory factors seems to differ after an action planning intervention. To observe increases in action control, a different intervention design (e.g., forming multiple plans; Wiedemann et al., 2012) might be necessary.

To conclude, the findings of Chapter 4 extend prior research by showing that increases in behavioural (i.e., FV intake) and specific self-regulatory outcomes (i.e., self-efficacy) can arise immediately after an action planning intervention, emphasizing the need to examine the short-term effects of action planning interventions in more detail. However, as the present analytical approaches are rather innovative and have been used rarely, results need further replication.

## Strengths, Limitations, and Outlook

In the following sections, strengths and limitations of the present thesis will be addressed and an outlook will be provided.

**Overall.** The major strength of this thesis is the investigation of action planning mechanisms at high resolution, providing insights into the question of when and how an action planning intervention unfolds its effects. This has rarely been done in prior research but is urgently needed to gain a better understanding of how action planning interventions work. Moreover, investigating how peoples' overall FV consumption can be increased is of great clinical relevance as FV intake is a highly relevant behaviour for overall global health (Aune et al., 2017).

**Sample and adherence.** As a limitation, the samples examined in this thesis were rather selective regarding (1) their sex and (2) their level of education. (1) Most of the participants were women. However, studies found substantial differences between women and men in the amount of FV intake itself (Mensink et al., 2017b, 2017a) and also regarding health behaviour change processes (e.g., intention and planning; Lange et al., 2018). Thus, a more elaborated picture could be drawn by examining a balanced sample and differentiating between women and men. (2) The samples used in this thesis were mainly recruited from universities and, therefore, consisted mostly of participants with higher education. For instance, in the BiBo project, 93% of participants had Abitur or a university degree (Table C1), which is an indicator of a high socioeconomic status (SES; de Ridder et al., 2017). Beyond the strong SES gradient in diet quality, that is, persons with low SES are less likely to eat healthily (de Ridder et al., 2017; for FV consumption see Giskes et al., 2010), interventions to increase healthy eating seem to be less effective in groups with low SES than in groups with high SES (e.g., Meurs et al., 2022). Thus, to reach higher generalisability, present results should be replicated in groups with low SES. Moreover, for secondary analyses in Chapters 2 and 3, subsamples of the full sample were used, which might have restricted statistical power.

Another limitation concerns the adherence to intervention instructions. In both study projects, participants who did not follow the instructions, that is, who did not return complete plan calendars (Happy 5; Chapter 2) or diaries (BiBo; Chapters 3 and 4), could not be included. As it might be possible that these participants were less successful in enacting their plans, future studies should focus on possibilities to increase participants' adherence by, for instance, using device-based technologies.

**Study design.** Both study projects used in this thesis were RCTs, allowing to test causal associations of action planning interventions. However, secondary analyses reported in Chapters 2 and 3 were of correlational nature, thus, no causal conclusions can be drawn.

Intensive longitudinal data were used for present analyses, which allows for investigating changes in study outcomes from day to day and thereby generating new insights into their temporal development. Moreover, intensive longitudinal data from the study project BiBo (Chapters 3 and 4) were assessed before and after the manipulation, enabling an even closer look into temporal dynamics by analysing changes concerning the development of study outcomes before and after the manipulation. However, analyses of this thesis refer to rather short assessment periods of 7 (Chapter 2) and 13 days (Chapters 3 and 4), which do not allow to draw conclusions on behaviour change maintenance for longer time periods (e.g., 6 or 12 months).

As a strength, participants were given high flexibility in formulating their plan(s). The plan calendar format (Happy 5; Chapter 2) allowed to plan temporally flexible for a comparatively large period of time (i.e., morning, noon/afternoon, and evening), which might have facilitated an easier, more individual plan generation as well as subsequent plan enactment. The study design of the BiBo project (Chapters 3 and 4) allowed for a flexible adaptation of the FV action plan for the next day, which might lead to advantages in plan enactment as plans can be adapted to changing circumstances during the assessment period. However, for future studies, a separate investigation of FV plans should be aspired, accounting for the different consumption patterns (Mensink et al., 2017b, 2017a) and plan enactment rates (see Chapter 2).

**Measurement.** One strength of measures in Chapter 2 is the detailed and highly reliable coding of plan characteristics, shedding light on the composition of action plans and, by relating them to plan enactment, revealing insights into the question of which plan characteristics are beneficial for facilitating plan enactment. As a limitation, the operationalization of plan enactment measures in Chapter 2 does not allow for assessing whether the situational cues (e.g., where- and when-cues) have been detected or not. Thus, additional consideration of situational cues would allow for investigating plan characteristic-plan enactment links in more detail (cf. Fleig et al., 2017; Keller et al., 2017). Hereby, considering not only when- and where-cues but also specifically focusing on social components of eating behaviour, such as accounting for *with whom* one consumes fruit or vegetables, would additionally inform about social aspects of eating (e.g., social norms; Higgs, 2015).

Referring to the overall heterogeneity of plan enactment measures in empirical evidence (e.g., de Vries et al., 2013; Kasten et al., 2017), the above considerations could be used to establish an appropriate and comparable measure of plan enactment. For instance, homogenous coding procedures, comparing planned situational cues (when, where, what, and with whom) and the behavioural response of the respective action plan with the daily FV intake (cf. Chapter 2), could be applied in the future. As a limitation, cue detection (Chapter 3) was coded from participants' self-reported daily FV intake, that is, it was assessed only in situations when participants had consumed an FV serving. Thus, participants may have detected their cue more frequently than reported (i.e., without consuming any fruit or vegetable or without consciously knowing), which is not reflected by the present data.

In Chapters 3 and 4 (BiBo project), the main study outcome, i.e., FV intake, was assessed using self-reports. As self-report data are likely to be biased (e.g., plan recall or social desirability bias), objective data assessments such as meal photographs could be used in future studies (König et al., 2021). This would improve the quality of outcome measures, which was found to be positively associated with action planning effects on healthy eating (Adriaanse et al., 2011). Moreover, data from both study projects have completely (BiBo; Chapter 3 and 4) or partly (plan calendars; Happy 5; Chapter 2) been assessed paper-pencil-based. Future studies should apply mobile-based assessments and reminder systems that allow for better controllability of study protocol adherence (i.e., when exactly are the questionnaires completed by participants) as well as better timing of the provision of study materials (Villinger et al., 2019). In this vein, mobile ecological momentary diet assessments (mEMDA) seem to be promising for future research in the nutritional context (Schembre et al., 2018). With this, repeated mobile-based data on a person's nutrition behaviour can be assessed in real-life settings (i.e., ecological) and quasi in real-time (i.e., momentary; Shiffman et al., 2008; Williams et al., 2021) while reducing recall biases and participant burden (Schembre et al., 2018).

**Data analyses.** The major strength of data analyses in all empirical chapters (Chapters 2 to 4) is that statistical analyses allowed to differentiate between interindividual between-person differences and intraindividual within-person changes (Hamaker & Wichers, 2017), extending prior research that mainly used aggregations of outcome measures (e.g., Verplanken & Faes, 1999). Moreover, in Chapter 4, segmented linear mixed models (Saeed et al., 2018) were used for data analyses. These allowed for modelling different time slopes for study phases prior to and after the intervention (cf. Berli et al., 2016; Inauen et al., 2017) and to examine intervention effects considering a discrete change between phases. As another strength, in Chapters 2 to 4, the random effects structure was tested so that the final model included as many random effects as possible (Chapters 3 and 4; Barr et al., 2013) or only those with significant variance (Chapter 2).

## Implications for Theory

When it comes to health behaviour change, various models try to explain why and how people change their behaviour (e.g., Social Cognitive Theory of Self-Regulation; Bandura, 1991). This thesis uses the HAPA model (Schwarzer, 2008) as the underlying theoretical model. However, the investigated research questions exceeded theoretical assumptions from the HAPA by examining very specific components of the model. That is, more knowledge was gained about: (1) how action plans should be formed (i.e., regarding plan characteristics), (2) what happens after formulating an action plan (i.e., plan pursuit), and (3) a temporal component was added. As Schwarzer (2014) proposed, health behaviour change models should be understood as conceptual frameworks that undergo permanent validation through empirical research and should be modified following robust empirical findings. Thus, after replication, present findings could be implemented into a health behaviour change model (e.g., the HAPA; Schwarzer, 2008) focusing on conditional outcome measures while, considering the suggestion of Scholz (2019), also accounting for temporal dynamics.

One focus of the present thesis was to integrate conditional behavioural outcome measures (i.e., plan enactment) into the research on action planning (Chapters 2 and 3). In contrast to the investigation of unconditional health behaviour outcomes (i.e., overall FV intake), conditional outcome measures refer directly to the formulated plan and build an important link to unconditional health behaviour change as the question can be answered whether the behavioural change (e.g., increase in FV intake) is based on behaviour that is provoked by formulating an action plan. However, it is not only important to examine these conditional behavioural outcomes (i.e., plan enactment) but also to form the link to unconditional outcome measures (i.e., FV intake). Empirical evidence has targeted this relationship, showing a generally positive association between plan enactment and overall behaviour change in different health behaviour domains, that is, for healthy eating (i.e., fruit consumption; Kasten et al., 2017), physical activity (Fleig et al., 2017), and smoking cessation (de Vries et al., 2013; Verbiest et al., 2014). These findings underline the importance of conditional behavioural actions for unconditional health behaviour change. Theory, however, lacks an explanation for this relationship. Thus, theorising about possible explanations for whether and why plan enactment is associated with overall behaviour change and investigating these theoretical assumptions in future studies is needed.

**Implications for Practice**

In the following sections, implications for practice, that is, for intervention designs and assessment methods, will be reviewed.

**Planning instructions.** In action planning interventions, participants are usually instructed to formulate a highly specific plan comprising when, where, and how they want to perform the planned behaviour (e.g., van Osch et al., 2010). This might be due to positive associations that have been homogenously found between plan specificity and overall health behaviour change (e.g., de Vet, Gebhardt, et al., 2011; de Vet, Oenema, et al., 2011). However, when considering plan enactment as the behavioural outcome measure, results in different health behaviour domains are mixed, showing positive (Verbiest et al., 2014), nonsignificant (see Chapter 2 and Keller et al., 2017) or even negative associations (Fleig et al., 2017). These findings question the assumption that planning instruction should encourage participants to plan highly specifically. It might be more appropriate if participants could choose which level of specificity fits best into their daily routine. Thus, intervention developers could provide instructions that allow for individually tailoring the level of plan specificity to the participants' needs and further for flexibly adapting the individual plan when needed, e.g., when circumstances change.

**Preparational plans and goal reminders.** In Chapter 2, plan enactment rates decreased throughout the day and vegetable plans showed lower enactment rates than fruit plans. Thus, the lowest enactment rates were found for evening vegetable plans, which were still comparably high (i.e., 58.7%). For intervention developers, it might nevertheless be of interest to facilitate plan enactment for these plans. When taking into account the high preparational effort for consuming vegetables (e.g., cooking), it might be beneficial to integrate action plans for preparational tasks into the intervention. For instance, when the FV plan comprises vegetable soup for dinner, an example for a preparational plan could read: "After breakfast, I will chop the vegetables for my soup in the evening." This specific action plan would also consider that enactment rates were found to be highest in the morning (cf. stable morning routines; Jastran et al., 2009).

Moreover, the decline of plan enactment rates throughout the day may reflect variations in the intention to eat healthily (Inauen et al., 2016). Thus, reminding participants of their intentions could be one possibility to achieve that participants enact their plan even when their intentions are low, for instance, in the evening (cf. intention-behaviour associations; Inauen et al., 2016; Keller et al., 2018). For this, device-based reminder systems or subliminal goal priming could be used (cf. Inauen et al., 2016; Papies & Hamstra, 2010).

**Just-in-time adaptive interventions.** Results from Chapter 2 indicated that FV plans formed for days that are rather far away (i.e., for the last days of the 7-day plan calendar) seem to be more difficult to enact than those formed for the next few days (i.e., for the first days of the plan calendar). To tackle this issue, *just-in-time adaptive interventions* (JITAIs) could be applied (Nahum-Shani et al., 2018). These aim to provide tailored support (i.e., the right type and amount of support) in the exact moment when it is needed by, additionally, adapting to the internal and external states of that person (Nahum-Shani et al., 2018; Wang & Miller, 2019). For action planning interventions, this would mean that participants would be able to formulate their plans on short notice, allowing them to flexibly adapt to daily circumstances that may not be predictable a few days ahead. Moreover, when delivering a device-based JITAI, a reminder system could be integrated. The example action plan "I will eat an apple at 8 am in the kitchen" could be coded to release a reminder at 8 am (e.g., "It is 8 am. Time for an apple?"). JITAIs are discussed to have a great impact on health behaviour change (Nahum-Shani et al., 2018) as the adaptation into one's daily life makes the intervention highly accessible for participants. This has been confirmed in the review by Wang and Miller (2019), revealing moderate to large effect sizes for JITAI treatments. JITAIs have a high potential for establishing new, dynamic ways of intervention delivery and should be evaluated further.

**Conclusion**

The overall aim of this thesis was to extend previous research by examining specific mechanisms of FV action planning interventions at high resolution (i.e., when and how an action planning intervention unfolds its effects). The main conclusions derived from the present findings can be summarized as follows: (1) People were successful in enacting their FV plans throughout a 7-day planning period; it was easier to enact fruit than vegetable plans and, in the morning, specific than unspecific plans; plan enactment was easier in the morning than during the rest of the day and on the first rather than the last days of the planning period. (2) People were successful in detecting the planned cue and executing the planned behaviour. Both cue detection and the execution of the planned behaviour seem to play a crucial role in unconditional health behaviour change after forming an FV action plan. (3) The present action planning intervention unfolded its effects on FV intake and self-efficacy immediately after the intervention, without leading to further increases.

This thesis accounted for the need to gain deeper knowledge on specific mechanisms of action planning interventions at a high resolution by investigating the question of when and how action planning interventions unfold their effects. Pending replication, instrumental insights and implications can be derived from the present findings. Particularly, the importance of integrating plan enactment as a conditional behavioural outcome measure and day-to-day temporal development of health behaviour change into the research is emphasized.

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# Appendix A

## Supplementary Material for Chapter 2

**Figure A1**

*Instructions of the Planning Intervention*

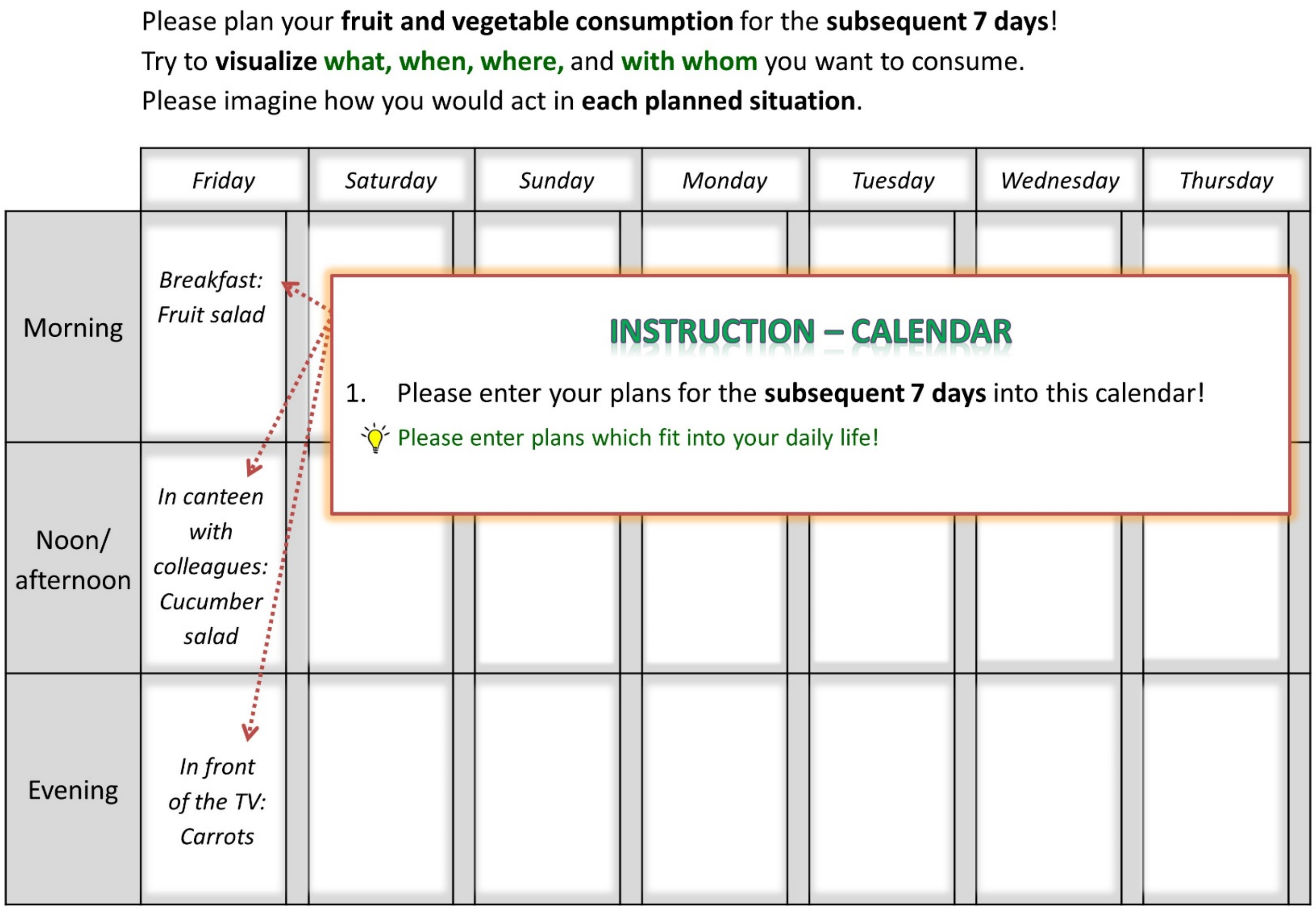


**Figure A2**

*Example of a Completed Plan Calendar*

**At the end of each day**, please label whether you **have enacted your daily plans (+)** or **not (-)!**

| | *Friday* | | *Saturday* | | *Sunday* | | *Monday* | | *Tuesday* | | *Wednesday* | | *Thursday* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Morning | *Breakfast: Fruit salad* | + | *Smoothie with almond milk and blueberries and raspberries* | + | *Smoothie with banana, apple and orange* | + | *Oatmeal with fruit* | + | *Tomato juice* | - | *Wholewheat bread with tomatoes & cucumbers* | + | | |
| Noon/ afternoon | *In canteen with colleagues: Cucumber salad* | + | *Pasta with zucchini, tomato & eggplant* | - | *Lunch with family: Potato gratin with broccoli* | + | *Vegetable slices with dip* | + | *Vegetables as garnish* | + | | | *2 portions of fruit* | - |
| Evening | *In front of the TV: Carrots* | + | Sliced vegetables | + | *Yoghurt with strawberries* | + | *Italian restaurant with friends: Vegetable salad* | - | *Dried fruit* | + | *Dinner with vegetables* | - | *Dinner with vegetables* | + |

**Table A1**

*Coding Manual for the Type of Planned Behaviour (Nutritional Choice)*

**Coding categories:**

1 = *the plan includes **only** fruit*
2 = *the plan includes **only** vegetables*
3 = *the plan includes fruit **and** vegetables*

**Definition Fruit**

Edible fruit or seeds from cultivated or wild growing trees and bushes. The plants are perennial. Fruit can be consumed raw, dried, simmered, as juice, or as a smoothie.

| | Examples | | Brief Description |
|---|---|---|---|
| **Pome Fruit** | • Apple<br>• Pear<br>• Quince | → | Seeds (kernels) are surrounded by a fleshy and greatly swollen receptacle |
| **Stone Fruit** | • Cherry<br>• Plum<br>• Peach<br>• Nectarine<br>• Apricot | → | A fleshy or fibrous fruit with thin skin, which can also be almost leathery and a central stone containing the seed |
| **Berries** | • Gooseberry<br>• Currant<br>• Raspberry<br>• Blackberry<br>• Avocado | → | „Soft, usually small and round“, sensitive to pressure |
| **Nuts** | • Nuts | → | Hard-shelled with an edible kernel |
| **Tropical and Citrus Fruit** | • Lemon<br>• Kiwi<br>• Mango<br>• Papaya<br>• Banana | → | Citrus fruit: juicy pulp, surrounded by a white and thick shell layer; Tropical fruit: botanically diverse group of fruit, indigenous to tropical and subtropical regions |

**Definition Vegetables**

Vegetables are edible parts of plants, for example, leaves, fruit, tubers, stalks, and roots from mostly annual plants. They can be eaten raw, cooked, simmered or preserved. Some vegetables can also be made into juice.

| | Examples | Brief Description |
|---|---|---|
| **Leaf vegetables** | • Spinach<br>• Lettuce<br>• Brussel Sprouts | Consumption of the leaves |
| **Leafstalk vegetables** | • Pak Choi<br>• Rapini | Fleshy leafstalks |
| **Inflorescenc es** | • Cauliflower<br>• Broccoli<br>• Artichoke | Edible inflorescences |
| **Fruit vegetables** | • Tomato<br>• Cucumber<br>• Eggplant<br>• Zucchini | A wide variety of shapes, usually round to elongated, sometimes pointy |
| **Root vegetables** | • Carrot<br>• Radish<br>• Black salsify<br>• Parsnip | Fleshy thickened storage roots (turnip) |
| **Tuber vegetables** | • Small radish<br>• Beetroot<br>• Celery | Fleshy thickened stalk area between the beginning of the roots and the cotyledons; they grow mainly in the underground |
| **Grains** | • Corn<br>• Legumes<br>- Beans<br>- Peas<br>- Lentils | Seeds (in some cases edible with the seedpod) |

| | | |
|---|---|---|
| **Bulb vegetables** | • Onion<br>• Garlic<br>• Fennel<br>• Leek | → Pungent flavour, they grow mainly in the underground |

Attention: Potatoes and rice do not count as vegetables, they are basic food! Mushrooms are also not botanically classified as vegetables!

**Table A2**

*Coding Manual for Plan Specificity*

**Coding categories:**

1 = *unspecific/vague/very general*
2 = *medium specific/medium precise*
3 = *highly specific/very accurate/very precise*

**Specificity** coding refers to **how accurate or how precise** the target behaviour was planned. You can try to visualize the meal in your mind. The easier it is or the more precise the picture is, the higher is the specificity of a plan.
If a plan only includes "fruit", there are many possibilities (apple, banana, strawberry…) and it is not possible to imagine a precise picture of the meal. This plan would be coded as 1 = *unspecific* as it only includes the target behaviour, but no additional situational cue(s). For the plan „Yoghurt with an apple", a more specific picture emerges. This plan would be coded as 2 = *medium specific* as is includes one additional situational cue (**i.e., further information about the meal; what-else cue)**. You can also plan **a location (where-cue), a time (when-cue), or include another person (with-whom cue)** as additional situational cues**.** If a plan includes at least two different additional cues, the plan would be coded as 3 = *highly specific*. A highly specific example plan would read: „Yoghurt with an apple for breakfast with my roommate".

Further pages contain more information and practical examples regarding the coding.

<table>
<tr><th>Coding</th><th colspan="2">Definition/Description</th><th>Examples</th></tr>
<tr><td>1 = unspecific</td><td colspan="2">A plan is unspecific (1) when it only contains the target behaviour.<br><br><u>Attention:</u> A plan is also unspecific if several types of fruit/vegetables are listed (e.g. „apple and banana“).<br><br><u>Additional information:</u> Salad and Smoothie are unspecific if there is no additional description of the ingredients.</td><td>▪ Vegetable<br>▪ Apple and banana<br>▪ Nectarine<br>▪ Raisins<br>▪ Cauliflower<br>▪ Apple juice<br>▪ Salad<br>▪ Smoothie<br>▪ Grated carrots</td></tr>
<tr><td rowspan="3">2 = medium specific</td><td colspan="3">A plan is medium specific (2) when it contains <u>exactly one</u> additional situational cue.<br>(What else? OR when? OR where? OR with whom?)</td></tr>
<tr><td>What else?</td><td>Additional information on the rest of the meal.</td><td>▪ Vegetable as garnish<br>▪ Sandwich, nectarine<br>▪ Cereals with fruit<br>▪ Pancakes with a banana<br>▪ Tomato salad<br>▪ Smoothie made from banana, apple, and orange</td></tr>
<tr><td>When?</td><td>Additional information on a time (e.g., mealtime, daytime, time interval).</td><td>▪ Lunch with vegetables/salad<br>▪ Carrots in the evening<br>▪ Before lunch: an apple</td></tr>
</table>

| | | | |
|---|---|---|---|
| | **Where?** | Additional information **on a location**. | ▪ A pear on the way<br>▪ Dried fruit in front of the TV |
| | **With whom?** | Additional information **on being alone or with a companion.** | ▪ Dried plums with my wife<br>▪ With my colleagues: Salad |
| **3 =** ***highly specific*** | A plan is highly specific (3) when there are **<u>at least 2</u> different additional** cues *(What else? OR when? OR where? OR with whom?).* | | |
| | **What else & when?** | | ▪ After classes: A bowl with mixed salad and bread<br>▪ Sandwich with paprika slices for breakfast<br>▪ Cereals with fruit before work |
| | **What else & where?** | | ▪ Cafeteria: Food with vegetables<br>▪ At home: vegetable stew<br>▪ Breakfast at home: Bread, olives, cucumbers, tomatoes |
| | **What else & with whom?** | | ▪ With my family: Sandwich with sausage, cucumber and tomato<br>▪ Alone: Porridge with 3 types of fruit<br>▪ Apple pie with my family |
| | **When & where?** | | ▪ For breakfast: 2 portions of fruit at the summer camp<br>▪ Lunch at the beach: Salad garnish<br>▪ Half of an apple each morning during vacations |

| | | |
|---|---|---|
| | **When & with whom?** | ▪ Grapes while having a walk with my best friend<br>▪ Salad for dinner with my family<br>▪ Dried fruit with my wife in front of the TV |
| | **Where & with whom?** | ▪ In the cafeteria with colleagues: vegetables as garnish<br>▪ Vegetable slices with my sister at the train<br>▪ Salad with colleagues in an Italian restaurant |

# Appendix B

## Supplementary Material for Chapter 3

**Figure B1**

*Study Design*

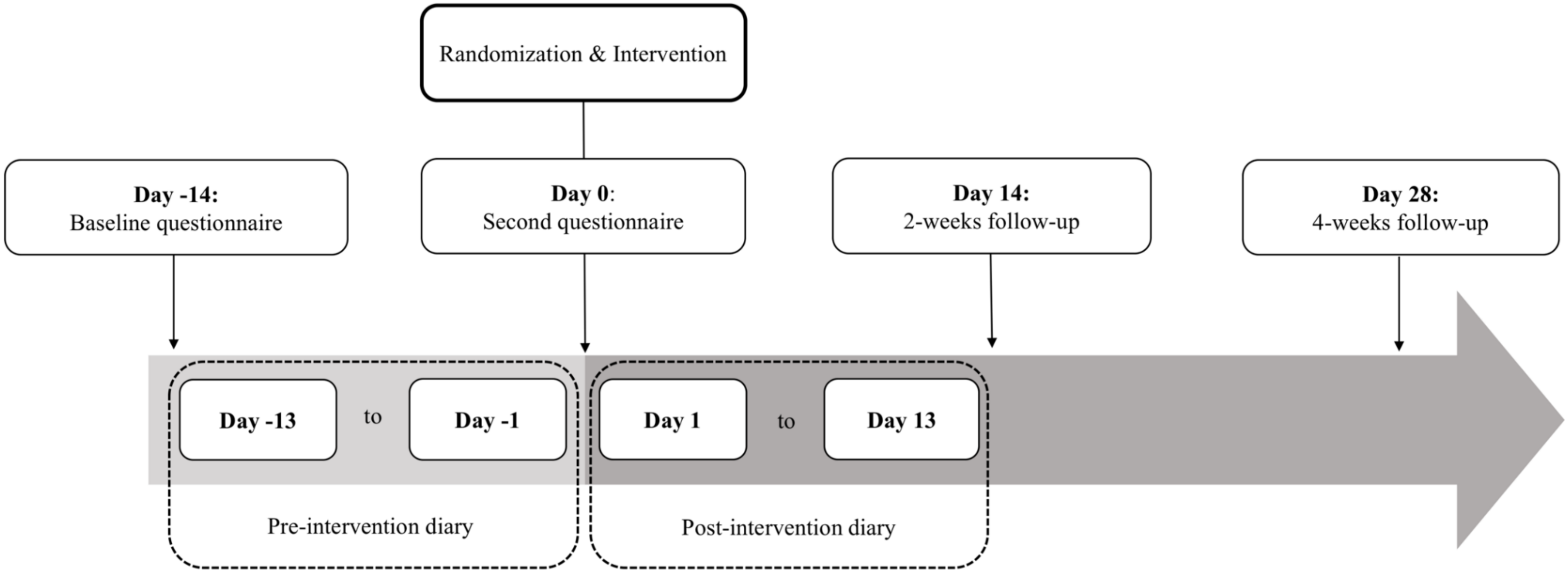


**Table B1**

*Sample Fruit and Vegetable Servings of Two Participants with Five and Four Total Servings for the Selected Sample Day*

| | | *What* | *When* | *Where* | *Cue detection* | *Planned behaviour* |
|---|---|---|---|---|---|---|
| Sample day of sample participant 1 | Plan | **Banana** | **In the evening (7 pm)** | **At home** | | |
| | 1th serving | **Banana** | 10 am | In the office | | yes |
| | 2nd serving | Apple | At lunchtime (12.15 pm) | Canteen | | |
| | 3rd serving | Apple | 3 pm | On the way | | |
| | 4th serving | Cauliflower | 5 pm | At home | | |
| | 5th serving | **Banana** | **7 pm** | **At home** | yes | yes |
| Sample day of sample participant 2 | Plan | **Apple** | **In the morning (9 am)** | **At home** | | |
| | 1th serving | Pineapple | **9 am** | **At home** | yes | |
| | 2nd serving | Salad topping | 2.30 pm | Canteen | | |
| | 3rd serving | **Apple** | 4 pm | At university | | yes |
| | 4th serving | Mandarin | 7 pm | Band rehearsal | | |

*Note.* Bold font indicates matching entries.

**Table B2**

*Sensitivity Analyses: Estimates of Multilevel Models Predicting Fruit and Vegetable Consumption, With Age, Sex, Body-Mass-Index, Number of Daily Reports, and Past Behaviour as Covariates*

| | Model 1a | | | Model 2a | | | Model 3a | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 3.90 (0.26) | **<.001** | [3.40, 4.40] | 3.71 (0.27) | **<.001** | [3.19, 4.22] | 3.85 (0.26) | **<.001** | [3.36, 4.34] |
| Between-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 1.64 (0.37) | **<.001** | [0.93, 2.34] | - | - | - | 1.02 (0.43) | **.018** | [0.22, 1.83] |
| Planned vs. different behaviour | - | - | - | 1.56 (0.38) | **<.001** | [0.83, 2.29] | 1.13 (0.43) | **.010** | [0.31, 1.95] |
| Within-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 0.46 (0.11) | **<.001** | [0.25, 0.68] | - | - | - | 0.43 (0.11) | **<.001** | [0.22, 0.64] |
| Planned vs. different behaviour | - | - | - | 0.34 (0.10) | **<.001** | [0.15, 0.53] | 0.27 (0.10) | **.006** | [0.08, 0.47] |
| Cue detection x Planned behaviour | - | - | - | - | - | - | -0.22 (0.24) | .376 | [-0.71, 0.25] |
| Sex[a] | 0.23 (0.29) | .421 | [-0.32, 0.78] | 0.44 (0.30) | .138 | [-0.12, 1.01] | 0.29 (0.28) | .293 | [-0.24, 0.82] |
| Age | -0.01 (0.01) | .264 | [-0.03, 0.01] | -0.01 (0.01) | .726 | [-0.02, 0.01] | -0.01 (0.01) | .252 | [-0.03, 0.01] |
| Body-mass-index | 0.06 (0.04) | .149 | [-0.02, 0.14] | 0.03 (0.04) | .435 | [-0.05, 0.11] | 0.06 (0.04) | .158 | [-0.02, 0.13] |
| Number of daily reports per person | 0.04 (0.05) | .399 | [-0.06, 0.14] | 0.01 (0.05) | .954 | [-0.10, 0.11] | 0.02 (0.05) | .760 | [-0.08, 0.11] |
| Past behaviour | 0.42 (0.07) | **<.001** | [0.27, 0.56] | 0.41 (0.08) | **<.001** | [0.26, 0.56] | 0.43 (0.07) | **<.001** | [0.29, 0.57] |
| Linear day trend | -0.01 (0.01) | .674 | [-0.03, 0.02] | -0.01 (0.01) | .982 | [-0.02, 0.02] | -0.01 (0.01) | .842 | [-0.02, 0.02] |

| Random Effects (variances) | Estimate | 95% CI | Estimate | 95% CI | Estimate | 95% CI |
|---|---|---|---|---|---|---|
| Intercept | 1.03 | [0.61, 1.44] | 1.08 | [0.73, 1.50] | 1.02 | [0.60, 1.47] |
| Cue detection vs. no cue detection (within-person level) | 0.21 | [0.02, 0.54] | - | - | 0.22 | [0.02, 0.55] |
| Linear day trend | 0.01 | [0.01, 0.01] | 0.01 | [0.01, 0.01] | 0.01 | [0.01, 0.01] |
| Residual | 1.19 | [1.07, 1.31] | 1.22 | [1.11, 1.35] | 1.17 | [1.06, 1.29] |

*Note.* CI = Confidence interval. Bold *p*-values indicate statistical significance at $p < .05$. Models are based on data from $n = 87$ participants and $n = 996$ observations. The variance inflation factor (VIF) of all predictors was < 2. Coefficients are unstandardized. Coefficients smaller than |0.005| were rounded to 0.01 or -0.01, respectively.

[a] Sex coded as 0 = *male*, 1 = *female*.

**Table B3**

*Sensitivity Analyses: Estimates of Multilevel Models Predicting Fruit and Vegetable Consumption, With Age, Sex, Body-Mass-Index, Number of Daily Reports, Past Behaviour, and Intention as Covariates*

| | Model 1b | | | Model 2b | | | Model 3b | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 4.18 (0.22) | **<.001** | [3.76, 4.60] | 4.13 (0.22) | **<.001** | [3.71, 4.55] | 4.14 (0.22) | **<.001** | [3.73, 4.56] |
| Between-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 0.51 (0.33) | .127 | [-0.11, 1.13] | - | - | - | 0.23 (0.37) | .526 | [-0.46, 0.93] |
| Planned vs. different behaviour | - | - | - | 0.69 (0.32) | **.034** | [0.08, 1.29] | 0.58 (0.36) | .113 | [-0.10, 1.25] |
| Intention | 0.61 (0.08) | **<.001** | [0.45, 0.77] | 0.61 (0.08) | **<.001** | [0.45, 0.76] | 0.59 (0.08) | **<.001** | [0.43, 0.75] |
| Within-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 0.32 (0.09) | **<.001** | [0.15, 0.49] | - | - | - | 0.29 (0.09) | **<.001** | [0.12, 0.47] |
| Planned vs. different behaviour | - | - | - | 0.29 (0.09) | **.002** | [0.11, 0.46] | 0.25 (0.09) | **.007** | [0.07, 0.43] |
| Cue detection x Planned behaviour | - | - | - | - | - | - | -0.16 (0.22) | .476 | [-0.60, 0.27] |
| Intention | 0.54 (0.04) | **<.001** | [0.46, 0.63] | 0.56 (0.04) | **<.001** | [0.47, 0.64] | 0.54 (0.04) | **<.001** | [0.45, 0.63] |
| Sex[a] | -0.05 (0.24) | .831 | [-0.50, 0.40] | 0.01 (0.23) | .997 | [-0.45, 0.45] | -0.01 (0.24) | .991 | [-0.45, 0.45] |
| Age | 0.01 (0.01) | .962 | [-0.01, 0.01] | 0.01 (0.01) | .948 | [-0.01, 0.01] | 0.01 (0.01) | .918 | [-0.02, 0.01] |
| Body-mass-index | 0.01 (0.03) | .822 | [-0.06, 0.07] | 0.01 (0.03) | .951 | [-0.06, 0.06] | 0.01 (0.04) | .995 | [-0.06, 0.07] |
| Number of daily reports per person | 0.01 (0.04) | .771 | [-0.07, 0.09] | -0.01 (0.04) | .924 | [-0.09, 0.08] | -0.01 (0.04) | .961 | [-0.08, 0.08] |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Past behaviour | 0.23 (0.06) | **<.001** | [0.10, 0.35] | 0.23 (0.06) | **<.001** | [0.11, 0.35] | 0.23 (0.06) | **<.001** | [0.11, 0.35] |
| Linear day trend | -0.01 (0.01) | .167 | [-0.04, 0.01] | -0.01 (0.01) | .245 | [-0.03, 0.01] | -0.01 (0.01) | .244 | [-0.03, 0.01] |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 0.70 | | [0.40, 1.00] | 0.71 | | [0.41, 1.02] | 0.70 | | [0.39, 0.98] |
| Linear day trend | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] | 0.01 | | [0.01, 0.01] |
| Residual | 1.02 | | [0.93, 1.13] | 1.03 | | [0.93, 1.13] | 1.01 | | [0.92, 1.12] |

*Note.* CI = Confidence interval. Bold *p*-values indicate statistical significance at $p < .05$. Models are based on data from $n = 87$ participants and $n = 988$ observations. The variance inflation factor (VIF) of all predictors was < 2. Coefficients are unstandardized. Coefficients smaller than |0.005| were rounded to 0.01 or -0.01, respectively.

[a] Sex coded as 0 = *male*, 1 = *female*.

**Table B4**

*Multilevel Model Estimates Predicting Daily Fruit and Vegetable Consumption, with Cue Detection and No Cue Detection (Model 1c), Planned and Different Behaviour (Model 2c) as Predictors, as well as Interaction Effects of Cue Detection and Planned Behaviour (Model 3c), with Standardized Coefficients*

| | Model 1c | | | Model 2c | | | Model 3c | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 4.12 (0.15) | **<.001** | [3.82, 4.41] | 4.11 (0.15) | **<.001** | [3.81, 4.41] | 4.12 (0.15) | **<.001** | [3.83, 4.41] |
| Between-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 0.52 (0.12) | **<.001** | [0.27, 0.76] | - | - | - | 0.35 (0.14) | **.017** | [0.07, 0.63] |
| Planned vs. different behaviour | - | - | - | 0.48 (0.13) | **<.001** | [0.23, 0.72] | 0.30 (0.14) | **.037** | [0.02, 0.58] |
| Within-person level | | | | | | | | | |
| Cue detection vs. no cue detection | 0.17 (0.04) | **<.001** | [0.09, 0.25] | - | - | - | 0.16 (0.04) | **<.001** | [0.08, 0.25] |
| Planned vs. different behaviour | - | - | - | 0.10 (0.04) | **.003** | [0.03, 0.17] | 0.08 (0.04) | **.018** | [0.01, 0.15] |
| Cue detection x Planned behaviour | - | - | - | - | - | - | -0.03 (0.03) | .345 | [-0.10, 0.03] |
| Linear day trend | -0.04 (0.08) | .556 | [-0.19, 0.10] | -0.03 (0.08) | .738 | [-0.18, 0.13] | -0.04 (0.08) | .644 | [-0.18, 0.11] |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 1.62 | | [1.10, 2.31] | 1.71 | | [1.16, 2.42] | 1.59 | | [1.06, 2.25] |
| Cue detection vs. no cue detection (within-person level) | 0.03 | | [0.01, 0.08] | - | | - | 0.03 | | [0.01, 0.08] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Linear day trend | 0.09 | [0.01, 0.27] | 0.13 | [0.01, 0.31] | 0.10 | [0.01, 0.27] |
| Residual | 1.21 | [1.10, 1.33] | 1.25 | [1.14, 1.38] | 1.20 | [1.09, 1.32] |

*Note.* CI = Confidence interval. Bold *p*-values indicate statistical significance at $p < .05$. Models are based on data from $n = 90$ participants and $n =$ 1,034 observations. The variance inflation factor (VIF) of all predictors was < 2. Coefficients smaller than 0.005 were rounded to 0.01.

# Appendix C

## Supplementary Material for Chapter 4

**Figure C1**

*Study Design*

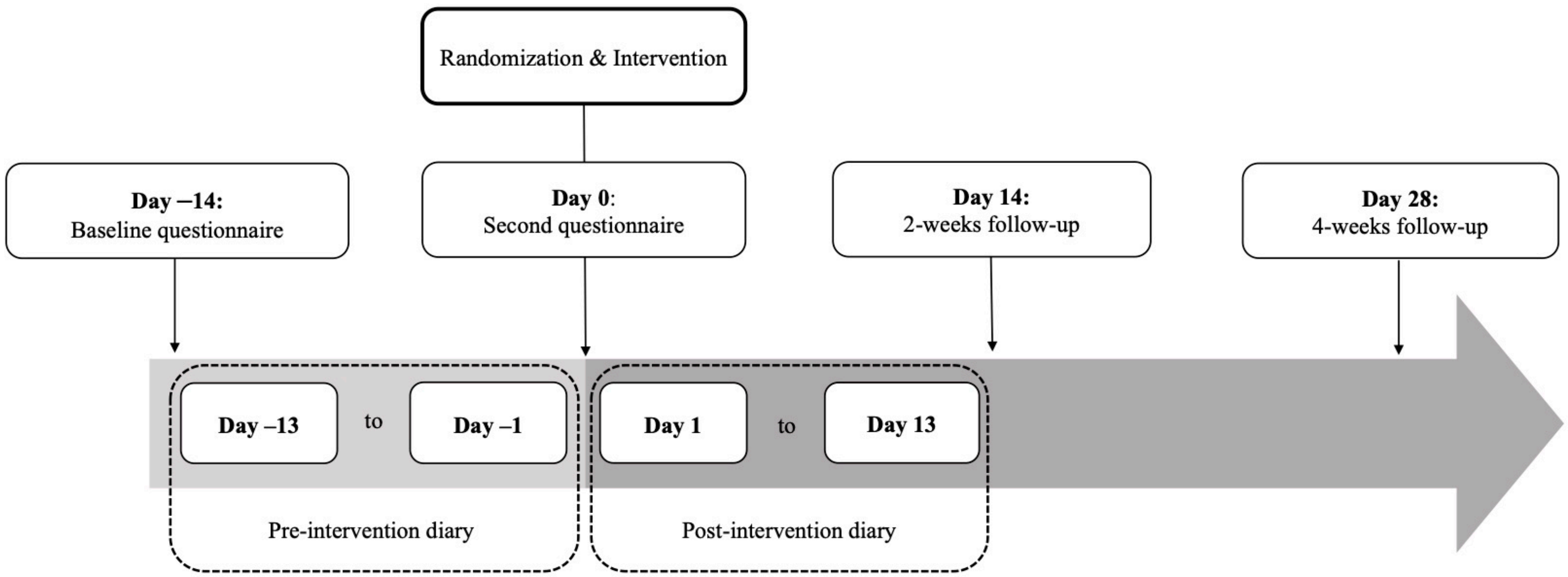


**Table C1**

*Baseline Sample Characteristics*

| | Planning condition (*n* = 106) | | Control condition (*n* = 100) | | All (*N* = 206) | |
|---|---|---|---|---|---|---|
| Sample Characteristics | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Age | 32.80 | 12.25 | 30.59 | 10.06 | 31.73 | 11.73 |
| Gender: female (%) | 78 | | 75 | | 77 | |
| Body mass index | 22.72 | 3.13 | 22.25 | 3.23 | 22.49 | 3.18 |
| Marital status (%) | | | | | | |
| Single | 50 | | 64 | | 57 | |
| Married/Partnership | 45 | | 35 | | 40 | |
| Divorced/Separated | 5 | | 1 | | 3 | |
| Relationship duration (years) | 10.79 | 11.57 | 8.50 | 9.95 | 9.76 | 10.86 |
| Level of Education (%) | | | | | | |
| High school diploma | 39 | | 56 | | 47 | |
| University degree | 55 | | 36 | | 46 | |
| Other | 6 | | 8 | | 1 | |
| Employed (%) | 72 | | 58 | | 65 | |

**Table C2**

*Manipulation Check: Estimates of Two-level Models Predicting Action Planning, With Age, Sex, Body Mass Index, and Employment Status as Covariates, and With Standardized Coefficients, Using the Control Condition at Day –11 as the Reference*

| | Model with unstandardized coefficients | | | Model with unstandardized coefficients and covariates | | | Model with standardized coefficients | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 2.66 (.10) | <.001 | 2.45, 2.86 | 2.57 (.17) | <.001 | 2.24, 2.90 | 2.66 (.10) | <.001 | 2.45, 2.86 |
| Interv. effect Day –11 | 0.02 (.14) | .912 | –0.27, 0.30 | –0.02 (.15) | .876 | –0.31, 0.26 | 0.01 (.10) | .912 | –0.19, 0.29 |
| Pre-interv. day trend CC | 0.01 (.01) | .235 | –0.01, 0.03 | 0.01 (.01) | .223 | –0.01, 0.03 | 0.18 (.15) | .235 | –0.11, 0.47 |
| Pre-interv. day trend x PC | 0.01 (.01) | .749 | –0.02, 0.03 | 0.01 (.02) | .695 | –0.02, 0.04 | 0.05 (.15) | .749 | –0.25, 0.34 |
| Phase effect CC | –0.08 (.15) | .588 | –0.38, 0.21 | –0.08 (.16) | .589 | –0.39, 0.22 | –0.06 (.11) | .588 | –0.28, 0.16 |
| Phase effect x PC | 0.34 (.21) | .113 | –0.08, 0.76 | 0.32 (.22) | .144 | –0.11, 0.75 | 0.18 (.11) | .113 | –0.04, 0.40 |
| Post-interv. day trend CC | –0.01 (.01) | .698 | –0.03, 0.27 | –0.01 (.01) | .700 | –0.03, 0.02 | –0.05 (.14) | .698 | –0.33, 0.22 |
| Post-interv. day trend x PC | –0.01 (.02) | .487 | –0.05, 0.02 | –0.01 (.02) | .456 | –0.05, 0.02 | –0.10 (.14) | .487 | –0.38, 0.18 |
| Age | - | - | - | 0.02 (.01) | .010 | 0.01, 0.03 | - | - | - |
| Sex[a] | - | - | - | 0.14 (.18) | .443 | –0.22, 0.49 | - | - | - |
| Body mass index | - | - | - | –0.03 (.02) | .221 | –0.08, 0.02 | - | - | - |
| Employment status[b] | - | - | - | –0.01 (.14) | .937 | –0.29, 0.26 | - | - | - |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 0.82 | | 0.63, 1.05 | 0.82 | | 0.61, 1.02 | 0.82 | | 0.63, 1.05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pre-interv. day trend CC | 0.01 | 0.01, 0.01 | 0.01 | 0.01, 0.01 | 0.90 | 0.50, 1.38 |
| Phase effect CC | 0.50 | 0.10, 0.99 | 0.54 | 0.15, 1.05 | 0.27 | 0.06, 0.54 |
| Post-interv. day trend CC | 0.01 | 0.01, 0.01 | 0.01 | 0.01, 0.01 | 0.75 | 0.38, 1.18 |
| Residual | 0.71 | 0.68, 0.74 | 0.70 | 0.67, 0.73 | 0.71 | 0.68, 0.74 |

*Note.* FV = Fruit and vegetable; Est = Estimate; Interv. = Intervention; CC = Control condition; PC = Planning condition; CI = Confidence interval. Models are based on data from $198 \leq n \leq 205$ participants and $4{,}287 \leq n \leq 4{,}451$ observations due to missing values. Intraclass correlation (ICC) for action planning: 0.50 ([0.45, 0.56)]. Coefficients smaller than 0.005 were rounded to 0.01.

[a] Sex coded as 0 = *male*, 1 = *female*. [b] Employment status coded as 0 = *unemployed*, 1 = *employed*.

**Figure C2**

*Day-to-Day Temporal Development of Action Planning*

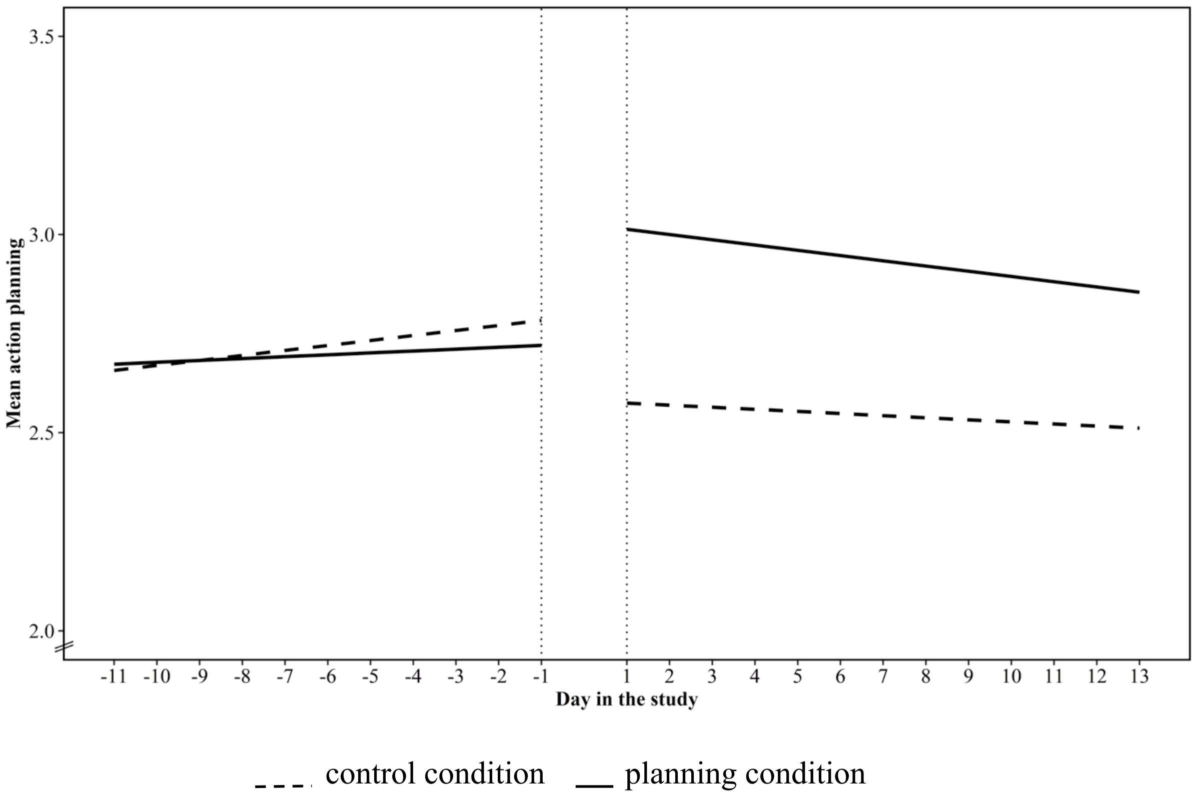
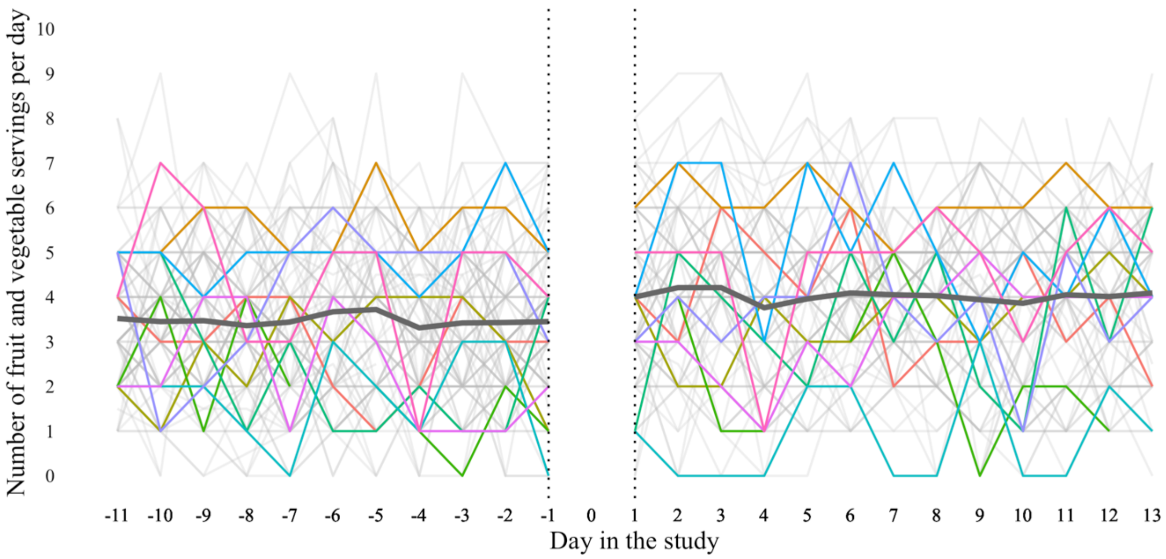


**Figure C3**

*Spaghetti Plots of Fruit and Vegetable Consumption in the Planning Condition (Panel 1) and in the Control Condition (Panel 2) over Pre- and Post-Intervention Diary (24 days)*

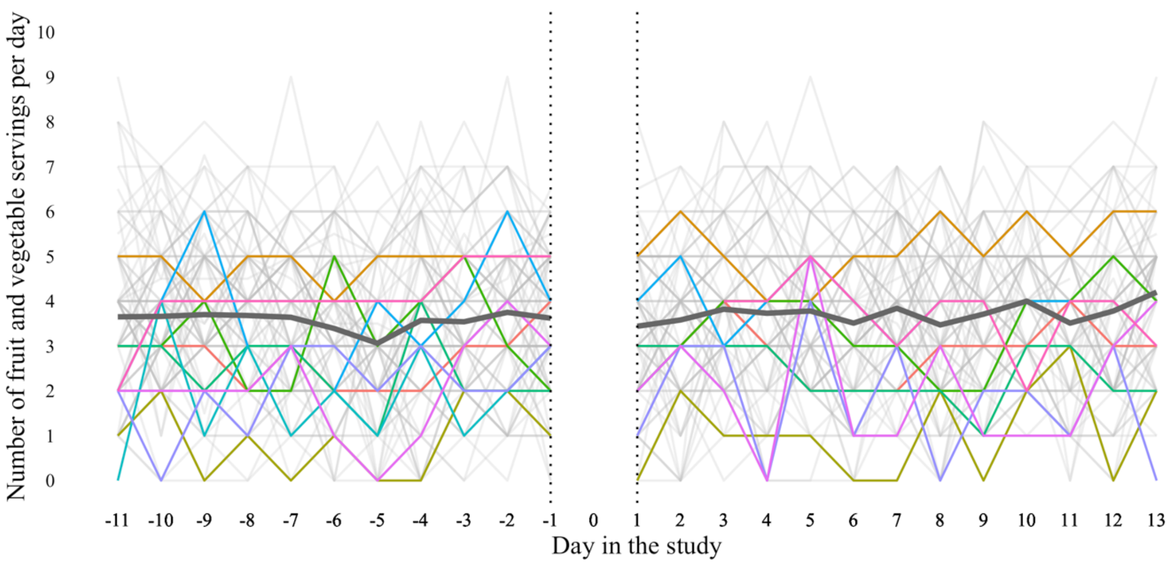
**Panel 1.**

Fruit and vegetable consumption of participants from the planning condition over time




**Panel 2.**

Fruit and vegetable consumption of participants from the control condition over time




*Note.* Coloured lines indicate developments of randomly chosen $n$ = 10 participants from the planning condition (Panel 1) and $n$ = 10 participants from the control condition (Panel 2).

Bold grey lines indicate average fruit and vegetable servings per day across all participants from the respective condition.

**Table C3**

*Sensitivity Analyses: Estimates of Multilevel Models Predicting Fruit and Vegetable Consumption, Self-Efficacy, and Action Control, With Age, Sex, Body Mass Index, and Employment Status as Covariates*

| | Model 1b: FV consumption | | | Model 2b: Self-efficacy | | | Model 3b: Action control | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 3.20 (.21) | <.001 | 2.80, 3.61 | 2.36 (.20) | <.001 | 1.96, 2.76 | 2.33 (.16) | <.001 | 2.02, 2.65 |
| Interv. effect Day –11 | –0.07 (.19) | .704 | –0.44, 0.29 | –0.16 (.19) | .390 | –0.53, 0.20 | 0.10 (.15) | .499 | –0.19, 0.39 |
| Pre-interv. day trend CC | –0.01 (.01) | .423 | –0.04, 0.02 | –0.01 (.01) | .559 | –0.03, 0.02 | 0.01 (.01) | .240 | –0.01, 0.03 |
| Pre-interv. day trend x PC | 0.01 (.02) | .696 | –0.03, 0.04 | 0.02 (.02) | .216 | –0.01, 0.06 | –0.01 (.02) | .449 | –0.04, 0.02 |
| Phase effect CC | –0.36 (.21) | .097 | –0.77, 0.06 | –0.20 (.20) | .306 | –0.60, 0.18 | 0.11 (.16) | .468 | –0.20, 0.41 |
| Phase effect x PC | 0.80 (.30) | .008 | 0.22, 1.39 | 0.56 (.28) | .044 | 0.03, 1.12 | –0.04 (.22) | .842 | –0.47, 0.39 |
| Post-interv. day trend CC | 0.04 (.02) | .041 | 0.01, 0.07 | 0.02 (.02) | .216 | –0.01, 0.06 | –0.02 (.01) | .232 | –0.04, 0.01 |
| Post-interv. day trend x PC | –0.03 (.02) | .178 | –0.08, 0.01 | –0.03 (.02) | .241 | –0.07, 0.02 | 0.02 (.02) | .199 | –0.01, 0.06 |
| Age | 0.01 (.01) | .616 | –0.02, 0.01 | –0.01 (.01) | .475 | –0.02, 0.01 | –0.01 (.01) | .854 | –0.01, 0.01 |
| Sex[a] | 0.49 (.22) | .025 | 0.06, 0.92 | 0.70 (.21) | .001 | 0.28, 1.11 | 0.46 (.17) | .006 | 0.13, 0.79 |
| Body mass index | 0.02 (.03) | .564 | –0.04, 0.08 | 0.01 (.03) | .804 | –0.05, 0.07 | –0.04 (.02) | .099 | –0.08, 0.01 |
| Employment status[b] | –0.34 (.18) | .056 | –0.68, 0.01 | –0.24 (.17) | .165 | –0.57, 0.09 | –0.19 (.13) | .161 | –0.45, 0.07 |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 1.22 | | 0.89, 1.53 | 1.44 | | 1.11, 1.58 | 0.88 | | 0.68, 1.09 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Pre-interv. day trend CC | 0.01 | 0.01, 0.01 | 0.01 | 0.01, 0.01 | 0.01 | 0.01, 0.01 |
| Phase effect CC | 0.56 | 0.12, 1.47 | 1.67 | 0.98, 2.47 | 1.06 | 0.65, 1.56 |
| Post-interv. day trend CC | 0.01 | 0.01, 0.01 | 0.01 | 0.01, 0.02 | 0.01 | 0.01, 0.01 |
| Residual | 1.52 | 1.45, 1.59 | 0.79 | 0.76, 0.83 | 0.47 | 0.45, 0.49 |

*Note.* FV = Fruit and vegetable; Est = Estimate; Interv. = Intervention; CC = Control condition; PC = Planning condition; CI = Confidence interval. Intercept reflects the mean of the control condition at Day –11. Models are based on data from $n$ = 198 participants and $4{,}278 \leq n \leq 4{,}356$ observations due to missing values. Coefficients are unstandardized. Coefficients smaller than |0.005| were rounded to 0.01 or –0.01, respectively.

[a] Sex coded as 0 = *male*, 1 = *female*. [b] Employment status coded as 0 = *unemployed*, 1 = *employed*.

**Table C4**

*Two-level Model Estimates Predicting Fruit and Vegetable (FV) Consumption, Self-Efficacy, and Action Control, With Standardized Coefficients and Using the Control Condition at Day –11 as the Reference*

| | Model 1c: FV consumption | | | Model 2c: Self-efficacy | | | Model 3c: Action control | | |
|---|---|---|---|---|---|---|---|---|---|
| Fixed Effects | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI | Est *(SE)* | *p* | 95% CI |
| Intercept | 3.62 (.13) | <.001 | 3.36, 3.88 | 2.90 (.13) | <.001 | 2.64, 3.16 | 2.68 (.10) | <.001 | 2.48, 2.88 |
| Interv. effect Day –11 | –0.09 (.13) | .519 | –0.49, 0.23 | –0.13 (.13) | .314 | –0.39, 0.13 | 0.06 (.10) | .585 | –0.15, 0.26 |
| Pre-interv. day trend CC | –0.13 (.18) | .479 | –0.35, 0.17 | –0.07 (.18) | .677 | –0.43, 0.28 | 0.22 (.15) | .156 | –0.08, 0.52 |
| Pre-interv. day trend x PC | 0.03 (.18) | .870 | –0.33, 0.39 | 0.19 (.18) | .303 | –0.17, 0.54 | –0.16 (.15) | .294 | –0.46, 0.14 |
| Phase effect CC | –0.26 (.15) | .096 | –0.56, 0.04 | –0.12 (.14) | .419 | –0.39, 0.16 | 0.10 (.11) | .366 | –0.12, 0.32 |
| Phase effect x PC | 0.46 (.16) | .003 | 0.16, 0.77 | 0.30 (.14) | .037 | 0.02, 0.58 | –0.03 (.11) | .769 | –0.25, 0.19 |
| Post-interv. day trend CC | 0.36 (.17) | .038 | 0.02, 0.70 | 0.20 (.17) | .243 | –0.13, 0.52 | –0.18 (.14) | .182 | –0.45, 0.08 |
| Post-interv. day trend x PC | –0.24 (.17) | .168 | –0.58, 0.10 | –0.18 (.17) | .284 | –0.51, 0.15 | 0.20 (.14) | .140 | –0.07, 0.47 |
| Random Effects (variances) | Estimate | | 95% CI | Estimate | | 95% CI | Estimate | | 95% CI |
| Intercept | 1.25 | | 0.94, 1.62 | 1.45 | | 1.14, 1.81 | 0.90 | | 0.71, 1.12 |
| Pre-interv. day trend CC | 0.54 | | 0.01, 1.26 | 1.65 | | 1.08, 2.31 | 1.44 | | 1.02, 1.93 |
| Phase effect CC | 0.30 | | 0.03, 0.79 | 0.86 | | 0.50, 1.29 | 0.55 | | 0.33, 0.81 |
| Post-interv. day trend CC | 0.42 | | 0.01, 1.05 | 1.37 | | 0.86, 1.97 | 1.00 | | 0.67, 1.39 |
| Residual | 1.54 | | 1.48, 1.62 | 0.81 | | 0.77, 0.85 | 0.48 | | 0.46, 0.50 |

*Note*. FV = Fruit and vegetable; Est = Estimate; Interv. = Intervention; CC = Control condition; PC = Planning condition; CI = Confidence interval.

Models are based on data from $n = 205$ participants and $4{,}451 \leq n \leq 4{,}522$ observations due to missing values.

## Curriculum Vitae

## Antonia Domke

*For reasons of data protection, the curriculum vitae is not included in this version.*

# List of Publications

## Journal articles (peer-reviewed)

**Domke, A.**, Keller, J., Knoll, N., Sniehotta, F. F., Heuse, S., & Wiedemann, A. U. (2022). Plan pursuit in the context of daily fruit and vegetable consumption: The importance of cue detection and the execution of the planned behaviour. *British Journal of Health Psychology, 27,* 1172–1187. http://doi.org/10.1111/bjhp.12593

Keller, J., Kwasnicka, D., Wilhelm, L. O., Lorbeer, N., Pauly, T., **Domke, A.**, Knoll, N., & Fleig, L. (2021). Hand washing and related cognitions following a brief behavior change intervention during the COVID-19 pandemic: A pre-post analysis. *International Journal of Behavioral Medicine.* https://doi.org/10.1007/s12529-021-10042-w

**Domke, A.,** Keller, J., Heuse, S., Wiedemann, A. U., Lorbeer, N., & Knoll, N. (2021). Immediate effects of a very brief planning intervention on fruit and vegetable consumption: A randomized controlled trial. *Applied Psychology: Health and Well-Being, 13*(2), 377-393. https://doi.org/10.1111/aphw.12254

**Domke, A.,** Keller, J., Fleig, L., Knoll, N., & Schwarzer, R. (2019). What makes a good action plan? Characteristics and enactment of fruit and vegetable plans. *Appetite, 142,* 104351. https://doi.org/10.1016/j.appet.2019.104351

Schultebraucks, K., Deuter, C. E., Duesenberg, M., Schulze, L., Hellmann-Regen, J., **Domke, A.,** Lockenvitz, L., Kuehl, L. K., Otte, C., & Wingenfeld, K. (2016). Selective attention to emotional cues and emotion recognition in healthy subjects: the role of mineralocorticoid receptor stimulation. *Psychopharmacology*, *233*(18), 3405-3415. https://doi.org/10.1007/s00213-016-4380-0

## Presentations

**2021**

**Domke, A.,** Keller, J., Heuse, S., Wiedemann, A. U., Lorbeer, N., & Knoll, N. (2021). *Immediate effects of a very brief planning intervention on fruit and vegetable consumption: A randomized controlled trial.* Oral presentation at the 7th Conference of the Society of Ambulatory Assessment, 30 June - 2 July 2021 in Zurich, Switzerland.

**2019**

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**List of Contributions**

Antonia Domke (AD) drafted Chapters 1 and 6.

For Chapter 2, Mirjam Motter (MM) and Susannah Motter (SM) designed the study under the supervision of Dr. Jan Keller (JK) and Prof. Dr. Ralf Schwarzer (RS). MM and SM collected the data. AD analysed and interpreted the data in consultation with JK. AD drafted the manuscript. JK, Prof. Dr. Lena Fleig (LF), Prof. Dr. Nina Knoll (NK), and RS revised the manuscript.

For Chapters 3 and 4, Dr. Amelie U. Wiedemann (AUW) and Prof. Dr. Silke Heuse (SH) designed the study and coordinated the research. AD conducted the analyses and interpreted the data in consultation with JK. AD drafted the manuscripts. For Chapter 3, JK, NK, Prof. Dr. Falko F. Sniehotta (FFS), SH, and AUW revised the manuscript. For Chapter 4, JK, SH, AUW, Noemi Lorbeer (NL), and NK revised the manuscript.

All authors approved the final manuscripts (applying to all chapters).

# 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.

Antonia Domke

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