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Multiple plans and memory performance: results of a randomized controlled trial targeting fruit and vegetable intake

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Abstract To test whether forming and memorizing more action plans has larger effects than generating fewer plans. In a randomized controlled trial with five intervention groups and one control group, 478 participants were asked to form one, two, three, four, or five action plans, or to complete questionnaires only (control group). One week later, behavior change was measured and participants of the intervention groups completed a free recall task. Outcome measures are daily intake of fruit and vegetables as well as recall of plans. Fruit and vegetable intake increased with higher numbers of plans, and was significantly larger in groups that formed four ($d = 0.36$) or five plans ($d = 0.48$) as compared to controls. The sum of recalled plans reflected the number of generated plans, but was unrelated to behavior change. Generating multiple plans benefits behavior change, but to be implemented they need not be recalled.

Keywords Action plan · Implementation intention · Randomized controlled trial · Healthy nutrition · Health behavior change

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In most western populations, consumption of fruit and vegetable remains below the recommendation of at least five servings per day despite considerable implications for health (WHO, 2003). Even if people hold positive intentions they often fail to implement health behaviors. Especially when intended actions cannot be carried out straight away, when competing goals are prioritized, or when prompting stimuli for retrieval of intentions are missing, intentions are forgotten. However, prospective memory performance (i.e., memory for executing intentions in the future) can be improved by *action plans* (implementation intentions; Gollwitzer & Sheeran, 2006). In action plans, situational cues (‘when’ and ‘where’ to act) are linked to goal-directed responses (‘what to do’ and ‘how to act’) to form mental cue-response associations. As soon as specified cues are encountered, they are assumed to trigger the retrieval of intentions and elicit the associated behavior. Accordingly, planning interventions improve memory for opportunities to act (Gollwitzer & Brandstätter, 1997) and attainment of health behavior goals, including healthy dieting (e.g., Luszczynska et al., 2007) with medium effect sizes on average (meta-analysis: $d = .59$; Gollwitzer & Sheeran, 2006). Adding planning components to interventions has induced larger effects than brief interventions based solely on information provision (Stadler et al., 2010), motivation (Milne et al., 2002), or asking participants to change their behavior (Wiedemann et al., 2011).

Forming multiple action plans

To follow a diet rich in fruit and vegetables, people must enact not only one intention ('I intend to eat five servings of fruit and vegetables per day.') but multiple ones (e.g., 'I intend to eat a banana in the morning/salad for lunch/an apple in the afternoon.'). Thus, planning interventions might be well adapted if participants are to form not only one but multiple plans, because each additional action plan may increase the likelihood that opportunities to act will be taken (Webb, 2006). The question arises, however, whether multiple plans work in orchestration without interference. Webb (2006) has summarized putative counterproductive consequences of multiple plans: (a) a larger cognitive load, possibly leading to encoding problems, and plans of a lower quality, which in turn may decrease behavioral performance (Van Osch et al., 2010) as well as the inhibition of a full processing of single plans, and thus the forming of less effective cue-response associations; (b) the consumption of cognitive resources to an extent at which the limited capacities are depleted and the execution of plans impeded, and c) a compromised detection of critical cues when multiple cues compete for attentional resources (Smith & Bayen, 2004). Few studies investigated effects of different quantities of plans or prospective memory tasks. In the laboratory, Cohen et al. (2008) found a larger number of prospective memory tasks to consume larger attentional capacities and to compromise the automaticity of behavioral responses. In field studies, a larger number of plans was generally associated with a better behavioral performance (adherence to speeding limits; Elliott & Armitage, 2006; physical activity; Wiedemann et al., 2011). However, curvilinear effects occurred in one study when four rather than five plans were superior, which may reflect detrimental effects of a larger number of plans on behavior (Wiedemann et al., 2011). But because these two studies used post-hoc ratings of an individually chosen number of plans, associations between the number of plans and behavior change may have been confounded by third variables. Up to this point, experimental field studies have not tested effects of different numbers of plans on behavior change. The primary objective of this RCT was to test whether a larger number of self-generated action plans improves fruit and vegetable intake.

Memory performance as explanatory factor of intervention effects

Memory may be an explanatory factor for the effects of plans: As planning supposedly increases the mental accessibility of planned cues (Gollwitzer & Sheeran, 2006), people should be able to retrieve these cues from memory. Memory of cues, in turn, should facilitate the detection and seizing of critical opportunities to act, and thus influence behavior change. Given that the planned cues elicit the planned responses, memory of specified situations should be more relevant for behavior change than memory of planned behavioral acts. Thus, memory of planned situations was tested as an explanatory factor of intervention effects in this study. However, the mere ability to remember planned situations may decrease with an increasing number of formed plans due to the higher cognitive load at the planning stage. Therefore, detrimental effects of forming multiple plans on memory were tested in addition.

Methods

Design and participants

The research aims were addressed in a double-blind RCT with a 6 × 2 mixed factorial design with condition (control group: questionnaire-only, intervention groups: one, two, three, four, or five plans to be formed, respectively) as between-subjects and time as within-subjects factor. 478[1] eligible participants (no restrictions on consuming five servings of fruit and vegetables per day; being available for the follow-up) were recruited in university courses and randomly assigned to one of the six experimental groups, resulting in 77–82 persons per group (see online resource 1 for flowchart). Questionnaires contained the '5 a day'-recommendation, all social-cognitive measures, and a planning sheet for the respective intervention groups if applicable. Measures were taken prior to (T1) and 1 week after the intervention (T2) in line with previous studies on short-term effects of planning on fruit and vegetable intake (e.g., Chapman et al., 2009). Follow-up data were available from 362 participants (75.7% of the initial sample). Blindness to conditions was enabled by cluster-randomization (three persons per cluster) and by asking participants not to communicate study content. The sample had a mean age of 25.7 years (SD = 7.1; range 18–68 years) and comprised 81.6% women. The majority were not married (58.6%). The study was approved by the departmental ethics committee and conducted in line with the National Psychological Society ethical guidelines. Participation was compensated by course credits and tickets for a prize drawing.

Planning interventions

At T1, participants in planning conditions were asked to generate one, two, three, four, or five action plans in illustra-

[1] An a priori sample size estimation resulted in a sample size of $n = 77$ participants per condition ($d = 0.59$; Gollwitzer & Sheeran, 2006; $\alpha = .05$, power = .95, dropout = 30%).

tions of notepads in accordance to their allocated condition.[2] Each notepad consisted of four interrogative ('when', 'where', 'what kind', and 'how'), and blank space to allow for participants' individual plans. Plans were formed regarding specific opportunities in which to consume *one serving,* and all plans should relate to *one average day* to ensure that a plan does not include multiple servings. A sample action plan was provided to facilitate comprehension. Participants were asked to check the completeness of their plans and to memorize them. For the surprise free recall task at T2, the last page of the questionnaire displayed notepads again. Participants were asked to recall all plans they had specified the week before. Similar planning interventions have proven effective in students (Gollwitzer & Sheeran, 2006).

Measures

Primary behavior

T1 and T2 fruit and vegetable intake, was assessed by the question 'How many servings of fruit and vegetable did you eat on a typical day of the last week?' A slightly adapted item had been validated against dietary biomarkers (Steptoe et al., 2003). The item followed the definition of a serving, i.e., the amount of food (e.g., grapes or salad) that fits into the palm of the hand, and the note that rice and potato products should be disregarded.

Social-cognitive measures

The social-cognitive measures used 6-point Likert scales (factorial and predictive validity, e.g., Chapman et al., 2009; Sniehotta et al., 2005), ranging from *completely disagree* (1) to *completely agree* (6). Intentions were assessed as control variable as a large body of research confirmed their influence on the effects of planning (e.g., Gollwitzer & Sheeran, 2006; Lippke et al., 2004), 'I intend to eat at least five servings of fruit or vegetables per day'. T1 and T2 action planning were assessed with a 5-item scale, 'I have already planned my fruit and vegetable intake precisely in terms of when/where/what/how/how many servings' (Cronbach's $\alpha = .87$ and .91 for T1 and T2). At T2, change in the content of plans ('I have changed my plans for fruit and vegetable intake in the meantime') and disengagement from plans ('I have refrained from my plans for fruit and vegetable intake.') were assessed, too.

Plan recall

Two raters independently coded all recalled situational cues as these are the action-inducing components of plans. Only recalls of people who provided T2 data and adhered to the protocol (i.e., formed as many plans as requested) were rated. One point (coded '1') was awarded if they recalled both, 'when' and 'where' specifications: A situation needs to be recognized as critical for action without ambiguity to trigger the automatic response (Gollwitzer & Sheeran, 2006). Not recalling one or both components, or writing down non-identical components was scored as '0' for that plan. Depending on intervention condition and memory performance, the sum of recalled situations per participant could range between zero and five. Krippendorff's α for the interrater reliability was .92.

Results

Preliminary analyses

Dropout analyses indicated that dropout was non-selective regarding intervention condition, fruit and vegetable intake, age, gender, education, employment, and marital status ($P > .10$). Randomization checks on these variables indicated a successful randomization procedure. T1 fruit and vegetable intake averaged 2.81 (SD = 1.69) servings across conditions. Of the 398 participants in the intervention groups, 95.7% ($n = 381$) formed as many action plans as requested. Adherence was alike across intervention groups, ($P = .38$). All action plans of adherent participants were meaningful and complete. Across planning groups, participants remembered about two-thirds of their plans, $M = 0.59$.[3] The planning groups did not differ regarding the mean recall of planned situations ($P = .29$), indicating that forming up to five plans had no detrimental effects on memory performance.

Intervention effects on fruit and vegetable intake[4] (primary outcome)

Across all conditions, T2 fruit and vegetable intake averaged 3.38 (SD = 1.64) servings per day and improved from T1 to T2 by 0.57 servings (SD = 1.01). These improvements were significant in all conditions but increased with a larger number of plans (see Table 1). ANCOVA identified that fruit and vegetable intake differed as a function of the number of plans, $F(5, 453) = 3.42$, $P = .005$[5] (see Fig. 1). Pairwise comparisons with Bonferroni correction indicated

[2] A PDF-version of the intervention is available upon request from the first author.

[3] Sum of recalled situations divided by the number of plans formed in the respective intervention, see Table 1.

[4] Analyses were run as two-tailed tests in an intention-to-treat framework with missing data being imputed using the EM algorithm (Enders, 2001).

[5] Analyses using data from the longitudinal sample only ($n = 362$; i.e., excluding dropouts) replicated the differential behavior change across groups, $F(5, 354) = 2.48$, $P = .03$.

Table 1 Pre-test and post-test means (adjusted for covariates); standard errors and effect sizes for the primary outcome measure

Condition	Fruit and vegetable intake[a] (*n* = 461)		Change in fruit and vegetable intake[a] (*n* = 461)					Recall of planned situations (*n* = 292)	
	T1 *M* (*SE*)	T2 *M* (*SE*; 95% CI)	*df*	*p*	*t*	d_{within}	$d_{between}$	Mean recall[c]	Sum score
Control (*n* = 80; 100%[b])	2.91 (0.21)	3.18 (0.10; 2.98–3.38)	1, 79	<.001	14.76	0.43	n.a.	n.a.	n.a.
1 plan (*n* = 80; 98%[b])	2.62 (0.17)	3.25 (0.10; 3.04–3.45)	1, 79	<.001	24.33	0.56	0.11	0.49 (0.50)	0.49 (0.50)
2 plans (*n* = 77; 99%[b])	2.95 (0.19)	3.29 (0.10; 3.09–3.50)	1, 76	<.001	12.94	0.47	0.06	0.60 (0.39)	1.20 (0.77)
3 plans (*n* = 72; 94%[b])	2.60 (0.21)	3.34 (0.11; 3.13–3.56)	1, 71	<.001	22.14	0.55	0.17	0.57 (0.38)	1.72 (1.15)
4 plans (*n* = 78; 95%[b])	3.05 (0.21)	3.62 (0.10; 3.41–3.82)	1, 77	<.001	34.79	0.68	0.36	0.64 (0.34)	2.60 (1.34)
5 plans (*n* = 74; 94%[b])	2.72 (0.16)	3.63 (0.11; 3.42–3.84)	1, 73	<.001	48.09	0.82	0.48	0.63 (0.35)	3.14 (1.76)

CI confidence interval, *T* time. [a] Servings/day. [b] Percentage of adherent participants of the baseline sample. [c] Recall of situations divided by number of specified plans. Standard deviations in parentheses d_{within} was corrected for repeated measures as recommended by Morris and DeShon (2002). $d_{between}$ refers to comparisons between control group and the respective intervention group

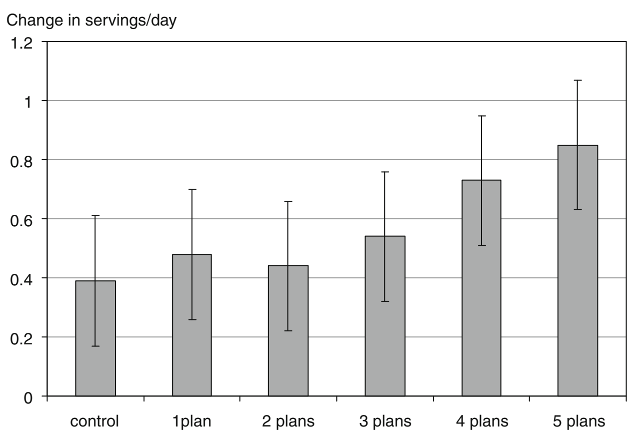

Fig. 1 Change in fruit and vegetable intake as a function of condition. *Bars* represent 95%-confidence intervals

that only participants who formed four or five action plans significantly increased their fruit and vegetable intake as compared to controls ($P = .04$ and $P = .03$, respectively) with small to moderate effects sizes (see Table 1). T2 fruit and vegetable intake was additionally influenced by T1 behavior and intention ($P < .001$).

Memory performance as explanatory factor of intervention effects

Recall of planned situations

Longitudinal data were provided by 292 participants in the planning groups. The sum of recalled situations of participants' plans was larger in groups with a larger number of plans to be specified, ranging from $M = 0.5$ (one plan was formed) to $M = 3.1$ (five plans were formed; see Table 1). ANCOVA with pairwise comparisons attested differences in the sum of recalled situations across the conditions, $F(4, 285) = 45.01$, $P < .001$, that were significant for all group comparisons, $P < .001$.[6] Recall of situations was also influenced by intention ($P < .05$) but not by baseline behavior ($P = .12$). Condition and recall of situations correlated by $r = .62$ ($P < .001$).

Plan recall and behavior change

To avoid small cell sizes when analyzing behavior change as a function of plan recall, participants were subdivided into three groups. ANCOVA indicated that change in fruit and vegetable intake was not associated with recall of situations, $F(2, 287) = 0.10$, $P = .91$. About the same level of increase in behavior was obtained in participants who recalled no or one situation ($n = 139$; $M_{adj} = 0.60$, $SE = 0.09$; CI = 0.42–0.77), two or three situations ($n = 107$; $M_{adj} = 0.64$, $SE = 0.10$; CI = 0.44–0.84) or four or five situations ($n = 46$; $M_{adj} = 0.66$, $SE = 0.16$; CI = 0.35–0.96). Correspondingly, the number of recalls and behavior change were not correlated across intervention groups, $r = .05$ ($P = .40$). To ensure that findings were not due to participants changing their plans and therefore not acting upon them, partial correlations were run, but indicated no association between the number of recalled situations and behavior change when controlling for changes in the content of plans ($r = .004$, $P = .94$), disengagement from plans ($r = .05$, $P = .38$), and change in the quantity of using self-regulatory planning ($r = .05$, $P = .39$), or all control variables together ($r = .01$, $P = .87$). Since plan recall was not related to change in fruit and vegetable intake, mediation analyses on effects of the number of plans on behavior change were not conducted.

[6] For comparisons between those who formed 2 and 3 plans, and between those with 4 and 5 plans, $P < .05$.

Discussion

This study primarily tested how forming multiple plans affects behavior change with the ultimate aim of optimizing the effectiveness of future planning interventions. This study provides initial experimental evidence that specifying a larger number of action plans can produce larger short-term changes in fruit and vegetable intake. This extends previous correlational evidence for the assumption that a rich repertoire of good opportunities to act facilitates health behavior (Elliott & Armitage, 2006; Wiedemann et al., 2011). Between-group comparisons indicated, however, that only persons who formed four or five plans outperformed controls. Increases in behavior in the control group are presumably due to measurement effects (Godin et al., 2008). The lack of larger effects in those who formed a small number of plans is in line with null effects of several other methodologically strict planning intervention studies (e.g., Michie et al., 2004). As no curvilinear effects on behavior occurred which would have pointed to 'dilution effects' of single plans (Webb, 2006; Wiedemann et al., 2011), the present findings suggest that the higher cognitive load during the process of forming multiple plans does not impede strong cue-response associations. Though results from the laboratory identified costs of additional prospective memory tasks (Cohen et al., 2008), these findings may not translate to the field, as the situational context in everyday life is far more complex. However, the effectiveness of unique plans may decline upon a critical threshold of plans which should be subject to future research. More experimental research on putative influencing factors such as the goal criterion, the required frequency and complexity of the goal behavior is needed to extend our findings: A larger number of plans seems relevant for complex and repetitive behaviors (e.g., dietary behavior) with a numeral goal due to the large variety of situations to act and behavioral choices, whereas a smaller number of plans might suffice for behaviors with a quality goal and those with little variance in terms of time, place, and the behavioral act (e.g., interdental cleaning). Nevertheless, even for the '5 a day' goal fewer plans might suffice if people include more than one serving in a plan. Future studies may also investigate effects of plans that link multiple situations to one behavioral response or multiple responses to one situation (Webb, 2006) and effects of contextual and semantic similarity in planned cues. Generalization to other samples is impeded by the study design, but previous studies found similar effects of plans in students and in the general public (Gollwitzer & Sheeran, 2006).

Our secondary aim was to test memory performance as an explanatory factor for the effects of plans.

Planning increases the accessibility of the mental representation of planned cues, which should be reflected by the recall of plans. This study found the recall of planned situations associated with the number of formed action plans but unrelated to behavior change. Is this an indication for the uselessness of memorizing one's plans? Alternative explanations for the missing memory-behavior change relation such as attention deficiencies are worth considering: Attentional resources are required for the monitoring of the environment for each additional planned cue (Smith & Bayen, 2004). When forming several plans they may be reduced to an extent that impedes the detection of good opportunities to act. Further, characteristics of the planned situations may impair the lack of association between plan memory and behavior. If recalled situations occur seldom and not in the time frame under study the planned behavior execution may not be measured. In the present study, however, plans were formed for typical situations that occur on a daily basis. A higher number of specified situations that were likely to occur might have enhanced the likelihood to encounter at least some of these planned situations, which in turn may explain the gradual accumulation of fruit and vegetable intake with each increase in the number of plans. At first sight, our finding conflicts with the correlation between plan recall and change in walking found by Prestwich et al. (2010). However, in their study, behavior and plan recall were boostered by reminders of plans, which might have had side effects on other factors and explain the recall-behavior relation. In sum, future research is needed to shed more light on the relation between memory of plans and behavior change.

Study limitations include that change in fruit and vegetable intake was measured by self-reports which may be biased by recall inaccuracy and social desirability. Although our and similar self-report measures have been validated against objective measures before (e.g., Steptoe et al., 2003), our approach should be complemented with objective measures. Also, the time frame under study was short but chosen with regard to our aim of testing memory effects during the process of behavior *initiation,* i.e., when individuals are developing new behavioral routines.

To conclude, this study provides first evidence that forming a larger number of plans may be more effective in promoting fruit and vegetable intake than forming fewer plans: By asking individuals to form multiple plans, interventions can elicit larger effects, while keeping the intervention delivery time- and cost-effective. The forming of multiple plans may thus be incorporated in the large-scale interventions that are needed to improve fruit and vegetable intake in the general population.

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