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Self-efficacy, planning and action control in an oral self-care intervention

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Abstract

To evaluate a theory-guided intervention on oral self-care and examine the possible mechanisms among self-regulatory factors, two brief intervention arms were compared, an information-based education treatment and a self-regulation treatment focusing on planning and action control. Young adults ($N = 284$; aged 18–29 years) were assessed at baseline and 1 month later. The self-regulation intervention improved levels of oral self-care, dental planning and action control. Moreover, a moderated mediation model with planning as the mediator between experimental conditions and dental outcome, and self-efficacy as well as action control as moderators elucidated the mechanism of change. More self-efficacious participants in the self-regulation condition benefitted in terms of more planning, and those who monitored their actions yielded higher levels of oral hygiene. Dental self-efficacy, dental planning and action control are involved in the improvement of oral self-care. Their joint consideration may contribute to a better understanding of health behavior change.

Introduction

Interdental cleaning, including the practice of regular use of dental floss or interdental brushes, is an effective preventive measure which impacts on both dental caries and periodontal disease [1]. Although the benefits of adherence to good oral hygiene behaviors are well known, a large number of young adults brush or floss their teeth less than the recommended time or not at all [2]. Lack of self-regulatory skills are associated with a disinclination to change health behaviors, including deficits in self-efficacy, planning and action control [3–6]. In this study, the health action process approach (HAPA) [7–9] was adopted to guide the study and provides a theoretical framework for the influence of motivational and self-regulatory factors in health behavior change. The HAPA assumes that self-efficacy, planning and action control operate in concert (mediator and moderator) when it comes to translate a behavioral intention into action [8, 9]. These processes involved in behavior change apply to the adoption as well as to the maintenance of health-enhancing behaviors. Beneficial effects of self-regulatory skills on dental flossing have been reported [4, 10, 11]. For young adults, using dental floss or interdental brushes is widely unfamiliar in major parts of the world [12]; thus, there is a need to develop effective, parsimonious interventions that are based on sound health behavior theory. Given the importance of self-regulatory factors such as self-efficacy, planning and action control on interdental cleaning behaviors, the interplay between these

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factors are examined in the context of such a brief, theory-based oral self-care intervention.

Perceived self-efficacy: confidence in being able to act

Perceived self-efficacy is the confidence in one's ability to execute a difficult or resource-demanding behavior [13]. The barrier in this context is not the technical difficulty of oral self-care behavior, but rather the regular performance as an integral part of daily life which is not easy for some people. Self-efficacy predicts a range of health behaviors including oral self-care [14–18]. One study, for example, investigated the combined roles of oral self-care self-efficacy and self-monitoring in predicting the frequency of dental flossing as part of one's dental routine, and whether a self-regulation intervention would make a difference to flossing behaviors by comparing an intervention group with controls [5]. The treatment improved dental self-efficacy levels. Completing self-regulatory tasks had strengthened individuals' self-beliefs of being capable to adhere to regular oral self-care. Furthermore, a sequential mediator model showed that the increase in self-efficacy also improved self-monitoring. Participants who optimistically believed that they could adhere to oral self-care were also more compliant with using their flossing calendar. As a result, their level of daily flossing was further improved. This finding showed that the health behavior process can be specified as a chain of constructs, with self-beliefs not only as an immediate outcome of interventions but also as a predictor of subsequent behaviors. Thus, those who had become more self-efficacious and who had self-monitored their behavior yielded higher frequencies of dental flossing [5]. A sequential mediation chain is just one possible mechanism that could link interventions with behavioral outcomes. Other mechanisms, such as moderation effects, may also yield meaningful results.

Planning: a prospective self-regulatory skill

Behavioral intentions are more likely to be translated into action when people develop preparatory strategies, such as making action plans of approaching a difficult task. Mental simulation helps to identify cues to action. Action plans may follow the SMART principles which means that they should be specific (a narrow behavior), measurable, assignable (who will perform), realistic and time-related (when to perform the action). These are well-known principles that stem from the field of business management and help to guide individuals in writing goals and objectives [19]. Meta-analyses support the effects of planning on health behaviors [20–23]. Planning may also include the anticipation of barriers and the generation of alternative behaviors to overcome them [24]. People imagine scenarios that hinder them in performing their intended behavior and develop one or more plans to cope with such a challenging situation. Planning can be altered and, furthermore, can be easily communicated to individuals with self-regulatory deficits. Randomized-controlled trials have documented evidence in support of such planning interventions [25]. In the context of oral self-care, action planning and coping planning have been found instrumental to improving people's oral hygiene practices [26, 27].

Action control: a retrospective and concurrent self-regulatory skill

While planning is a prospective strategy, i.e. behavioral plans are made before the situation is encountered, action control is a concurrent self-regulatory strategy, where the on-going behavior is continuously evaluated with regard to a behavioral standard. Action control comprises monitoring one's progress, comparing performance with goals and investing more effort if needed [4, 6]. Action control, in particular self-monitoring, is an essential behavior change technique (BCT) that can be applied to a variety of health behaviors [28]. When people keep records of their behavior, such as in the form of a diary or checkmarks on their calendar, they become aware of gains and deficits which lead them to take further action. In a study by Schüz *et al.* [4], in which an intervention to adopt dental flossing was conducted, action control had a beneficial effect only for those participants who

were already somewhat motivated to increase their oral self-care. In other words, action control worked in the volition (post-intentional) stage but not in the earlier motivation (pre-intentional) stage. In a study by Suresh *et al.* [6], however, the action control intervention enhanced adherence to dental flossing regardless of participants' stage of change. Patients with periodontal disease received a brief intervention consisting of a self-monitoring tool for dental flossing in the form of a diary. Flossing frequency, dental plaque and bleeding scores improved in both stage-matched and stage-mismatched patients. In another study by Schwarzer *et al.* [5], the self-monitoring component of action control operated as a mediator between dental self-efficacy and dental flossing. In this latter study, it was the component of making daily recordings in the dental calendar that was revealed as the most proximal predictor of improved oral self-care.

The proposed self-regulatory mechanisms

When it comes to translating intentions into action, the most likely and well-established mechanism is to specify planning as a mediator between independent and dependent variables [25]. One study, for example, explored the effects of a brief behavioral intervention for dental flossing, and whether a planning intervention would yield greater effects than an education group [2]. A randomized-controlled trial was used to assign 194 participants into two groups. The results showed that individuals receiving the planning intervention significantly outperformed those in the education control condition at 2 and 8 weeks post-intervention. However, the functional role of self-efficacy was less obvious. Most research on self-efficacy has pointed to its value as a predictor, mediator or outcome, depending on the research context [5]. Self-efficacy can be a facilitator of behavior as well as a consequence of behavior [13]. Recent work on other health behaviors, however, has found self-efficacy to operate as a moderator, either with motivation on planning or with planning on behavior [29–31]. This interactive effect means that the relationship between two variables depends on levels of self-efficacy. For example, in highly self-efficacious individuals the slope between an independent and a dependent variable can be much steeper than for less self-efficacious individuals. People who harbor self-doubts may not see a point in planning their actions. Thus, they would not benefit from a self-regulation treatment compared with those with optimistic self-beliefs who would be expected to experience more gain.

Even when people make good plans, this does not guarantee that they will perform and maintain the planned action. They may try to floss a few times, but eventually discontinue their actions. Thus, action control needs to come into play. Suresh *et al.* [6], for example, evaluated the effects of action control on dental flossing with a prospective trial among 73 dental patients and found that keeping a flossing diary can increase flossing and reduce plaque and bleeding scores at a 4-week follow-up. Motivated individuals who monitor their behaviors carefully, by recording them in their calendar for example, become aware of discrepancies between their intentions and their actual performance which, in turn, lets them recover from lapses and trigger maintenance. The relationship between planning and behavior may, therefore, depend on levels of action control. The latter then operates as a moderator. Self-efficacious individuals feel encouraged to monitor their progress and gain more confidence from their mastery experience. Accordingly, the proposed mechanism is a moderated mediation model with planning as the mediator and self-efficacy and action control as moderators.

Aims and hypotheses

To our knowledge, this is the first study to examine the moderator roles of self-efficacy and action control in a self-regulation intervention to improve oral health behaviors. In this study, the self-regulation intervention included two targeted constructs: planning and action control. A theory-based self-regulation oral health intervention focused on planning and action control was compared with an information-based education intervention. An experimental 2 (conditions: self-regulation group

versus education group) × 2 (times: Time 1 versus Time 2) design was conducted among young adults. Oral health behavior, indicated by dental flossing frequency, served as the primary outcome whereas planning and action control served as secondary outcomes. The aim of this study was to evaluate the effectiveness of the two brief intervention arms on oral hygiene behavior and to elucidate the possible mechanisms among self-regulatory factors for this important health behavior.

It is assumed that the self-regulation intervention will improve levels of oral self-care, planning and action control. Moreover, dental self-efficacy, dental planning and action control will be involved in the behavior change process in terms of a moderated mediation model.

Hypothesis 1: The self-regulation group will perform dental self-care at a higher level than the education group.

Hypothesis 2: The self-regulation group will achieve a higher level of dental planning than the education group.

Hypothesis 3: The self-regulation group will achieve a higher level of action control than the education group.

Hypothesis 4: Planning will mediate between intervention and dental hygiene behavior.

Hypothesis 5: Dental self-efficacy will moderate the intervention-planning relationship.

Hypothesis 6: Action control will moderate the planning-behavior relationship.

Method

Participants and procedure

Participants comprised a convenience sample drawn from optional and compulsory courses in a major university in China who had indicated interest to participate in the study on oral health. To detect medium-size effects (Cohen's $d = 0.5$) with a power of 0.80 ($\alpha = 0.05$) [22], a sample size of at least 51 participants per condition was determined using the software G*Power 3. A 3:2 oversampling of the self-regulation intervention group compared with the education group was chosen to obtain a larger sample of individuals participating in the novel intervention condition. Trained graduate psychology research assistants approached 294 potential study participants of whom $N = 284$ (ages 18–29 years; 83% male) gave their informed consent to participate. Participants were assigned to the two conditions (166 participants in the *self-regulation group* and 118 participants in the *education group*) according to the specified 3:2 ratio. Of these 284 college students, 69 dropped out at follow-up, reporting a lack of time to attend the second measurement occasion. For the final data analyses, 88 participants were allocated to the education intervention arm and 127 to the self-regulation intervention arm.

The research assistants allocated participants, who were blinded to the study conditions, to one of the two intervention arms. In their respective classes, participants were instructed by the research assistants to complete the pre-test materials. The pre-test questionnaires (Time 1) asked for demographic information as well as social-cognitive variables and dental care frequency. Participants then received the interventional materials and completed the corresponding tasks based on their group assignment. One month later (Time 2), during their same class time, participants were invited to fill in an identical post-test questionnaire. See Fig. 1 for the flow of participants throughout the study. All participants were offered three interdental brushes and those who completed the questionnaires at the two assessment points had a chance to enter into a prize draw to win 100 yuan (∼ US$16 dollars).

Measures

All measures in this study were adopted from Schwarzer [7], except the assessment of dental flossing which was taken from Sniehotta *et al.* [11]. The questionnaires were translated from English to Chinese by two bilingual psychology researchers and approved by two clinical psychologists, and tested in a pilot study to assure all scales could be well understood.

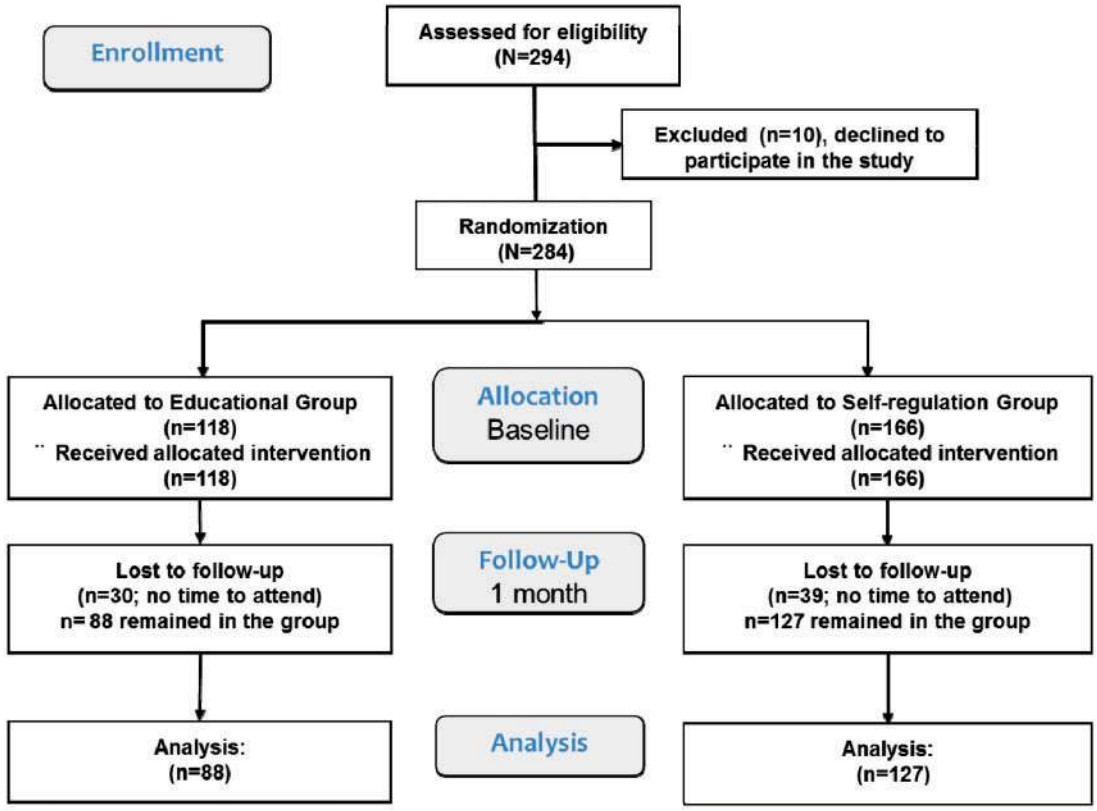

Fig. 1. CONSORT flow diagram.

Dental flossing was assessed with an open-format item: 'During the last week, I have flossed my teeth... times per day'. Daily flossing frequency was multiplied by seven to yield the weekly frequency. The assessment has been validated against a measure of residual dental floss [11, 32].

Self-efficacy was assessed with three items for task self-efficacy. A sample item is 'I am confident that I can start flossing immediately on a regular basis even if it is time consuming'. Responses were rated from 1 (*not at all true*) to 4 (*exactly true*). Cronbach's α was 0.79 at Time 1 and 0.62 at Time 2.

Planning was assessed with six items, three items measuring action planning and three items measuring coping planning. A sample item of action planning is 'I have made a concrete and detailed plan regarding when and where to floss my teeth'. One sample item of coping planning is 'To keep my flossing habit in difficult situations, I have made a concrete plan regarding what to do if something interferes with my flossing goal'. Responses were rated from 1 (*not at all true*) to 4 (*exactly true*). Cronbach's α was 0.87 at Time1 and 0.83 at Time 2.

Action control was assessed with three items. A sample item is 'I have consistently monitored when, how often and how to floss my teeth'. Responses were rated from 1 (*not at all true*) to 4 (*exactly true*). Cronbach's α was 0.80 at Time 1 and 0.73 at Time 2.

Interventions

The interventions were delivered by the same trained research assistants in participant classrooms after class. Participants in both groups received

educational materials related to oral health, which were adopted from the American Dental Association [33] by two clinical psychologists. They were instructed to read the materials and then completed corresponding tasks depending on their group assignment. The planning intervention was adapted from Schüz *et al.* [2]. The whole process lasted ~15 min.

The *education intervention* provided information about oral hygiene. In terms of BCTs, the leading components were goal setting (BCT 1.1), instruction on how to practice oral self-care (BCT 4.1) and information about health consequences (BCT 5.1) [28]. Participants received a package with detailed information on why and how to perform oral self-care. This was followed by asking participants to anticipate at least three benefits of performing oral self-care twice a day, and three risks of not doing so. After that, participants were asked to set a goal to achieve oral health by using dental flossing at least two times per day. To balance the time length with the self-regulation group, they also received a quiz on fruit and vegetable consumption.

In the *self-regulation intervention*, in addition to receiving the education materials, individuals were instructed to generate three action plans and three coping plans on dental flossing, and also required to fill in a calendar with their daily flossing records. In terms of BCTs, the main components were planning (BCT 1.2 and BCT 1.4) and self-monitoring of behavior (BCT 2.3) [28]. First, participants read the materials and completed the same tasks about oral health as the education group. Second, they were required to fill in two table boxes to generate their own plans for dental flossing. One table pertained to action plans, in which participants were instructed to fill in when, where and how often they planned to practice dental flossing. The other table was designed to let them generate their own coping plans. For this task, participants were required to fill in three obstacles that may prevent them from performing oral self-care and then identify corresponding methods to overcome these obstacles. Finally, participants in the self-regulation group were given a dental flossing calendar with the suggestion to record their daily flossing over 1 month.

Ethical considerations

The study was approved by the local participating college Institutional Review Board.

Analytic procedure

First, using SPSS 22, independent-sample *t*-tests, χ^2 test and MANOVA were used for attrition analysis and to investigate potential differences at Time 1. Second, repeated-measures ANOVA were conducted with experimental conditions (education intervention = 0, self-regulation intervention = 1) as a between-subjects factor using dental flossing per week, dental planning and action control of dental flossing as dependent variables, measured at two points in time. Third, a mediation analysis was performed using the PROCESS macro [34]. Planning to floss was specified as a mediator between experimental conditions and dental flossing at Time 2, controlling for baseline behavior (Time 1 dental flossing as a covariate). Bias-corrected bootstrapping with 5000 resamples was chosen to establish 95% confidence intervals for direct, indirect and total effects. A confidence interval not including zero as well as a P value < 0.05 for the indirect path indicated significant mediation. Fourth, a conditional process analysis was performed [34] to examine the possible moderation of mediation. Moderated mediation was tested with planning at Time 2 as a mediator between experimental groups and dental flossing at Time 2 while self-efficacy at Time 1 served as a first-stage moderator (between conditions and planning), and action control at Time 2 served as a second-stage moderator (between planning and dental flossing). All analyses were based on the longitudinal sample with 215 participants. (In addition, we have generated 10 imputed SPSS data sets with the full sample of 284 participants. Based on multiple imputation, ranges of effects from 10 repeated measures ANOVAs are presented in the following [from worst to best]. For dental flossing, the main effects of time $F(1282)$, values ranged from 30.47 to 57.73, η^2 ranged from 0.10 to 0.15 and all P values were < 0.05. For the interaction effects $F(1282)$, values ranged from 2.45 to

Table I. *Means and standard deviations for dental flossing, planning, self-efficacy and action control for both groups at two points in time*

	Time 1					Time 2				
Variable/Group	***M***	**SD**	***F* (1282)**	*P*	η^2	***M***	**SD**	***F* (1213)**	*P*	η^2
Dental flossing[a]										
Self-regulation	0.59	2.49	0.56	0.46	0.002	2.70	4.41	3.42	0.06	0.02
Education	0.83	2.92				1.67	3.36			
Planning										
Self-regulation	2.02	0.78	2.97	0.09	0.01	2.53	0.69	17.57	0.00	0.08
Education	2.19	0.87				2.14	0.63			
Self-efficacy										
Self-regulation	2.12	0.82	1.70	0.19	0.01	2.25	0.65	0.79	0.38	0.01
Education	2.25	0.91				2.17	0.73			
Action control										
Self-regulation	1.96	0.87	0.46	0.50	0.002	2.58	0.71	26.47	0.00	0.11
Education	2.03	0.89				2.08	0.72			

Note. [a]Flossing during the past week.

8.33, η^2 ranged from 0.01 to 0.03 and 9 of 10 *P* values were < 0.05. For planning, the main effects of time, *F*(1282), values ranged from 31.50 to 42.55, η^2 ranged from 0.10 to 0.13 and all *P* values were < 0.05. For the interaction effects *F*(1282), values ranged from 68.94 to 99.73, η^2 ranged from 0.20 to 0.26 and all *P* values were < 0.05. For action control, the main effects of time *F*(1282), values ranged from 29.70 to 41.28, η^2 ranged from 0.10 to 0.13 and all *P* values were < 0.05. For the interaction effects, *F*(1282), values ranged from 39.46 to 63.45, η^2 ranged from 0.12 to 0.18 and all *P* values are < 0.05.) The expectation maximization method was used to impute missing data for self-efficacy Time 1 (0.5%), dental flossing Time 1 (3%), planning Time 2 (0.2%) and dental flossing Time 2 (2%).

Results

Attrition analyses

Results indicated that individuals who remained in the study ($n = 215$; 75.7%) reported slightly higher self-efficacy ($M = 2.21$, $SD = 0.81$ versus $M = 2.07$, $SD = 1.00$; $t(282) = 1.80$, $P < 0.05$), action control ($M = 2.13$, $SD = 0.74$ versus $M = 1.95$, $SD = 1.04$; $t(282) = 3.18$, $P < 0.05$), planning ($M = 2.13$, $SD = 0.74$ versus $M = 1.95$, $SD = 1.03$, $t(282) = 1.69$, $P < 0.05$) and dental flossing ($M = 0.97$, $SD = 3.31$ versus $M = 0.57$, $SD = 2.37$, $t(282) = 1.11$, $P < 0.05$) compared with those who dropped out. No differences emerged with regard to sex ($\chi^2 = 1.09$) and age ($M = 21.35$, $SD = 1.39$ versus $M = 21.11$, $SD = 1.25$), both $P > 0.05$.

Randomization check

A χ^2 test and MANOVA revealed no baseline differences across experimental conditions (self-regulation group versus education group) regarding age and sex as well as dental flossing ($M = 0.59$, $SD = 2.49$ versus $M = 0.83$, $SD = 2.97$), self-efficacy ($M = 2.12$, $SD = 0.82$ versus $M = 2.25$, $SD = 0.91$), planning ($M = 2.02$, $SD = 0.78$ versus $M = 2.19$, $SD = 0.87$) and action control ($M = 1.96$, $SD = 0.87$ versus $M = 2.03$, $SD = 0.89$) (all $P > 0.05$, see Table I).

Intervention effects

To examine the intervention effects at Time 2, repeated-measures ANOVAs were computed. For dental flossing, there was a main effect for time, $F(1213) = 40.44$, $P < 0.01$, $\eta^2 = 0.16$, indicating that behavior had increased overall. Moreover, a

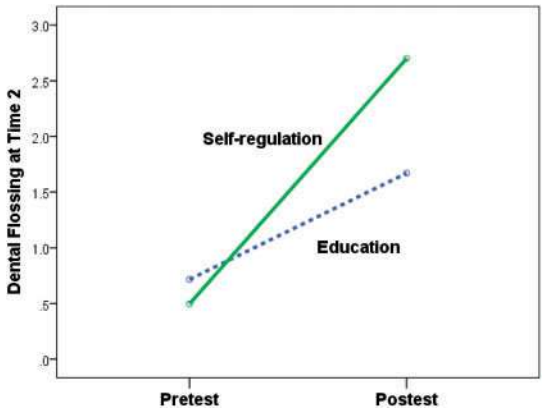

Fig. 2. Dental flossing times per week in the experimental conditions (self-regulation and education) at two points in time.

significant time × condition interaction, $F(1213) = 6.33$, $P < 0.05$, $\eta^2 = 0.03$ emerged, indicating that participants of the self-regulation intervention had benefitted more than those from the education intervention (see Fig. 2). Hypothesis 1 was confirmed.

For planning, there was a main effect for time, $F(1213) = 30.62$, $P < 0.01$, $\eta^2 = 0.13$, indicating that planning had increased. Moreover, a significant time × condition interaction, $F(1213) = 59.11$, $P < 0.05$, $\eta^2 = 0.22$ emerged, indicating that participants of the self-regulation intervention had benefitted more than those from the education intervention. Hypothesis 2 was confirmed.

For action control, there was a main effect for time, $F(1213) = 24.24$, $P < 0.01$, $\eta^2 = 0.10$, indicating that action control had increased. Moreover, a significant time × condition interaction, $F(1213) = 41.61$, $P < 0.01$, $\eta^2 = 0.16$ emerged, indicating that participants of the self-regulation intervention had benefitted more than those from the education intervention. Hypothesis 3 was confirmed.

Mediation analysis

Planning at Time 2 was considered to serve as a mediator between experimental condition and dental flossing at Time 2. A path model, controlling for baseline behavior, yielded the expected results. The indirect effect of treatment on dental flossing via planning at Time 2 was 0.93 (95% CI [0.46, 1.58]). Hypothesis 4 was confirmed.

Moderated mediation analysis

Moreover, it was examined whether the former simple mediation effect was different for individuals with different levels of self-regulatory skills. Participants who had higher or lower self-efficacy and action control may benefit differently from the treatment. Based on the procedures by Hayes [34] to test moderation, Time 1 self-efficacy was specified as a moderator between the experimental condition and planning, whereas Time 2 action control was specified as a moderator between planning and dental flossing at Time 2. A path model, controlling for Time 1 dental flossing, yielded the expected results (see Fig. 3). Planning Time 1 was predicted by condition ($\beta = -0.32$, 95% CI [−0.81, 0.15], SE = 0.24, $P > 0.05$), self-efficacy ($\beta = 0.11$, 95% CI [−0.04, 0.26], SE = 0.08, $P > 0.05$) and the condition × self-efficacy interaction ($\beta = 0.35$, 95% CI [0.14, 0.55], SE = 0.10, $P < 0.05$) at Time 2, with 24% of planning variance being accounted for. Dental flossing Time 2 was predicted by baseline behavior ($\beta = 0.75$, 95% CI [0.44, 1.05], SE = 0.10, $P < 0.05$), condition ($\beta = 0.09$, 95% CI [−0.85, 1.02], SE = 0.07, $P > 0.05$), planning ($\beta = -0.44$, 95% CI [−2.65, 1.78], SE = 0.14, $P > 0.05$), action control ($\beta = -2.08$, 95% CI [−4.24, 0.08], SE = 0.15, $P > 0.05$) and the planning × action control interaction at Time 2 ($\beta = 1.09$, 95% CI [0.21, 1.96], SE = 0.06, $P < 0.05$), with 39% of behavior variance being explained. Given the overall significant interaction terms, significance tests were conducted on the hypothesis that the conditional indirect effect equals zero at specific values (M,±1 SD) of the moderators. Planning mediated the effect of the condition on dental flossing at the mean (M) and high levels (±1 SD) of action control and at the high levels (±1 SD) of self-efficacy. In particular, the strength of the conditional indirect effect increased along with levels of self-efficacy ($\beta = 0.42$ at ±1 SD, $P < 0.05$) and action control ($\beta = 1.54$ at M, $P < 0.05$). At the high levels of both moderators, the conditional indirect effect from experimental groups to dental flossing outcome was 0.29 (95% CI [0.15, 0.48], whereas at the low levels of both moderators, the

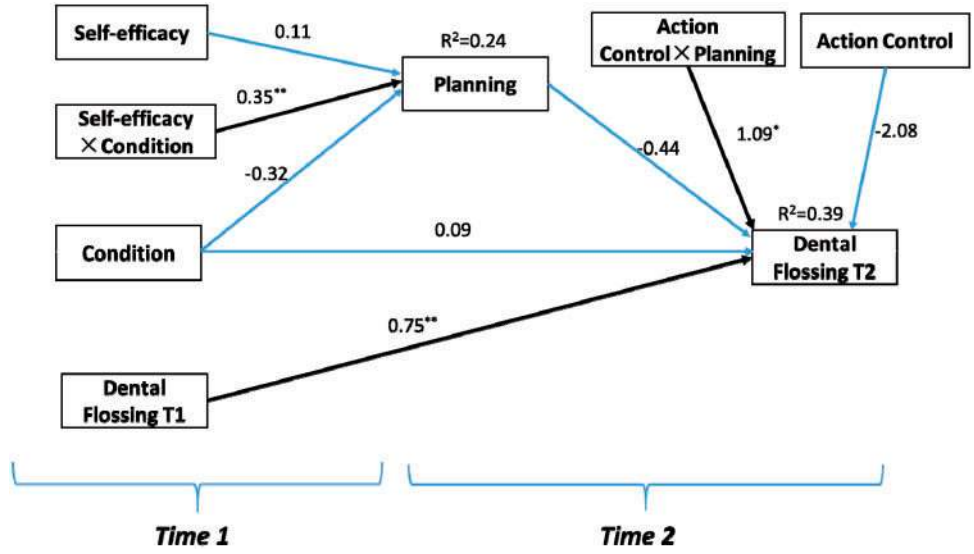

Fig. 3. Effects of experimental conditions (1 = self-regulation intervention, 0 = education intervention) via planning to floss on dental flossing, moderated by action self-efficacy in the first stage and by action control at the second stage, controlling for baseline dental flossing. Unstandardized solution; bootstrapped with 5000 resamples ($n = 215$). Note: $^{*}P < 0.05$; $^{**}P < 0.01$.

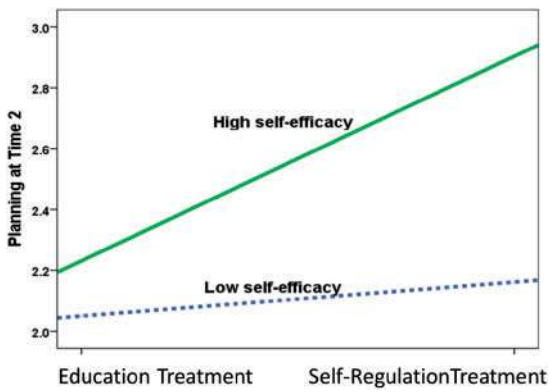

Fig. 4. Interaction of self-efficacy (Time 1) with experimental conditions on planning to floss (Time 2).

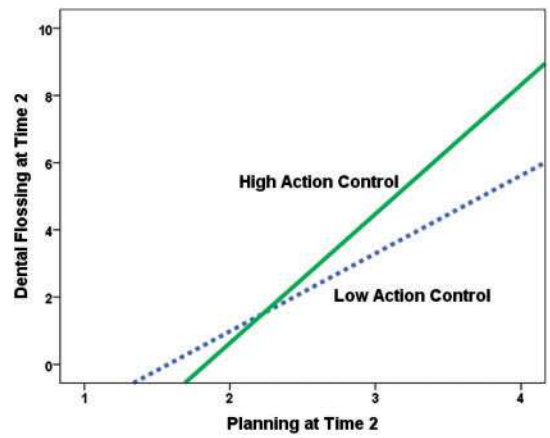

Fig. 5. Interaction of planning to floss (Time 2) with action control (Time 2) on weekly dental flossing (Time 2).

conditional indirect effect from experimental groups to dental flossing outcome was 0.02 (95% CI [−0.03, 0.10].

Probing the moderated effects of self-efficacy and action control yielded two simple slope diagrams (see Figs. 4 and 5) showing that participants with higher self-efficacy at Time 1 and with higher action control at Time 2 benefitted most from the self-regulation intervention. Hypotheses 5 and 6 were confirmed.

Discussion

This study evaluated a theory-based oral health intervention in young adults with the aim to identify social–cognitive mechanisms of behavior change. The active control group consisted of the usual information approach to educate participants about the

benefits of oral hygiene and how to use dental floss. The self-regulation intervention had a particular focus on planning and action control in addition to the educational materials. Findings revealed that this latter group achieved a higher level of dental flossing frequency at 1-month follow-up in line with higher levels of planning and action control. This finding highlights the role of these two key self-regulatory skills as active ingredients of the treatment. Moreover, planning mediated between experimental conditions and the dental flossing outcome, underscoring its operative function in the change process. Such findings are emerging as commonplace for a range of health behaviors [25].

A significant contribution of this study was the identification of the moderator roles of self-efficacy and action control. In the conditional process analysis [34], the simple mediation model was enriched by these two moderators, with dental self-efficacy operating on the left side of the model as a first-stage moderator, whereas action control operated on the right side as a second-stage moderator. Participants with higher levels of self-efficacy evidenced more positive effects from the intervention and reported higher levels of planning at follow-up. It is likely, but not examined in this study, that these participants may have also generated more plans during the intervention session itself. Furthermore, participants with higher levels of action control at Time 2 were more likely to translate their plans into dental flossing compared with those who did not monitor their behavior and, as such, were not as successful in adopting or maintaining this type of oral self-care.

It is the main characteristic of conditional process models that the mediation does not work for everyone. As moderators come into play, the mediation effects are valid only for subgroups of participants, in the case of this study for those with higher levels of self-efficacy and action control. This discovery provides an important insight into mechanisms of behavior change. Previous studies that did not succeed in changing behaviors may have ignored the possibility that certain subgroups actually have been successful. Not applying conditional process analyses prevents researchers from discovering such hidden effects. To identify such subgroups, one needs relevant constructs that operate in concert. In this study, the joint functioning of self-efficacy, planning and action control was examined, which are key constructs in the HAPA [7, 8].

The findings of this study need to be interpreted in light of its limitations. Assessments were self-reported and dental flossing was measured retrospectively for the past week. As an alternative to self-report, one could use on-going behavioral assessments such as dental calendars that allow for constant record keeping [4]. In this study, however, the dental calendars were used as a treatment and not as a daily assessment tool. Dental floss was provided but its use was not objectively measured. In the study by Schüz *et al.* [4], participants returned their leftover floss and residual floss was measured, yielding a correlation of $r = 0.65$ with self-reports. Another limitation lies in the lack of discriminant validity between action planning and coping planning. Due to their high intercorrelation, the two measures needed to be collapsed into a single planning variable. Future research should collect more process data on the intervention itself, assessing the number and quality of plans that participants generate during the session. The same applies to all BCTs [28] that are more or less active ingredients of the treatment. Moreover, a longer period of time for follow-up assessments is suggested to investigate long-term effects of the intervention and behavioral maintenance. Nevertheless, this study which adopted a theory-guided intervention has attempted to further elucidate the mechanisms of changing oral hygiene behaviors. The findings make a contribution to the cumulative knowledge about self-regulatory and social-cognitive components in health behavior change.

Conflict of interest statement

None declared.

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