Prediction of stage transitions in fruit and vegetable intake

Amelie U. Wiedemann1*, Sonia Lippke1, Tabea Reuter1, Benjamin Schüz2, Jochen P. Ziegelmann1 and Ralf Schwarzer1

Abstract

Stage theories propose that individuals pass through different stages on their way toward behavior change. The present study examines stage-specific prediction patterns of social–cognitive variables (risk perception, outcome expectancies, perceived self-efficacy, action planning and social support) regarding transitions between the three stages of the Health Action Process Approach (HAPA; preintention, intention and action stage). In an online study (n = 494) on fruit and vegetable intake, social–cognitive variables and stages were assessed at baseline and stage transitions 4 weeks later. Transitions between the preintention, intention and action stage were predicted by social–cognitive variables using binary and multinomial logistic regression analyses. Stage-specific prediction patterns emerged for stage progression and stage regression. Outcome expectancies predicted progression from the preintention stage, whereas social support predicted progression to the action stage. Low levels of planning were associated with relapse to the preintention and the intention stage. Self-efficacy emerged as a universal predictor of stage transitions. Stage-matched interventions targeting the variables identified as stage-specific predictors might support stage progression toward the goal behavior.

Introduction

Stage theories of health behavior change posit that people pass through several mind-sets (stages) with certain cognitive and behavioral characteristics on their course of health behavior change [1]. This study aims at identifying stage-specific predictors of transitions between stages of health behavior change in fruit and vegetable intake. In particular, this study has the purpose to extend prior research by examining the role of volitional variables, namely planning and social support, in the adoption and maintenance of health behavior. The three-stage Health Action Process Approach (HAPA) [2, 3] serves as a theoretical background of this longitudinal study with two measurement points in time, 4 weeks apart.

Stage models of behavior change

Continuum theories, such as the Theory of Planned Behavior [4] posit that the same parsimonious set of social–cognitive factors induces movement along a continuum of action likelihood in all persons. Accordingly, interventions based on continuum models would try to increase levels of all change-inducing factors by ‘one-size-fits-all’ treatments.

In contrast, stage theories, such as the transtheoretical model (TTM) [5], construe behavior change
as a transition through an ordered series of discrete stages. Thus, persons at different stages are characterized by different mind-sets, delineated by differences in terms of their cognitions, perceived barriers and action tendencies [1, 5]. The process of actual behavior change is reflected by a person’s forward and backward transitions (progression and regression) between the stages: individuals may progress toward a behavioral goal, for example by initiating behavior change, but they might also face backdrops or lapses, for example by failing to maintain a regular regimen of health behaviors. The idea of stages implies that for each stage, specific factors are responsible for remaining in this stage, progressing to the next one or regressing to the previous one.

Interventions based on stage theories, therefore, can be matched to a person’s stage by targeting stage-specific needs. If such stage-matched interventions turn out to be more effective than untailored ones, then the stage construct will have proven useful. According to a meta-analysis by Noar et al. [6], interventions matched to the stages of change proposed by the TTM [5] yielded better results than unmatched ones, but these additional effects were rather small (Fisher’s $r^+ = 0.09$, sample size-weighted mean effect size for the comparison between interventions tailored to TTM stages of change or not). However, the effectiveness of interventions, whether stage-matched or not, largely depends on the factors being targeted [6, 7]. Therefore, it is essential to identify which variables are facilitators of stage transitions.

**Health action process approach**

The HAPA [3] specifies stages and specific predictors for transitions between these stages. It suggests a three-stage distinction between (i) a preintention stage, including persons who have not (yet) set a goal to act (preintenders), (ii) an intention stage, comprising persons with the goal to change their behavior, but who are not yet acting (intenders) and (iii) an action stage, including those persons who already perform the behavior in question (actors). The HAPA specifies the following stage-specific sets of predictors.

**Stage progressions**

*Progression from the preintention stage to the intention stage: setting a goal*

Determinants of goal setting are the subjective risk to recognize a serious health condition (risk perception), the perceived consequences of health actions (outcome expectancies) and the perceived ability to perform a behavior (self-efficacy) [3]. There is convincing evidence for the prominent role of these factors for individual goal setting [3, 13].

*Progression from the intention stage to the action stage: initiating the behavior*

The specification of predictors of transitions from the intention stage to the action stage is particularly important, as it marks the crucial shift from cognition to action. Proximal factors that might explain the initiation of health behavior are self-efficacy,
planning and external facilitators such as social support [2, 3]. Planning facilitates action initiation by specifying ‘when’, ‘where’ and ‘how’ to perform the goal behavior [14–16]. The few published studies examining planning as a predictor of stage transitions provide inconsistent results [11, 17], but the effectiveness of planning to promote behavior particularly among intenders has been underlined by experimental studies [18]. Social support has rarely been examined as a predictor of stage progression, too. However, some promising results suggest including this resource factor. For example, in a study on physical activity by Courneya et al. [19], higher levels of social support were predictive of progression out of a preaction stage, whereas lower levels of social support were predictive of regression out of action stages. The role of self-efficacy as a prerequisite for action has been consistently confirmed [10, 20].

**Stage regressions**

As outlined above, high scores on the specified social–cognitive factors are assumed to facilitate stage progression to definite stages. Conversely, low scores on these facilitators of progression are supposed to make regression out of this stage more likely. For example, individuals who cease to believe that they are susceptible to a specific disease (e.g. by getting a vaccination or taking specific medication) and accordingly lower their risk perceptions [21], are assumingly more likely to reduce their intentions to change their behavior and thus to regress from the intention stage to the preintention stage. Self-efficacy, for example, predicts progression into as well as regression out of the intention and the action stage, with high self-efficacious persons being more likely to progress and persons with low levels of self-efficacy being more likely to regress [11, 19, 20, 22–24]. As self-efficacy predicts transitions between more than two stages and in both directions (progression and regression), it is proposed to be a universal facilitator of transitions, regardless of baseline stage, whereas the other social–cognitive variables are seen as stage-specific predictors of transitions [25].

**Aims and hypotheses**

One of the key protective factors against premature morbidity and mortality is a balanced diet [26]. The present study focuses on fruit and vegetable intake, which is associated with lower fat and higher fiber intake, an improved antioxidant status, and thus, a lower risk for ill health such as cardiovascular disease [27]. Despite these beneficial effects, the majority of people do not meet the recommendations of a minimum intake of 400 g (five servings) of fruit and vegetable per day [27]. Theory-based interventions to improve this aspect of dietary behavior are needed because the establishment of a theoretical basis is a precondition for successful intervention development. Therefore, this study aims at examining stage-specific predictors of stage transitions in the domain of fruit and vegetable intake. The following hypotheses were derived from the HAPA:

(i) High levels of self-efficacy, outcome expectancies and risk perception predict progression from the preintention stage to a further stage.

(ii) High levels of self-efficacy, planning and social support predict progression from the intention stage to the action stage.

(iii) Low levels of self-efficacy, risk perception and outcome expectancies predict regression from the intention stage to the preintention stage.

(iv) Low levels of self-efficacy, planning and social support predict regression from the action stage to an earlier stage.

**Methods**

**Participants and procedure**

An online panel study was conducted because online studies have the potential to reach large samples of persons with diverse socioeconomic status and age and from different geographic regions. The
present online study on fruit and vegetable intake was advertised by press releases (magazine reports and university press), announcements on university Web sites and mailing lists. The online procedure was generated with the software dynQuest [28]. In accordance with previous studies on stage transitions [11], the follow-up measures at Time 2 (T2) were taken 4 weeks after baseline (Time 1; T1). Persons with medical conditions that conflict with eating five portions of fruit and vegetable were not eligible to participate. The initial sample comprised the 1102 persons who completed the T1 assessments; those answering the follow-up questionnaire constituted the longitudinal sample (n = 494; 44.8% of baseline). The longitudinal sample comprised 77.5% women and had a mean age of 37.3 years, SD = 12.70, range = 18–72 years. About 53.2% of this sample were unmarried and 79.6% were senior high school graduates.

Fruit and vegetable intake averaged 3.21 servings per day, SD = 1.64, with 80.4% of the participants not meeting the World Health Organization recommendations for fruit and vegetable intake [27]. The body mass index (BMI) averaged 24.62, SD = 4.72, range = 16.98–36.66.

**Dropout analysis**

A multivariate analysis of variance (MANOVA) dropout analysis yielded no significant baseline differences between the longitudinal sample and those who dropped out after T1 regarding age, fruit and vegetable intake, BMI (see Table I), marital status, employment status, social–cognitive variables (self-efficacy, outcome expectancies, risk perception, planning and social support) and baseline stage, indicating the representativeness of the longitudinal sample for the T1 sample on these variables. However, less women, \( \chi^2 (1) = 6.23, P < 0.05 \), and less study participants with a senior high school degree or higher education, \( \chi^2 (1) = 12.04, P < 0.01 \), dropped out.

Missing data on all social–cognitive variables (<5% on all variables) were imputed using the expectation maximization algorithm in SPSS [29].

**Representativeness check**

As an estimate of the external validity of the present findings, the longitudinal sample was compared with the average German online population [30, 31] and the German general population [32–34] on recent sociodemographic and behavioral data (Table I). People with a higher education and women were overrepresented in the present study. This might be due to the study’s advertisement on a university Web site and a higher interest of women in topics concerning nutrition [35]. However, the present sample was representative for the German population regarding age, fruit and vegetable intake and BMI.

**Measures**

Predictors were measured at T1, and stage was assessed at both T1 and T2. Unless otherwise stated, items had four-point Likert scales, ranging from ‘completely disagree’ (1) to ‘completely agree’ (4). Measures had been validated in previous studies [11, 18, 25, 36, 37]. Item examples were translated from German.

The ‘self-efficacy’ scale comprised three items, such as ‘I am confident that I can eat five servings of fruit and vegetables a day’ (Cronbach’s \( \alpha = 0.94 \)). ‘Outcome expectancies’ were measured by two positively framed items, such as ‘Eating five servings of fruit and vegetables a day would be good for my health’ (Cronbach’s \( \alpha = 0.72 \)). ‘Risk perception’ was assessed by asking ‘How likely is it that you will ever get a severe disease (e.g. diabetes, cardiovascular disease)?’ on a five-point Likert scale ranging from ‘very unlikely’ (1) to ‘very likely’ (5).

‘Planning’ was measured with two items, such as ‘I have already precisely planned when, where, and how to eat five servings of fruit or vegetables throughout the day’ (Cronbach’s \( \alpha = 0.88 \)). ‘Social support’ was assessed by two items, for example, ‘My relatives help me to lead a healthy lifestyle’ (Cronbach’s \( \alpha = 0.70 \)).

‘Stage’ was assessed with a validated algorithm for the stages of the HAPA, ‘Do you eat five servings of fruit and vegetables on an average day?’ The
response format allowed a mutually exclusive answer on one of five statements, with ‘No, and I do not intend to do so’ and ‘No, but I am thinking about it’ representing the preintention stage, ‘No, but I strongly intend to do so’ representing the intention stage and ‘Yes, but it is difficult for me’ and ‘Yes, and it is easy for me’ representing the action stage. ‘Stage transitions’ were calculated by subtracting $T_1$ stage from $T_2$ stage.

‘Fruit and vegetable intake’ was measured using an open-ended item: ‘How many servings of fruit and vegetable do you eat on an average day?’ The item followed the definition of ‘one serving’, i.e. ‘one handful of fruit (e.g. grapes) and vegetable (e.g. lettuce)’.

**Analytical procedure**

To analyze whether the number of forward and backward transitions varied as a function of baseline stage and whether social–cognitive variables allowed a better classification into persons with different transition patterns than could be expected by chance, $\chi^2$ tests were conducted.

The prediction of stage transitions was examined by use of multiple binary logistic regression (BLR) and multiple multinomial logistic regression (MLR) analyses separately for the different baseline stages (BLR: $T_1$ preintender, $T_1$ actor; MLR: $T_1$:intender). BLR analyses were conducted to predict progression out of the $T_1$ preintention stage and regression out of the $T_1$ action stage with stage transition as dependent variable and $T_1$ social–cognitive variables as independent variables. The dichotomous stage transition variables were coded as follows: for individuals in the preintention stage at $T_1$, ‘0’ indicated remaining in the preintention stage and ‘1’ indicated progression. For actors, regression was coded 0 and 1 indicated remaining in the action stage. MLR was conducted simultaneously for all three possible stage transitions out of the intention stage: thus, the dependent variable (stage transition) was trichotomous, with remaining in the intention stage (reference group) coded 0, progression coded 1 and regression coded ‘−1’.

Odds ratios (ORs) with a 95% confidence interval are reported as effect size estimates and the Wald statistic as indicator of the significance of each regression coefficient in BLR and MLR. The rate of correct classifications into the respective groups of people progressing, regressing or those remaining in the same stage is used as an indicator of the accuracy of the prediction model. All analyses were conducted using SPSS 15.0.

**Results**

**Preliminary results**

$T_1$ stage distribution and stage transitions are displayed in Table II. Across all possible transitions, the majority remained in the same stage (61.1%), and more participants progressed (27.9%) than regressed (10.9%). It was tested whether the number of forward and backward transitions varied as function of baseline stage. More preintenders than
intenders progressed, $\chi^2 (1) = 4.16, P < 0.05$. Intenders and actors did not differ in the number of regressions, $\chi^2 (1) = 2.13$, non-significant (ns).

Stage groups differed significantly regarding their fruit and vegetable intake [$F(2, 491) = 206.65, P < 0.001$]: preintenders had an average intake of 2.2 servings (SD = 1.0) and intenders consumed 3.1 servings (SD = 1.1) per day. Actors showed the highest intake on average and almost met the recommendations of five servings per day ($M = 4.9$, SD = 1.5). Preintenders progressing to further stages showed an increase in their average fruit and vegetable consumption as well and almost met the recommended levels at follow-up ($T1 M = 3.4, T2 M = 4.9$). Intenders regressing to preintention did not change their fruit and vegetable intake ($T1 M = 2.7, T2 M = 2.7$), indicating that the backward transition occurred on a cognitive but not on a behavioral level. Actors regressing to earlier stages did not meet the criterion of five servings of fruit and vegetable intake at baseline and showed an additional decrease in their fruit and vegetable intake at follow-up ($T1 M = 4.0, T2 M = 3.3$). In sum, transitions to and from action were corresponding with behavioral changes (i.e. increase or decrease in fruit and vegetable intake), while this held not true for transition from the rather cognitively defined regression from the intention stage to the preintention stage.

At follow-up, significant differences in fruit and vegetable intake between people in the three HAPA stages were identified [$F(2, 491) = 332.71, P < 0.001$] and intake paralleled the average number of servings obtained at $T1$ (preintenders, $M = 2.4$, SD = 1.1; intenders, $M = 3.3$, SD = 1.0; actors, $M = 5.0$, SD = 1.5). Actors were meeting the recommendations for daily fruit and vegetable intake at $T2$.

Correlations of social–cognitive variables are displayed in Table II. None of the correlations exceeds $r = 0.80$, thus multicollinearity should not occur [38].

### Predictors of stage transitions
Uneven distribution patterns of participants across the stages and uneven transition patterns between the stages resulted in small cell sizes which would have led to underpowered analyses when fully decomposing transitions by $T1$ and $T2$ HAPA stage (cf. Table III). Thus, progression out of the preintention stage includes progression to both the intention stage and the action stage, and regression out of the action stage includes regression to both the intention stage and the preintention stage.

### Table II. Intercorrelations between $T1$ social–cognitive variables

<table>
<thead>
<tr>
<th></th>
<th>Self-efficacy</th>
<th>Risk perception</th>
<th>Planning</th>
<th>Social support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome expectancies</td>
<td>0.52**</td>
<td>-0.02</td>
<td>0.39**</td>
<td>0.04</td>
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<td>Self-efficacy</td>
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<td>-0.09*</td>
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<td>0.15**</td>
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<td>Risk perception</td>
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<td>-0.08</td>
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<tr>
<td>Planning</td>
<td>1</td>
<td>0.003</td>
<td>0.08</td>
<td>0.12**</td>
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</tbody>
</table>

**$P < 0.01$, *$P < 0.05$.**

### Table III. HAPA stage distributions and transitions of the longitudinal sample ($n = 494$)

<table>
<thead>
<tr>
<th>Time 2 (4 weeks after Time 1)</th>
<th>Preintention stage</th>
<th>Intention stage</th>
<th>Action stage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td>Preintention stage</td>
<td>145 (29.4)</td>
<td>56 (11.3)</td>
<td>34 (6.9)</td>
</tr>
<tr>
<td></td>
<td>Intention stage</td>
<td>22 (4.4)</td>
<td>47 (9.5)</td>
<td>48 (9.7)</td>
</tr>
<tr>
<td></td>
<td>Action stage</td>
<td>11 (2.2)</td>
<td>21 (4.3)</td>
<td>110 (22.3)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>178 (36.0)</td>
<td>124 (25.1)</td>
<td>192 (38.9)</td>
</tr>
</tbody>
</table>

Numbers in parentheses represent percent of $n = 494$. 

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Stage transitions in fruit and vegetable intake
Preintention stage: progression
The rate of correct classifications of participants into those remaining in the preintention stage versus those progressing using social–cognitive predictors was 68.1%, which was higher than could be expected by chance (50%), \(\chi^2 (1) = 64.14, P < 0.01\).

The results of BLR analyses indicated that self-efficacy and outcome expectancies were significant predictors of stage transition in fruit and vegetable intake. Risk perception was not predictive of stage progression. ORs, Wald statistics and descriptive data are summarized in Table IV.

Intention stage: progression and regression
The correct classification rate by social–cognitive variables was 58.1%, which is significantly higher than expected by chance (33.3%), \(\chi^2 (1) = 135.45, P < 0.01\).

MLR was conducted for all three possible stage transitions (remaining in the intention stage, progression and regression) simultaneously. For the ease of interpretation, the results of MLR analyses in the text and Table IV are reported as comparisons between (i) persons remaining in the intention stage and those progressing, respectively, (ii) persons remaining in the intention stage and those regressing (with ORs reported as if regression was coded 0 and remaining in the intention stage coded 1: that is, the more ORs exceed 1, the more likely it is to remain in the intention stage compared with regression due to the influence of the respective variable; Table IV).

Stage progression out of the intention stage was significantly predicted by social support. Neither

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Wald</th>
<th>OR</th>
<th>95% CI&lt;sub&gt;OR&lt;/sub&gt;</th>
<th>Remaining in baseline stage</th>
<th>Transition</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(M)</td>
<td>SD</td>
</tr>
<tr>
<td>Preintention stage: remaining (0) versus progression (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome expectancies</td>
<td>7.44**</td>
<td>1.91</td>
<td>1.20–3.03</td>
<td>2.94</td>
<td>0.77</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>4.66*</td>
<td>1.56</td>
<td>1.04–2.33</td>
<td>2.00</td>
<td>0.76</td>
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<td>Risk perception</td>
<td>0.49</td>
<td>0.89</td>
<td>0.64–1.23</td>
<td>2.86</td>
<td>0.93</td>
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<tr>
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<td>1.69</td>
<td>0.97–2.95</td>
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<td>0.44</td>
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<tr>
<td>Social support</td>
<td>2.24</td>
<td>1.33</td>
<td>0.91–1.95</td>
<td>2.11</td>
<td>0.73</td>
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<tr>
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<tr>
<td>Outcome expectancies</td>
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<td>0.65–2.20</td>
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<td>0.64</td>
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<tr>
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<td>4.21*</td>
<td>2.02</td>
<td>1.03–3.94</td>
<td>2.23</td>
<td>0.67</td>
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<tr>
<td>Intention stage: regression (0) versus remaining (1)</td>
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<tr>
<td>Outcome expectancies</td>
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<td>1.77</td>
<td>0.48–6.49</td>
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<tr>
<td>Self-efficacy</td>
<td>10.07**</td>
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<td>2.11–23.11</td>
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<tr>
<td>Risk perception</td>
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<td>1.43</td>
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<tr>
<td>Action stage: regression (0) versus remaining (1)</td>
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</table>

**P < 0.01, *P < 0.05; CI<sub>OR</sub> = 95% confidence interval of the OR.
planning nor self-efficacy predicted forward stage transition out of the intention stage.

Results indicated that self-efficacy was predictive of remaining in the intention stage (vs. regression). Neither risk perception nor outcome expectancies were predictive of backward stage transition out of the intention stage.

**Action stage: regression**

The correct classification rate by social–cognitive variables was 76.8%, which is significantly higher than classification by chance (50%). \( \chi^2 (1) = 141.08, P < 0.01 \). The results of BLR analyses indicated that self-efficacy and planning predicted remaining in the action stage. Social support was not predictive for backward stage transitions. Figure 1 summarizes the discontinuous prediction pattern of social–cognitive variables for fruit and vegetable intake.

### Discussion

The aim of our study was to identify stage-specific predictors of transitions between the three stages of the HAPA. To our knowledge, this set of social–cognitive variables, including the volitional variables planning and social support, was tested as predictor of stage transitions for the first time. The results suggest stage-specific prediction patterns for stage transitions and thus implications for stage-matched interventions to enhance fruit and vegetable intake.

In the present study, most participants remained in the same stage as at baseline. In all, 27.9% of the participants progressed and only 10.9% regressed (Table III). While the proportion of people progressing appears to be high, non-experimental studies with a similar time frame show similar proportions of stage transitions. For example, a study on fruit (F) and vegetable (V) intake found 21% (F) and 17% (V) of the participants progressing, 22% (F) and 19% (V) regressing and 57% (F) and 64% (V) remaining in the same stage [39]. Participants of the present study were self-selected to be in a study on health behavior and, thus, probably more inclined to make positive changes, reflecting a higher ‘readiness to change’. The higher percentage of progressions than regressions might also depend on the baseline stage distribution: a larger number of individuals resided in the preintention stage (47.6%) as compared with the action stage (28.7%), which allowed more of them to progress than to regress.

The transitions in this study included movement to adjacent stages and two-stage transitions. Latter ones are transitions through the intention stage: thus, by definition people in this stage intend to change. As fruit and vegetable intake not necessarily requires a long time for preparation, residence in the intention stage may last for a few moments only and two-stage transitions are likely to occur in short time intervals. Accordingly, prior research found preintention stages and action stages to be more stable over time than preparation (intention) stages [39].

Some of the social–cognitive variables derived from the HAPA do not operate equivalently across all stage transitions. This is in line with the assumption of different stages of behavior change. Some variables predict transitions between the earlier stages of health behavior change, while others predict later transitions. In the following, the usefulness of specific variables as predictors is discussed in more detail.

In line with theoretical assumptions [3], higher levels of planning predicted remaining in the action stage.
stage. The mediating factors for such effects on behavioral maintenance have been examined in laboratory studies: planning (i.e. forming implementation intentions) inhibits counterproductive behavioral responses by suppressing fatigue, tempting distractions and ego depletion [40]. However, in contrast to the assumptions, planning failed to predict progression out of the intention stage. Experimental research suggests stronger effects of planning in intenders. In a study by Lippke et al. [18], planning was experimentally manipulated in all stages and its effect was moderated by stage: the planning intervention facilitated the uptake of physical activity in intenders and, to a smaller extent, maintenance in actors, while preintenders did not benefit from the intervention. In a study on low-fat diet, experimentally induced planning facilitated stage progression from all preaction TTM stages, including progression from preparation (i.e. HAPA intention stage) to action [17]. This suggests differences with regard to the operationalization of planning: While experimentally manipulated planning might promote progression to action, self-induced planning as measured in the present study might not be sufficient. Additionally, psychometrically measured planning has been found to be predictive of behavior change only if values of moderating variables such self-efficacy [41] or intentions [42] lay beyond certain thresholds.

The finding that social support predicted progress to the action stage corresponds with the assumption that social support promotes goal pursuit among intenders. It might be subject to future studies to examine whether the beneficial effects of social support are context specific or source specific (e.g. by relatives or friends). That is, social support might facilitate behavior initiation particularly in behavior domains such as fruit and vegetable intake that are frequently performed in environments where social support might be more easily available than in other contexts [9, 43].

Outcome expectancies were a significant predictor of transitions out of the preintentional stage. The failure of risk perception to predict stage transitions in preintenders was not in line with the theory, but might be due to the unspecific operationalization of risk perception: Strong conceptual links between specific risk perceptions and corresponding behaviors, such as refraining from eating red meat and the subjective risk perception for livestock-related diseases, yield stronger correlations and predictive values of risk perception [44] than conceptual links between unspecific risk perception items and measures of specific behaviors as used in the present study.

Self-efficacy predicted most stage transitions in fruit and vegetable intake. These results are in line with the theoretical assumptions and evidence outlined above: The confidence to overcome problems and obstacles due to one’s own competency is a crucial factor for the initiation and maintenance of behavior changes [3, 23, 24]. Accordingly, self-efficacy can be considered a universal determinant rather than a stage-specific driver of change: The prediction pattern suggests interpretations in line with a continuum approach, since self-efficacy predicted three out of four transitions. Such a consistent function of self-efficacy is in line with meta-analyses on cross-sectional TTM studies [45]. However, it has been recommended to differentiate phase-specific self-efficacy scales that differ in their wording, depending on the stage of the participants [24]. When self-efficacy is differentiated in terms of stages, it can be assumed that this modified construct would be capable of predicting transitions in a stage-specific manner. Additionally, different types of planning, such as action planning and coping planning [37] and negative outcome expectancies regarding healthy nutrition [46], warrant further examination.

Some limitations of the current study need to be addressed. First, the attrition rate was very high. This dropout, however, was in line with an average 40% response rate that was obtained in a meta-analysis on internet-based studies [47], in which participation is usually voluntary and without financial compensation. The longitudinal sample was representative of the baseline sample with regard to behavioral and social–cognitive variables, but overrepresented women and individuals with higher education. Thus, replication in other samples with a special emphasis on recruiting more men and
individuals from lower socioeconomic backgrounds is needed to gauge the generalizability of the present findings. Second, two predictors (risk perception and social support) were assessed with behavior-unspecific items, which is suboptimal for the correspondence with the outcome. In addition, significant predictions provide no evidence for causal effects of the specified variables on stage transitions, but rather indicate that scores on these variables correlate longitudinally with changes in stage. These changes in stage may not only represent shifts in mind-sets or behavioral tendencies but may also be caused by measurement instability due to a low reliability and validity of the staging algorithms. However, evidence exists for the reliability and validity of staging algorithms such as the one used in our study [36].

Our study focused on dynamic variables, that is, variables that are open to change [8]. Thus, the stage-specific results may not only improve the understanding of the process of health behavior change but also suggest implications for theory-based interventions to promote health behavior change. Stage-matched interventions targeting the variables significantly predicting transitions from a specific stage (as suggested by the stage-specific prediction pattern identified in this study) might support stage progression toward the goal behavior. For instance, intervention components might target social support in intenders rather than in preintenders due to its unique effect in the intention stage. Only if such stage-matched interventions would turn out to be more effective than unmatched interventions, then the stage construct would prove useful as a theoretical foundation for interventions and transitions between the three stages could be used as intermediate indicators of the effectiveness of such interventions.

The present findings on specific predictors of stage transitions need to be corroborated to make qualified assumptions on factors relevant for behavior change (i.e. stage transitions). Further research might, for example, compare effect sizes for progressions and regressions across studies on fruit and vegetable intake. The effect sizes in the present study ranged from 1.56 (self-efficacy; progression out of the preintention stage) to 7.01 (self-efficacy; regression out of the intention stage), raising questions about practically meaningful effect sizes. Some authors refer to ORs ~2 to be meaningful [20], but no clear interpretation guidelines exist for OR in logistic regression analyses. Before practical implications may be drawn, however, experimental tests are needed to support the different relative importance of the HAPA constructs. If these tests support the relevance of the hypothesized constructs, even small effect sizes may have a high population impact if interventions are delivered to high numbers of persons, e.g. via internet. In this line of reasoning, such studies might place more emphasis on practical significance (i.e. effect size) than on statistical significance (i.e. P values). If the empirical support for the theoretical assumptions would generalize across different behaviors, a stronger evidence base would be accumulated than from single-behavior studies [48]. Furthermore, robust evidence for determinants of stage transitions can only be drawn from experimental studies with a matched/mismatched design, which provide the strongest evidence for the usefulness of stage-specific determinants of change [1]. Even stronger evidence could be provided by employing intervention designs with matched/mismatched intervention content and matched/mismatched intervention sequences.

To conclude, the results of our study lend support for the usefulness of the stage construct to describe health behavior change as stage-specific predictors of transitions. The stage-specific importance of variables such as planning and social support might inspire future research on stage-matched interventions for fruit and vegetable intake.

Conflict of interest statement
None declared.

References


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