Testing the transtheoretical model for fruit intake: comparing web-based tailored stage-matched and stage-mismatched feedback

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Abstract
A match–mismatch test was conducted to test the transtheoretical model applied to fruit intake. Precontemplators and contemplators were randomly assigned to receive a web-based individualized precontemplation feedback (PCF), contemplation feedback (CF) or action feedback (AF) letter promoting fruit intake. Immediately and 1 week after reading this letter, post-test measures were obtained. Fruit intake increased significantly between pre- and post-test in contemplators, but not in precontemplators. No differences between the feedback conditions were found in fruit intake, stage progression, use or credibility of the feedback in precontemplators and contemplators. In precontemplators, also no differences between the conditions were found in personal relevance of the feedback. Contemplators, however, rated AF as more personally relevant than PCF or CF. To conclude, the present study failed to show superiority of stage-matched information in the promotion of fruit intake.

Introduction
According to the transtheoretical model (TTM) of behavior change, health behavior change involves progress through a series of five discrete, qualitatively different, stages of change (SOC). The first stage is precontemplation, which is characterized by a lack of motivation. Precontemplation is followed by contemplation, preparation, action and maintenance. In maintenance, a healthy behavior is adopted and maintained for >6 months [1, 2]. People in these different stages are assumed to differ on important and relevant stage-specific factors. The TTM defines several of these factors, i.e. decisional balance, self-efficacy and processes of change. Decisional balance reflects the individual’s weighing of the importance of pros and cons of a behavior. Self-efficacy reflects the situation-specific confidence people have that they can cope with high-risk situations for unhealthy habits. Processes of change are the experiential and behavioral strategies that individuals use to progress through the stages [2]. Interventions should be matched to the relevant stage-specific factors in order to produce progress through the stages [3]. A relevant goal for such stage-matched information is forward stage transition to the next SOC [2].

The TTM has been subject to criticism (e.g. 4–6). However, the TTM is still widely applied by clinicians and practitioners in various fields of health behavior change. This is probably because the TTM seems relatively easy to apply, while critical experimental theory tests are largely lacking. A match–mismatch test has been proposed as a strong and definite test of the TTM [3]. A match–mismatch study experimentally tests whether individuals in
a given stage respond better to an intervention matched to their stage than to an intervention that is mismatched. A mismatched intervention is an intervention that is matched to a different irrelevant stage [7]. For example, in precontemplators a precontemplation intervention (the matched intervention) should reveal better results than a contemplation intervention (the mismatched intervention). A match–mismatch study is presented in this manuscript. Web-based tailored stage-matched and stage-mismatched feedback was tested among precontemplators and contemplators for fruit intake. Although a match–mismatch test is considered a strong TTM test, only few match–mismatch studies have been reported to date, which have revealed conflicting results [8–10]. Some useful lessons can be derived from these studies, which we attempted to incorporate in the present study. First, many stage-matched interventions only involve a targeting strategy [9–11]. Targeting means that respondents in the same stage receive identical materials. However, the TTM recommends to develop (computer) tailored individualized materials, because large differences exist within stages in decisional balance, self-efficacy and processes of change [12–14]. Only two match–mismatch tests used computer tailoring [8,15]. The inclusion of a tailoring strategy in addition to stage targeting seems useful, because in both studies stage-matched interventions outperformed the stage-mismatched interventions. Therefore, the present study tested tailored interventions. Second, most match–mismatch studies did not include feedback on the Transtheoretical processes of change. Yet, the TTM suggests that these processes should guide intervention development. The processes of change have shown to be relevant for fruit intake [2,16,17]. Our interventions tailored decisional balance, self-efficacy, and additionally, processes of change. Third, all match–mismatch studies had a delay between stage assessment and intervention delivery. Longitudinal studies on the stability of SOC have shown that stage transitions occur frequently in natural settings, also over short time intervals [18,19]. For example, ~17% of precontemplators and contemplators made a stage transition within only 3 days [18]. An intervention matched to a SOC measurement of some days earlier may no longer be matched at the time of intervention delivery. Web-based tailoring was applied in the present study, since it allows for generating immediate feedback and for correcting for stage instability [20]. Fourth, the (lack of) differences in effects between matched and mismatched interventions may depend on the extent and direction of the mismatch. For example, action feedback (AF) may be a larger mismatch than contemplation feedback (CF) in precontemplators [9]. In a randomized trial, we tested whether different types of stage-matched feedback induce more stage progress than stage-mismatched feedback. In summary we tested the following:

(i) In precontemplators, whether web-based tailored precontemplation feedback (PCF) was more effective than CF or AF.
(ii) In contemplators, whether web-based tailored CF was more effective than PCF or AF.

We focused on precontemplation and contemplation, since previous research has shown that a large proportion of individuals are in these stages [18,21,22]. The present study aimed to promote fruit intake. Ample fruit intake may contribute to the prevention of obesity [23], cardiovascular diseases [24] and certain cancers [25], whereas in most countries, only a minority of people eats ample amounts of fruit [26,27]. Further, fruit intake has previously been used to study the TTM [17,28,30].

Method

Participants and procedures
A random sample of 5026 people from a Dutch Internet research panel was invited to participate. To include adult precontemplators and contemplators, a screening instrument assessing SOC had to be completed (n = 3257, response rate 65%). Respondents in preparation, action and maintenance, and respondents younger than 18 years were excluded for further participation (n = 2,297, 71%). The screening revealed 593 and 367 eligible respondents in the precontemplation and contemplation
stages, respectively. The study was powered to detect a 20% difference in forward stage transition between the stage-matched and mismatched condition. Based on a power of 0.80, a two-tailed alpha level of 0.05, and 20% drop out between the measurements, 385 precontemplators and contemplators were required. In total, 775 individuals were included to participate further. Of the precontemplators, 408 were randomly selected to participate and all 367 contemplators participated. Respondents in the precontemplation and contemplation stages, separately, were randomly assigned to one of three feedback conditions. Of the precontemplators, 138, 134 and 136 respondents were randomly assigned to the PCF, CF and AF conditions, respectively. Of the contemplators, 119, 122 and 126 were randomly assigned to the PCF, CF and AF conditions, respectively.

Two days after screening (T0), the 775 participants were sent the pre-test questionnaire (T1) and received and read the web-based tailored feedback. The participants completed questions on the use, credibility and relevance of the feedback immediately after reading the feedback (T2). The first phase of the study (T1 and T2) had to be completed in one session. Completing the entire first phase of the study took ~20 min. Participants had 1 week to complete the first phase of the study (n = 636, response rate 82%). The program could not be entered anymore after this deadline. Respondents received the T3 questionnaire exactly 1 week after they had completed the first phase of the study (n = 573, response rate 90%).

Study conditions
Generating tailored feedback involves three components: (i) a diagnostic questionnaire, (ii) a message library with messages for all possible diagnoses and (iii) a tailoring program that links the diagnostic questionnaire to the message library using decision rules (if-then rules). The program selects the appropriate messages for each individual respondent and generates the individualized feedback [20,31]. Web-based tailoring offers extra flexibility. For example, also the diagnostic questionnaire can be tailored [32]. In the present study, respondents assigned to the PCF answered diagnostic questions on pros, consciousness raising, dramatic relief and environmental reevaluation process of change. Those assigned to the CF completed diagnostic questions on cons, self-efficacy and the self-reevaluation process of change. In the AF, self-efficacy, counterconditioning, helping relationships, reinforcement management and stimulus control were diagnosed. After completing the questions, the answers were entered to the tailoring program. Next, the tailored feedback appeared on screen via Internet in the form of a computer-generated individualized feedback letter. The letter addressed the respondents by name. It started with a statement that the information was tailored to their personal situation. At the end of the letter, participants were encouraged to print the letter so they could refer to it in the future. The content as well as the communication of the feedback were stage specific as proposed by the TTM.

Precontemplation feedback
The PCF included individualized information on the pros, e.g. health profits and weight regulation (cf. [33]). Information on consciousness raising focused on promoting efforts by the individual to seek new information. Feedback aimed to increase emotional reactions followed by strategies to reduce concern (dramatic relief). Further the effect of serving as a role model for children and partners was discussed in the environmental reevaluation feedback (cf. [2, 34]).

Directive feedback was avoided by encouraging cognitive or mental activities instead of behavioral actions (cf. [2, 35]). At the end of the feedback, respondents were asked to think about the feedback they had read and if they would be willing to eventually consider change in the future.

Contemplation feedback
The CF contained individualized communication that combined cognitive with behavioral activities. The cons of fruit intake, e.g. cost of fruit (cf. [33]) were tailored. Next the feedback asked respondents to imagine what would change if one would start to
eat at least two servings of fruit each day (self-reevaluation, 2). Finally, the information addressed situations that may make eating sufficient amounts of fruit difficult (self-efficacy). The feedback was aimed at building self-efficacy through the use of cognitive skills, because contemplators may rely more on the perception of difficulties than on actual experience with difficult situations [35–37]. At the end of the letter, respondents were asked to think about the feedback and to consider if they would be willing to change in the near future.

Action feedback
The AF communicated behavioral skills and activities directed at maintaining behavioral changes that are typically made by respondents in action. The AF addressed self-efficacy by means of behavioral skills [34,37]. Further, use of action-specific processes of change was discussed. First, counterconditioning was tailored by discussing the substitution of snacking by eating fruits. Next, gathering social support and developing simple rewards for eating fruits were discussed. The feedback further focused on adding cues to eat fruits, e.g. by placing a filled fruit bowl on the table (cf. [2, 34]). After reading the letter, respondents were asked to rethink the feedback and to incorporate some of these tips in their daily lives.

Measures
Fruit intake
Fruit intake was measured at T1 and T3 with a validated 14-item food frequency questionnaire (FFQ). The FFQ asked frequency and amount of consumption of citrus fruit, apples and pears, bananas, freshly squeezed or unsweetened fruit juice, tangerines and other fruit including preserved fruit. The FFQ referred to the past week. Fruit intake was calculated in grams per day. The reliability and validity of the FFQ have been described in detail elsewhere [38,39].

Stage of change
SOC was measured at all assessments by a single-item algorithm. This measurement has been recommended [40] and is consistent with earlier studies [18,21,22]. First, a description of the Dutch recommendations for fruit intake was presented. Respondents were asked whether they ate at least the recommended two servings of fruit each day by selecting one of five statements each representing a SOC: ‘No, and I do not intend to change this within the next six months’ (precontemplation), ‘No, but I intend to change this within the next six months’ (contemplation), ‘No, but I intend to change this within the next month’ (preparation), ‘Yes, and I have started doing so in the last six months’ (action), ‘Yes, and I have done so for more than six months’ (maintenance).

Use, credibility and personal relevance of feedback letter
At T2, the extent to which the feedback had been read was asked ranging from not at all (0) to completely (3). Next, respondents rated how credible they perceived the information ranging from very incredible to completely credible (0) to very credible (2). Personal relevance was assessed with four items, i.e. the information was specifically directed to me, the information was of personal relevance to me, I felt personally addressed, the information was adjusted to my personal situation. Five-point Likert scales ranging from totally disagree to totally agree were used.

Data analyses
As outlined in the introduction, an intervention that appears to be stage matched after random assignment at T0 may be stage mismatched at the time of intervention delivery at T1. Therefore, SOC was assessed again at the pre-test immediately before intervention delivery (at T1) to ensure the inclusion only of precontemplators and contemplators. Respondents who were in precontemplation or contemplation at T0, but who had already progressed to preparation or action before intervention delivery were excluded from the analyses (n = 112, 14%). Precontemplators who had progressed to contemplation between T0 and T1 remained in the study but were considered contemplators. Similarly, contemplators who had regressed to precontemplation
between T0 and T1 were treated in the data analyses as precontemplators.

Descriptives were used to describe fruit intake, SOC and demographic characteristics of the remaining 524 respondents (636 participants at T1—112 participants who progressed to preparation or action between T0 and T1). A randomization check with analysis of variance (ANOVA) and chi-square tests tested for differences between feedback conditions in baseline fruit intake, SOC, age, sex, level of education and ethnicity. Next, logistic regression analyses tested if condition, fruit intake, SOC, age, sex, level of education and ethnicity predicted drop out.

Repeated measures ANOVA tested the effects of the feedback conditions on fruit intake. Time, feedback condition, SOC, time $\times$ condition, SOC $\times$ condition and time $\times$ SOC $\times$ condition were entered as the independent variables. Eta squared ($\eta^2$) was used as the effect size estimate [43]. A small effect size was defined as $\eta^2 = 0.01$, a medium effect size as $\eta^2 = 0.06$ and a large effect size as $\eta^2 = 0.14$ [41]. Paired sample $t$-tests were conducted to test whether fruit intake at T3 was higher than at T1 for precontemplators and contemplators, separately. Cohen’s standardized differences between means ($d$) were computed to interpret the magnitude of effect size. A small effect size was defined as $d = 0.20$, a medium effect size as $d = 0.50$ and a large effect size as $d = 0.80$ [41].

The effects of the feedback conditions on forward stage transition were tested with logistic regression analyses with forward stage transition between two assessments as the dependent variable and dummy-coded feedback conditions as the independent variable. For both time intervals (T1–T2 and T1–T3), stage transitions were transferred into a dichotomous variable (1 = individuals who progressed at least one stage, 0 = individuals who remained stable or regressed at least one stage). The three feedback conditions were represented by two dummy-coded variables. To analyze the effects of feedback in precontemplators, the PCF was made the reference category. One dummy represented a comparison between AF and PCF. The second dummy represented a comparison between AF and CF. Odds ratios (OR) were computed as the effect size estimate. An OR near 2.0 is usually interpreted as meaningful [42].

Next, ANOVA with Scheffé multiple comparison tests were conducted to test for differences between conditions in the use, credibility and appreciation of the feedback in precontemplators and contemplators, separately. $\eta^2$ was again used as the effect size estimate [43]. If the $F$-test was significant, Cohen’s $d$ was calculated for the post hoc tests. Finally, repeated measures ANOVA tested the effects on fruit intake of use, credibility and the four personal relevance indicators. Separate analyses were run for use, credibility and the four personal relevance indicators. The model included time, feedback condition, the specific process evaluation measure and the interaction between feedback condition $\times$ process evaluation. $\eta^2$ was used as the effect size estimate. All tests were two-tailed and alpha was set at 0.05.

**Results**

**Participants**

The study sample comprised 336 (64%) men and 188 (36%) women. Mean age was 39.25 (SD = 11.42) years and ranged from 18 to 74. Respondents who had no education, primary school, secondary school and lowest level of high school or lower vocational training were classified as having a low level of education. Respondents with a medium level of education had completed intermediate or high level high school, or medium level vocational training. Respondents who had completed higher vocational training, college or university training had a high level of education. Of the respondents, 31, 43 and 25% had a low, medium or high level of education, respectively. Most respondents were of Dutch origin (94.4%). Foreign respondents were most frequently from German (1.9%), Indonesian (1.0%), Belgian (0.8%) or Surinam origin (0.6%). Pre-intervention fruit intake
averaged 139 g day$^{-1}$ (SD = 116). No differences between the three feedback conditions were found, indicating that the randomization was successful. Further, no differences were found between completers and non-completers in sex, age, level of education, ethnicity, fruit intake and feedback condition. Pre-contemplators were significantly more likely to drop out of the study than contemplators (13 versus 7%, OR = 1.88, $P$ = 0.04).

**Effects of feedback conditions on fruit intake**

At T1, fruit intake averaged 126 (SD = 116) and 155 (SD = 115) grams per day in pre-contemplators and contemplators, respectively. Average fruit intake at T1 and T3 by SOC and feedback condition is presented in Table I.

Repeated measures ANOVA revealed a marginally significant effect of time on fruit intake $[F(1,464) = 3.54, P = 0.06, \eta^2 = 0.01]$, indicating that respondents marginally significantly increased their fruit intake over time. A significant time $\times$ stage interaction effect was found $[F(1,464) = 11.29, P = 0.001, \eta^2 = 0.02]$, indicating that SOC had a significant impact on the increase in fruit intake. Further analyses showed that fruit intake remained constant between T1 and T3 for pre-contemplators ($t = 1.07, P = 0.29, d = 0.07$), but increased significantly for contemplators ($t = -3.42, P = 0.001, d = 0.22$). The interactions between time $\times$ condition $[F(2,464) = 0.82, P = 0.44, \eta^2 = 0.004]$ and time $\times$ stage $\times$ condition $[F(2,464) = 0.39, P = 0.68, \eta^2 = 0.002]$ were not significant. These results indicate that the feedback conditions had no effects on the change in fruit intake between T1 and T3. Further, the impact of the feedback conditions on the change in fruit intake was not different for respondents in pre-contemplation and contemplation.

**Effects of feedback conditions on stage progress**

**Between T1 and T2**

No effects of the feedback conditions on forward stage transition between T1 and T2 were found (Table II). Of the respondents in pre-contemplation at T1, 19, 19 and 18% were in a more advanced SOC immediately after the feedback for PCF, CF and AF condition, respectively. Progress to a more advanced stage occurred in 17, 27 and 18% of the contemplators for the three feedback conditions, respectively.

**Between T1 and T3**

No effects of the feedback conditions on forward stage transition between T1 and T3 were found (Table II). Of the respondents in pre-contemplation at T1, 21, 17 and 22% were in a more advanced SOC 1 week after the feedback for PCF, CF and AF condition, respectively. Progress to a more advanced stage occurred in 32, 30 and 38% of the contemplators at T1 for the three feedback conditions, respectively.

**Use, credibility and personal relevance of feedback**

The feedback letter was largely or completely read by 74% of the pre-contemplators and by 79% of the contemplators. ANOVA revealed no differences in the use, credibility and personal relevance of the feedback.
between the PCF, CF and AF conditions in the extent to which the feedback letter had been read by precontemplators \[ F (2,289) = 0.90, P = 0.41, \eta^2 = 0.01 \] or contemplators \[ F (2,235) = 0.76, P = 0.47, \eta^2 = 0.01 \].

The feedback letter was rated as credible or very credible by 64% of the precontemplators and by 80% of the contemplators. ANOVA revealed no differences between PCF, CF and AF conditions in credibility for precontemplators \[ F (2,289) = 0.43, P = 0.65, \eta^2 < 0.01 \] or contemplators \[ F (2,235) = 0.32, P = 0.73, \eta^2 < 0.01 \].

ANOVA revealed significant differences between the feedback conditions in personal relevance for contemplators, but not for precontemplators (see Table III). ANOVA showed that contemplators perceived AF as more personally relevant than CF \( (d = 0.43, P = 0.03) \) and PCF \( (d = 0.67, P < 0.001) \). Contemplators further evaluated AF as more adjusted to their personal situation than PCF \( (d = 0.42, P = 0.05) \), but not more than CF \( (d = 0.22, P = 0.42) \).

Repeated measures ANOVA showed no effect of use on fruit intake \[ F (3,458) = 1.30, P = 0.27, \eta^2 < 0.01 \], but significant effects on fruit intake were found for credibility and personal relevance. More specifically, respondents ate more fruit if they (i) rated the feedback as more credible \[ F (4,456) = 3.03, P = 0.02, \eta^2 = 0.03 \], (ii) perceived the feedback as specifically directed to them \[ F (4,455) = 2.65, P = 0.03, \eta^2 = 0.02 \], (iii) considered the feedback of personal relevance \[ F (4,455) = 7.20, P < 0.001, \eta^2 = 0.06 \], (iv) felt personally addressed \[ F (4,455) = 4.79, P = 0.001, \eta^2 = 0.04 \], (v) rated the feedback as adjusted to their personal situation \[ F (4,455) = 3.57, P = 0.007, \eta^2 = 0.03 \].
The interactions between use, credibility, personal relevance and the feedback conditions were not significant. This indicated that the effect of use, credibility and personal relevance on fruit intake were similar across the feedback conditions.

**Discussion**

The present study failed to support the superiority of stage-matching compared with stage-mismatching for fruit intake. Fruit intake increased significantly between pre- and post-test in contemplators, but not in precontemplators. No differences between the feedback conditions were found in fruit intake, stage progression, use or credibility of the feedback in precontemplators and contemplators. In precontemplators, also no differences between the conditions were found in personal relevance of the feedback. Contemplators, however, rated AF as more personally relevant than PCF or CF. Four explanations can be given for these results. First, the feedback was stage-matched on content and communication. Dijkstra et al. (8) suggested that also other intervention components might require an adaptation to SOC, e.g., the method of intervention, the intervention channel or the message source. Matching more aspects to SOC than content and communication has not been studied yet.

Second, stage-matched interventions are only able to outperform stage-mismatched interventions provided that the variables tailored in such interventions are stage specific. If these variables are actually relevant for several stages, individuals in several stages will profit from the same information. Previous longitudinal research indeed showed that self-efficacy and behavioral processes predicted both forward stage transition out of precontemplation and contemplation [17,28]. Thus, both precontemplators and contemplators may benefit from feedback designed to increase self-efficacy. We attempted to test the TTM as it was developed, and not an adaptation of the TTM. However, the TTM is not very clear in the factors that should be tailored at each stage. This has been illustrated by a Delphi study with SOC experts. This study showed that consensus about determinants of forward transitions is generally lacking [44].

Third, the lack of effects may be related to the type of behavior under investigation. Fruit intake is a 'continuous' behavior that needs to be performed repeatedly. Consumption of fruit requires several actions to be taken (e.g., food purchase and food preparation) and involves a continuous effort even if individuals are not yet in action [17]. To exemplify, individuals in early stages may not be motivated to increase their fruit consumption to the recommended level of two daily servings in the near future. However, they may very well consume smaller amounts of fruit or may have increased their fruit intake with a small amount. Also (increasing the) consumption of small amounts of fruit may require engagement in behavioral strategies, even if individuals are not prepared to eat according to the recommendations. As such, diet is different from behaviors for which complete cessation is the goal or where actual behavior change only occurs in the action stage, such as addictive behaviors. According to the transtheoretical model using behavioral strategies is typical for individuals in more advanced SOCs (e.g., smokers who have recently quit). Feedback about behavioral strategies is therefore assumed to be particularly suited to individuals in the advanced stages. However, for continuous behaviors individuals in all stages might benefit from this feedback. The TTM has been originally developed to understand addictive behaviors. It might be that the TTM is more applicable to these behaviors than to dietary or other continuous behaviors.

Fourth, it might also be possible that the feedback conditions were targeting the right variables, but that we failed to design feedback that actually produced changes in these variables. The effect of the feedback on the targeted variables was not assessed, which is a clear limitation of this study. All three feedback conditions led to an increase in fruit intake in contemplators, with an overall significant increase in fruit intake between T1 and T3. This may indicate that the interventions were at least to some extent potentially effective.

The present study has further limitations. First, one might argue that the time interval between intervention exposure and post-test was rather short for stage transitions and increases in fruit consumption to occur. However, the TTM proposes
that stages are states. Individuals can move rapidly between stages, even within a single-session intervention ([45], p. 1046). Furthermore, previous studies on SOC and diet have shown that people may make small dietary changes as they progress through the early stages (e.g. [17, 46]). Second, the use of an Internet research panel may have reduced the external validity of the results. However, the use of an Internet panel did provide the opportunity to give immediate feedback. Therefore, the risk that beliefs, SOC or behavior may already have changed between assessment and feedback delivery could be minimized. In the 2 days between T0 and T1, already 14% of respondents progressed further than contemplation. Though this figure is similar to earlier research [18], our results indicate again stage-matched interventions should be delivered immediately after stage assessment. Third, we did not include a no-feedback control group. The objective was to test whether stage-matched feedback would outperform the stage-mismatched feedback and not whether providing (stage-matched) feedback would perform better than no feedback at all. However, a control group could have excluded the possibility that we failed to design effective feedback.

It is for that particular reason that from the present results it cannot be concluded that the TTM is invalid. Our study may still contribute to future research, since it is one of very few studies applying a strong design to test the validity of stage models. It may function as an illustration on the complexities that are involved with testing a stage model, and may help researchers to develop future match–mismatch tests.

To conclude, we found no evidence for the merits of stage-matching interventions. These results are similar to the results from systematic reviews on the effectiveness of stage-based interventions [47–49] and consistent with earlier studies on stage-matched and -mismatched interventions [8].

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References

Stage-matched and -mismatched feedback

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