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Cross-behavior associations and multiple health behavior change: A longitudinal study on physical activity and fruit and vegetable intake

Lena Fleig[1], Carina Küper[2], Sonia Lippke[3], Ralf Schwarzer[4,5] and Amelie U Wiedemann[1]

Abstract

This study aimed to examine the interrelation of physical activity and fruit and vegetable intake. The influence of stage congruence between physical activity and fruit and vegetable intake on multiple behavior change was also investigated. Health behaviors, social-cognitions, and stages of change were assessed in 2693 adults at two points in time. Physical activity and fruit and vegetable intake were assessed 4 weeks after the baseline.

Social-cognitions, stages as well as stage transitions across behavior domains were positively interrelated. Stage congruence was not related to changes in physical activity and fruit and vegetable intake. Physical activity and nutrition appear to facilitate rather than hinder each other. Having intentions to change both behaviors simultaneously does not seem to overburden individuals.

Keywords

fruit and vegetable intake, multiple health behavior change, physical activity, stage congruence, transfer

Many causes of morbidity and premature mortality are influenced by multiple health-risk behaviors including unhealthy nutrition and physical inactivity (Lanas et al., 2007). In fact, research has shown that certain risk behaviors occur in combination and tend to cluster within individuals (e.g. Poortinga, 2007). Therefore, it has been argued that health behavior interventions should address more than one single behavior to produce greater impacts on health (e.g. Prochaska et al., 2008). While multiple behavior change *interventions* are increasingly being implemented, the theoretical basis for doing so has received less attention (e.g. Noar et al., 2008).

Usually, theories have been applied in research on single health behaviors, giving insights into that specific behavior but providing little understanding on relationships between multiple behaviors and processes of change (Noar et al., 2008). To develop effective methods for addressing multiple behaviors, the *multiple behavioral approach* (MBA) (Noar et al., 2008) suggests to concentrate

[1]Freie Universität Berlin, Germany
[2]Humboldt-Universität zu Berlin, Germany
[3]Jacobs University Bremen, Germany
[4]Australian Catholic University, Australia
[5]University of Social Sciences and Humanities, Poland

Corresponding author:
Lena Fleig, Social and Economic Psychology Unit (PF 9), Health Psychology Division (PF 10), Freie Universität Berlin, Habelschwerdter Allee 45, 14195 Berlin, Germany.
Email: lena.fleig@fu-berlin.de

on the linkage between at least two health behaviors and the association between specific psychological constructs (e.g. self-efficacy). Further emphasis should be placed on the question as to how individuals go about changing more than one behavior (e.g. sequentially or simultaneously). In line with the MBA, this study examined how specific health behavior constructs taken from the *health action process approach* (HAPA; Schwarzer, 2008) relate to each other (i.e. *cross-behavior associations*) and how individuals change physical activity (PA) and fruit and vegetable intake (FVI) (i.e. *processes of multiple behavior change*).

When looking at behavioral measures, various studies provide evidence that healthy nutrition and PA are positively related to each other (De Vries et al., 2008; Kremers et al., 2004; Södergren et al., 2012). In other words, both health behaviors appear to rather facilitate than hinder each other. Theoretically, both behaviors may represent two similar contexts between which psychological resources and strategies can be transferred (i.e. resource and strategy *transfer*; Fleig et al., 2011; Lippke et al., 2012; Nigg et al., 2009). A "facilitating pattern" between PA and nutrition should thus not only transpire on a behavioral level but also with regard to psychological constructs. Indeed, previous research suggests that individuals who believe that they are able to engage in PA despite barriers also hold more positive beliefs about their ability to change their nutrition (Annesi and Marti, 2011; Kremers et al., 2004). Similarly, individuals who are motivated to change their PA levels have been found to also hold the *intention* to change their nutrition (Kremers et al., 2004). According to the HAPA (Schwarzer, 2008), individuals are more likely to change a behavior if they complement their intentions and efficacy beliefs with concrete plans on when and where to change their behavior (i.e. *planning*). This study therefore aimed to investigate cross-behavior associations between motivational (i.e. intention, self-efficacy) and volitional constructs (i.e. planning).

Behavior change toward a particular goal can be either understood as a continuous process (such as translating intentions into behavior) or as a series of distinct stages. These categories reflect cognitive or behavioral characteristics. According to the stage assumptions of the HAPA (Schwarzer, 2008), individuals in the pre-intention stage (non-intender) are not motivated to change their behavior. Individuals in the intention stage (intender) have already set the goal to engage in a new behavior, individuals in the action stage (actor) are already active. Studies following the MBA can investigate linkages between *stages* for different health behaviors to establish cross-behavior associations. Previous stage-based studies which were mainly conducted within the framework of the transtheoretical model (TTM) (Prochaska and DiClemente, 1991) provide evidence for a positive association between stages of change for PA and FVI (e.g. Clark et al., 2005; Lippke et al., 2012). Individuals who reside in an advanced stage for PA are also more likely to be in an advanced stage for healthy nutrition. The aim of this study was to replicate these findings within the framework of the HAPA.

In addition, the MBA raises the question as to whether *changes* in different behavior domains are related and, if so, whether individuals modify their health behaviors at the same time (i.e. simultaneously) or step by step (i.e. sequentially). One way to answer this question is to look at associations of stage transitions across behavior domains. If change processes of different behavior domains are related, individuals who show progress with regard to PA should also be more likely to progress with regard to healthy nutrition.

Finally, multiple behavior change can be investigated by comparing the rates of behavior change in PA and FVI as a function of whether individuals intend to change both behaviors at the same time (i.e. *simultaneous changer*) or whether they intend to change their lifestyle by starting with a single behavior (e.g. either PA or FVI; *one-at-a-time changer*). This can be easily conducted by comparing individuals who either reside in the intention stage for both behaviors (i.e. double-intender, simultaneous changer) and those who are in the intention stage for one behavior but in the pre-intention stage for

another behavior (i.e. single-intender, one-at-a-time changer). Individuals who intend to change both behaviors and thus reside in the same stage for both behaviors can be referred to as "stage congruent," whereas those who reside in different stages can be described as "stage incongruent." If rates of success in multiple behavior change are in favor of either of the subgroups, this could be interpreted as one pathway of change—either simultaneous or one-at-a-time—being superior to the other.

One-at-a-time changers are assumed to be more successful in mastering multiple behaviors as they can focus their resources (Annesi, 2012), perceive less goal-conflict, and can make use of cross-behavioral transfer (e.g. Fleig et al., 2014; Nigg et al., 2009) as compared to simultaneous changers. On the other hand, *simultaneous changers* may maintain an advantage as they experience synergistic effects when changing related behaviors (Annesi, 2012; Atkins and Clancy, 2004) and are more confident about their ability to regulate multiple goals (Jung and Brawley, 2013). So far, only very few experimental trials have directly investigated the impact of targeting two health behaviors simultaneously versus one at a time, yielding inconsistent results. Whereas three studies (see review by Prochaska and Prochaska, 2011) indicated no differences between conditions, two other studies provided evidence in favor of the sequential intervention (Hyman et al., 2007; Schulz et al., 2012). In contrast to that, King et al. (2013) recently showed that individuals receiving the simultaneous intervention were more likely to meet recommendations, but not in the sequential interventions. With such few and inconsistent findings, this study explored the role of stage congruence—as indicative of a sequential versus a simultaneous pathway—on multiple health behavior change.

Aims of this study

The primary objective was to examine the interrelation between PA and FVI. This was done by looking into three different indicators of cross-behavior relationships. The following hypotheses were tested: FVI and PA as well as its social-cognitive determinants (i.e. intention, self-efficacy, and planning), and stages are positively correlated.

A second aim of this study was to investigate how change in PA was related to change in FVI. Following a stage theory approach, the following hypothesis was tested: there exists a positive interrelation between the stage progression concerning PA and FVI.

Finally, the effect of stage congruence on changes in PA and FVI was explored. More specifically, the study explored whether or not participants in the same stage (stage congruence) for two behaviors are more successful at changing than those who have stage incongruence between two behaviors.

Methods

Design

The research aims were addressed in an online study with two measurement points in time. Measures were taken via web-based questionnaires at baseline (Time 1, T1) and reassessed at a 4-week follow-up period (Time 2, T2). The study was approved by the Departmental Ethics Committee and conducted in line with German Psychological Society ethical guidelines.

Participants and recruitment

Participants were recruited from the German general population via press releases, announcements on university websites, and mailing lists. At baseline and at 4 week follow-up period, participants filled in an online questionnaire without receiving any incentives. Persons with medical conditions that conflicted with engaging in regular PA and eating five portions of fruit and vegetable were excluded. The initial sample comprised $N = 2693$ participants. Data at follow-up were available from $n = 1002$ participants (37.2% of the initial sample). Mean age of the longitudinal sample was 37.2 years (standard deviation (SD) = 11.4 years; range 18–78 years), and the sample consisted of more

women (77.3%) than men. Of all participants, 38.1 percent were married or in a permanent relationship, 39.2 percent had at least one child. Two-thirds of the longitudinal sample (83.6%) reported having completed high school or a higher degree, and 53.2 percent were employed. At baseline, FVI averaged 3.1 ($SD = 1.6$) daily servings, and moderate and vigorous PA averaged 131.7 minutes per week ($SD = 118.3$ minutes). The average reported body mass index was 25.0 ($SD = 5.1$).

Measures

PA was measured with a modified version of the Godin Leisure-Time Exercise Questionnaire (GLTEQ;Godin and Shephard, 1985). This self-report measure has been validated with physiological and anthropometrical measures (i.e. VO_2 max and body fat; Jacobs et al., 1993). Participants were asked to report the average number of sessions per week and the average duration of a session regarding vigorous (heart beats rapidly, sweating) and moderate (not exhausting, light perspiration) PA in the past month. Only activities outside of work duties (at work or at home) and voluntary activities were addressed. Total PA was calculated by multiplying the number of sessions per week by the number of minutes per session. Change scores for PA were operationalized by subtracting T1 from T2 minutes. In line with the "small steps approach" (Hill et al., 2003) and similar to Vandelanotte et al. (2008), successful behavior change was defined as an increase of at least 10 minutes of moderate and/or strenuous PA per week on average.

T1 and T2 FVI were measured by the open-ended question "How many servings of fruit and vegetable did you eat on a typical day of the last month?" This item was adapted from an English measure that has been validated against dietary biomarkers (Steptoe et al., 2003). One portion was defined as the amount of food that fits into the palm of the hand. Participants were asked not to take into account products made of potatoes. Change scores for FVI were calculated by subtracting number of ingested portions reported at T1 from T2 intake. For FVI, successful behavior change was defined as an increase of at least one serving of fruit and/or vegetables on average per day. To combine behavior change in PA and FVI, a nominal variable with four categories was computed: successful change in both behaviors, successful change in only one behavior (either PA or FVI), or no or negative change in either behavior (Prochaska et al., 2008).

Social-cognitive variables were assessed using 4-point Likert scales, ranging from not at all true (1) to completely true (4). *PA intention* was assessed with two items matching the two behavior intensities: "I intend to engage in vigorous PA (increased heart rate, sweating) during the next month" and "I intend to engage in moderate PA (hardly exhausting, light sweating) during the next month" (Nigg, 2005; $r = .18$). *Intentions to consume fruit or vegetables* were measured by two items "I intend to eat at least five servings of fruit or vegetables per day during the next month" and "I intend to eat fruit and vegetables with every meal" (Lippke et al., 2009; $r = .53$).

Self-efficacy was measured with seven items for each behavior domain. The item "I am confident that …" was supplemented with the following exemplary statements for PA: "… I can manage to be more physically active" (Schwarzer et al., 2007) or "… I can engage in regular physical activity even if I have worries or problems" (Dijkstra et al., 1998; Cronbach's $\alpha = .86$) and for nutrition: "… I can manage to eat five servings of fruit and vegetables per day" or "… I can manage to eat five portions of fruit and vegetables per day even if I have worries or problems." (Dijkstra et al., 1998; Cronbach's $\alpha = .92$).

Planning was measured with two items per behavior, such as "I have already precisely planned when, where, and how to eat five servings of fruit or vegetables throughout the day" and "I have already precisely planned where, when, and for how long to be physically active." Similar measures of planning have shown factorial and predictive validity (Sniehotta et al., 2005).

S*tages of change* for both behaviors were measured with validated algorithms for HAPA stages (Lippke et al., 2009). For both behaviors,

Table 1. Stage distribution and stage congruence in the baseline sample (n = 2693).

		Fruit and vegetable intake (FVI)			
		Non-intender, *n* (%)	Intender, *n* (%)	Actor, *n* (%)	Total, *n* (%)
Physical activity (PA)	Non-intender	375 (13.9)	100 (3.7)	116 (4.3)	591 (21.9)
	Intender	365 (13.6)	319 (11.8)	204 (7.6)	888 (33)
	Actor	500 (18.6)	325 (12.1)	389 (14.4)	1214 (45.1)
	Total	1240 (46.1)	744 (27.6)	709 (26.3)	2693 (100)

Numbers in parentheses represent percent of n = 2693. Shaded sub-groups are included in further analyses on the effect of stage congruence on multiple behavior change.

participants were instructed, "Please think about the last month" and then instructed, "Did you engage in PA at least 3 days per week for 30 minutes or more?" Regarding nutrition, the question was "Did you eat at least five portions of fruit and vegetables per day?" Participants responded on a rating scale with the verbal anchors "No, and I don't intend to do so" and "No, but I am considering it" referring to the pre-intention stage, "No, but I seriously intend to do so" representing the intention stage, and finally, "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 T1 stage from T2 stage.

Statistical methods

All analyses were run with SPSS 20. Dropout analyses compared retained participants and those lost after T1 using analyses of variance (ANOVAs) for continuous measures and χ^2-tests for categorical measures. Associations between behavioral and social-cognitive measures were examined using Pearson's correlations. To examine the association between categorical data, Pearson's chi-square test was conducted. Multinomial logistic regression (MLR) was used to evaluate the effect of stage congruence on behavior change in a subgroup of individuals who were intending to change both behaviors (i.e. double-intender, stage congruent group), who were intending to change PA only (i.e. single-intender, stage incongruent group A), and those who were intending to change only their nutrition (i.e. single-intender, stage incongruent group B). Stage congruence formed the predictor variable and was dummy coded, with the stage congruent group as baseline category. In line with Prochaska et al. (2008), multiple behavior change was operationalized by an index with four categories (see measures). Age, gender, body mass index, and educational status were entered as covariates. Odds ratios (ORs) with a 95 percent confidence interval are reported as estimates of effect size. Missing values in the data of the longitudinal sample were imputed using the expectation–maximization (EM) algorithm.

Results

Descriptive results

Dropout analyses indicated that individuals who continued in the study were more likely to be male, unemployed, with a low educational degree, and in an earlier stage of PA than those who dropped out ($ps < .05$). Besides that, no other differences were found. T1 stage distribution and stage congruence across the two health behaviors are displayed in Table 1.

With regard to stage congruence, the majority of participants were assessed as being stage incongruent ($n = 1610$, 59.8%). Of the nine possible stage combinations, most individuals were allocated to the pre-intention stage regarding FVI and the action stage regarding PA (i.e. stage

Table 2. Cross-behavior associations between T1 PA and FVI and social-cognitive variables.

		FVI			
		Number of daily servings	Intention	Self-efficacy	Planning
PA	Weekly minutes of moderate to vigorous PA	.16**	.04*	.05*	.08**
	Intention	.10*	.19**	.12**	.14**
	Self-efficacy	.12**	.16**	.27**	.18**
	Planning	.12**	.15**	.11*	.25**

PA: physical activity; FVI: fruit and vegetable intake.
*$p < .05$; **$p < .01$.

incongruent), followed by those who were already engaging in both health behaviors and those who did not intend to change any behavior (stage congruent; see Table 1). Analyses on stage congruence focused on the following three groups: those individuals who intended to change both behaviors (i.e. stage congruent, $n = 319$) were compared to those who intended to change either PA only ($n = 365$) or FVI only ($n = 100$; stage incongruent).

With regard to PA stage transitions, 12.7 percent of the longitudinal sample regressed to a previous stage, while almost twice as many individuals progressed to a higher stage (22.3%). The majority of participants remained in their stage (65.1%). For FVI, 11.3 percent of the longitudinal sample showed stage regression, whereas 27 percent progressed to a higher stage.

Successful behavior change was defined as an average increase of at least 10 minutes of moderate to vigorous PA per week and at least one serving of fruit or vegetables more on average per day from T1 to T2. Overall, one-third of participants showed positive changes in both behaviors. Among those individuals who changed only one behavior (45.2%), the majority opted to change PA (29.1%). The remaining participants (25.6%) did not change any behavior (see supplementary material for a Figure of behavior change).

Associations between PA and FVI

Intercorrelations between health behaviors and its social-cognitive antecedents are displayed in Table 2.

Overall, correlation coefficients revealed positive associations of small to moderate effect sizes. In more detail, analyses revealed a positive association of medium effect size between self-efficacy to engage in PA and self-efficacy to eat more fruit and vegetables, and planning PA and FVI (see Table 2). Correlations between the two behaviors and between intentions to perform the two behaviors were positive but only of small effect size. With regard to stage allocation, chi-square analysis revealed that there was a positive association between the stages of change for PA and FVI (χ^2 (1) = 99.85, $p < .01$, *Cramer's V* = .22).

Processes of multiple behavior change

Stage transitions. Chi-square analysis confirmed a positive association between PA and FVI stage transitions (χ^2 (4) = 11.74, $p < .05$, *Cramer's V* = .15).

Behavior change as a function of stage congruence. As displayed in Table 3, MLR analysis revealed no significant results.

The likelihood of behavior change in PA only, in fruit and vegetable only, and in both behaviors compared to no behavior change was equal in the twostage-incongruent subgroups compared to the reference group (i.e. stage congruent group). In other words, similar amounts of participants changed no, one, or both behaviors in the different groups, suggesting that stage congruence was not significantly associated with successful behavior

Table 3. Summary of results from multinomial logistic regression.

	No change ($n=66$)	Changed PA ($n=74$)	Changed FVI ($n=43$)	Changed both behaviors ($n=71$)
		OR (95% CI)	OR (95% CI)	OR (95% CI)
Stage congruence	Reference category			
Stage congruent		1	1	1
Stage incongruent (PA intender)		1.35 (0.63, 2.91)	1.57 (0.73, 3.34)	1.34 (0.69, 3.04)
Stage incongruent (FVI intender)		1.60 (0.54, 4.75)	1.55 (0.54, 4.41)	1.61 (0.57, 4.57)

PA: physical activity; FVI: fruit and vegetable intake; OR: odds ratio; CI: confidence interval.

change. Furthermore, none of the covariates was significant.

Discussion

The aim of this study was to gain further insight into the relationship between PA and FVI by investigating (1) cross-behavior associations between theory-based health behavior constructs and by examining (2) processes of multiple behavior change.

The question about the interrelation of different health behaviors is of practical importance. If PA and healthy nutrition share similarities, it seems justified targeting both energy-related behaviors in one intervention (Paiva et al., 2012). Present findings support this notion: The hypothesized positive cross-behavior associations could be confirmed with regard to behavior, social-cognitive variables, as well as stage measures.

In line with previous findings, the respective social-cognitive variables correlated even stronger across PA and nutrition than the behaviors themselves (Kremers et al., 2004). First of all, *intention* to be physically active was positively associated with the intention to consume fruit and vegetables, implicating that the two health goals rather facilitate than hinder each other. This argument was also supported by findings on self-regulatory strategies (Annesi, 2012): Individuals who reported to plan their PA also engaged in more *planning* activities with regard to their FVI. This may be interpreted in terms of a transfer effect (Fleig et al., 2014; Fleig et al., 2011; Lippke, 2014; Lippke et al., 2012; Nigg et al., 2009): Individuals apply self-regulatory strategies that have been proven successful for one behavior to another behavior. Furthermore, positive associations between *self-efficacy* suggest that participants who were more confident in their ability to be physically active also held more positive beliefs about their ability to maintain a healthy diet (Annesi and Marti, 2011; Kremers et al., 2004). As findings were cross-sectional in nature, no conclusions can be drawn as to whether accomplishments in one behavior boost self-efficacy to change another (Annesi and Marti, 2011).

Apart from cross-behavioural transfer of strategies (i.e. planning) and resources (i.e. self-efficacy), previous research among obese individuals has identified other facilitating mechanisms such as autonomous motivation (Mata et al., 2009), negative body image, and mood (Carraça et al., 2013) which can account for positive activity-nutrition associations.

Besides behavior and social-cognitions, stages of change were used as a third indicator of cross-behavior relationships. Interrelations were in the expected direction revealing that individuals who were in an advanced stage for one behavior were also more likely to be in an advanced stage for another behavior. The stage algorithm used in this study is based on intentional and behavioral indicators (Lippke et al., 2009), and accordingly, the correlation between the stage allocation for both behaviors is in line with our findings that intentions and the behavioral performance per se are related across behaviors.

In addition, our results are well aligned with previous stage-based studies in the PA and nutrition domain (Boudreaux et al., 2003; Lippke et al., 2012) as well as within the nutrition domain (De Vet et al., 2006). In the context of smoking, however, previous research revealed a different pattern. Stage associations between PA and smoking have been shown to be comparatively lower than that between PA and nutrition (Lippke et al., 2012) or did not show any association at all (Boudreaux et al., 2003; King et al., 1996). Thus, targeting certain types of behavior may create more synergies in comparison to behavior clusters that include a health-risk behavior. Finally, whereas previous studies were merely based on the TTM (Prochaska and DiClemente, 1991), this is the first study to show that cross-behavior stage associations also hold true for the stages of the HAPA (Schwarzer, 2008).

Summing up, the present results on cross-behavior associations are a starting point to understand the mechanisms that lie at the core of multiple behavior change. The cognitive mechanisms associated with changes in PA were related to the cognitive variables which have been shown to predict changes in nutrition indicating potential transfer effects. PA and FVI seem to rather facilitate than hinder each other, in terms of resources (i.e. self-efficacy) as well as in terms of self-regulatory strategies (i.e. planning) and intention. Therefore, interventions might profit from the inclusion of similar health-promoting behaviors.

Results on the association of *change processes* between PA and FVI confirmed correlational findings: Positive interrelations between *stage transitions* suggest that individuals who progress with regard to one behavior are likely to show progression for the other behavior (Paiva et al., 2012; Yin et al., 2013). Stage transitions indicate individuals' progress toward a behavioral goal such as eating more healthily. Hence, associations between stage transitions can be tentatively interpreted as exercise and nutrition to rather change in concert rather than interfering with each other.

To obtain a more detailed picture on *patterns* of multiple health behaviour change, this study explored whether the combination of stage allocation for PA and healthy nutrition—either stage incongruent or stage congruent—affected multiple behavior change (see Table 1, grey-shaded area).

Results of MLR analysisrevealed that stage congruence was not predictive of multiple behavior change: Similar amounts of participants changed no, one, or both behaviors across the three different groups of stage combinations. In this study, stage congruence served as an indicator of whether individuals intended to change a single behavior or two behaviors at a time. Findings, thus, suggest that it is a worthwhile endeavor to further explore with interventions studies whether both change strategies—either a simultaneous or a one-at-a-time pathway—are equally effective when it comes to changing PA and nutrition. Based on previous experimental research (Prochaska and Prochaska, 2011) and our observational findings, changing PA and nutrition seems to be equally successful irrespective of whether individuals intend to change their behaviors simultaneously or wish to change one behavior at a time.

The study was subject to several limitations. Overall, attrition rate was rather high but at a comparable level to those found in other internet-based studies (Schulz et al., 2012). Furthermore, prospective longitudinal trials in which the social-cognitive variables and stages of the HAPA model are investigated at more frequent measurement points with longer follow-ups are needed. Finally, to advance multiple behavior theory and intervention design, different pathways of change are to be evaluated not only in terms of behavior but also in terms of psychologically meaningful mediators of cross-behavior regulation (e.g. transfer, habit, Fleig et al., 2011; mood, Carraça et al., 2013).

In conclusion, positive cross-behavior relationships among behavior, stages, and social-cognitive constructs for PA and FVI support the potential efficacy of joint health promotion efforts. Irrespective of whether a sequential or simultaneous intervention mode is chosen, intervention developers may stimulate synergistic

effects between target behaviors in attempting to facilitate multiple behavior change.

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