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Testing an integrated model of the theory of planned behaviour and self-determination theory for different energy balance-related behaviours and intervention intensities

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Objectives. The aim of the study was to test the relations between constructs from the self-determination theory (autonomous and controlled motivation), the theory of planned behaviour (attitudes, self-efficacy, and intentions), and behaviour change within a theoretically integrated model. Additionally, the aim was to test if these relations vary by behaviour (physical activity or dietary behaviour) or intervention intensity (frequency).

Design. It was a randomized controlled trial with a 'usual care' condition (medical screening only) and an intervention condition (medical screening + access to a website and coaching). Participants in the latter condition could freely determine their own intervention intensity.

Methods. Participants ($N = 287$) completed measures of the theoretical constructs and behaviour at baseline and after the first intervention year ($N = 236$). Partial least squares path modelling was used.

Results. Changes in autonomous motivation positively predicted changes in self-efficacy and intentions towards a healthy diet. Changes in controlled motivation positively predicted changes in attitudes towards physical activity, changes in self-efficacy, and changes in behavioural intentions. The intervention intensity moderated the effect of self-efficacy on intentions towards physical activity and the relationship between attitude and physical activity. Changes in physical activity were positively predicted by changes in intentions whereas desired changes in fat intake were negatively predicted by the intervention intensity.

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Conclusions. Important relations within the theoretically integrated model were confirmed but others were not. Moderation effects were found for behaviour and intervention intensity.

Cardiovascular disease can be prevented by an active life-style and a healthy diet (Graham *et al.*, 2007). Although vigorous-intensity physical activity leads to greater improvements than moderate-intensity physical activity, both types should be promoted (Swain & Franklin, 2006). As most people are sedentary they are more likely to view physical activity of moderate intensity as appealing in order to change their inactive life-style. A healthy diet can further lower this risk by reducing or modifying dietary fat intake and increasing fruit and vegetable consumption (Hooper *et al.*, 2000; Mirmiran, Noori, Zavareh, & Azizi, 2009).

Despite the benefits of making positive life-style changes, people generally fail to meet the recommendations for physical activity and dietary behaviour. Consequently, the literature reports the psychosocial determinants that promote or thwart life-style changes (Hagger & Chatzisarantis, 2009). Physical activity and dietary behaviour are thought to be associated and cluster analyses have shown that such energy balance-related behaviours tend to co-occur (de Vries *et al.*, 2008).

Research on the psychosocial determinants of these energy balance-related behaviours has been performed before adopting theoretically integrated models of health behaviour incorporating the theory of planned behaviour (TPB; Ajzen, 1985) and self-determination theory (SDT; Hagger, Chatzisarantis, & Harris, 2006b; Ryan & Deci, 2000).

The primary postulate of the TPB is that an individual's intention is the most proximal predictor of his/her behaviour and mediates the effect of three sets of belief-based perceptions on behaviour: attitudes, subjective norms, and perceived behavioural control (PBC; Ajzen, 1985). Attitudes reflect beliefs as to whether the behaviour (e.g., physical activity and dietary behaviour) will lead to desirable outcomes. Subjective norms summarize beliefs about whether salient others want an individual to participate in the behaviour. The concept of PBC is similar to Bandura's concept of self-efficacy (Bandura, 1982; Conner & Armitage, 1998) and reflects whether a person believes he/she has the resources or capacity to engage in the behaviour. Cumulative quantitative reviews of research across a wide variety of behaviours (Armitage & Conner, 2001), including physical activity (Hagger, Chatzisarantis, & Biddle, 2002) and dietary behaviours (Hagger, Chatzisarantis, & Harris, 2006a) have identified attitudes and PBC as having medium effects on intention with subjective norm demonstrating a substantially weaker effect (Armitage & Conner, 2001; Hagger *et al.*, 2006a).

In contrast, SDT is a theory of human motivation that distinguishes between the quality of the reasons or *motives* (i.e., autonomous vs. controlled) that regulate behaviour (Ryan & Deci, 2000). At the centre of the theory is the distinction between self-determined or *autonomous* forms of motivation and non-self-determined or *controlled* forms of motivation. Autonomous motivation reflects engaging in behaviours and activities that are perceived to originate from the self and fulfil personally relevant goals. Controlled motivation reflects engaging in behaviours for reasons perceived to emanate outside the self. The driving force behind the forms of motivation that people adopt is basic psychological needs. People have the tendency to be attracted to autonomously motivated activities in order to satisfy three innate psychological needs: the needs for autonomy, competence, and relatedness. The need for autonomy refers to the need to experience oneself as an initiator and regulator of one's actions. The need for competence refers to the need to master one's environment. The need for relatedness refers to people's innate need to seek close and intimate relationships with others. Autonomous motivation is associated with increased psychological well-being and persistence with health-related behaviours. Controlled motivation is associated with negative psychological outcomes and desistance or avoidance of tasks (Deci & Ryan, 2002; Ryan & Deci, 2007). Autonomous motivation can also be supported or thwarted by environmental contingencies (Hagger & Chatzisarantis, 2009). Autonomy-supportive environments offer a rationale for the proposed health behaviour, offer choice, take the perspective of the individual, and acknowledge difficulties associated with changing behaviour (Ryan & Deci, 2000). SDT is often adopted for tailored behaviour–change intervention programmes as autonomous motives positively affect behavioural engagement (Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003; Jacobs & Claes, 2008).

Theoretically integrated models of TPB and SDT have been effective in explaining physical activity and dietary behaviour (e.g., Hagger & Chatzisarantis, 2009; Hagger *et al.*, 2006a,b). In these models, a motivational sequence is proposed such that the effects of autonomous versus controlled motivation on intentions and behaviour are mediated by the proximal determinants of intentions: attitudes and self-efficacy (Hagger *et al.*, 2006a). Although the motivational sequence has been confirmed in several correlational studies, few intervention or experimental studies have tested this sequence (Chatzisarantis & Hagger, 2009; Edmunds, Ntoumanis, & Duda, 2006, 2008; Palmeira *et al.*, 2007) and only one study focusing on physical activity adopted a true intervention or experimental design using randomization (Edmunds *et al.*, 2008). No study to date has adopted a theoretically integrated model to evaluate behaviour change in the context of dietary behaviour (Hagger, 2009). There is also very little research that has identified the components of interventions that would target the key psychosocial and motivational constructs that influence behaviour in the context of this integrated model. This is necessary in order fully realize the importance and contribution of formative theoretical

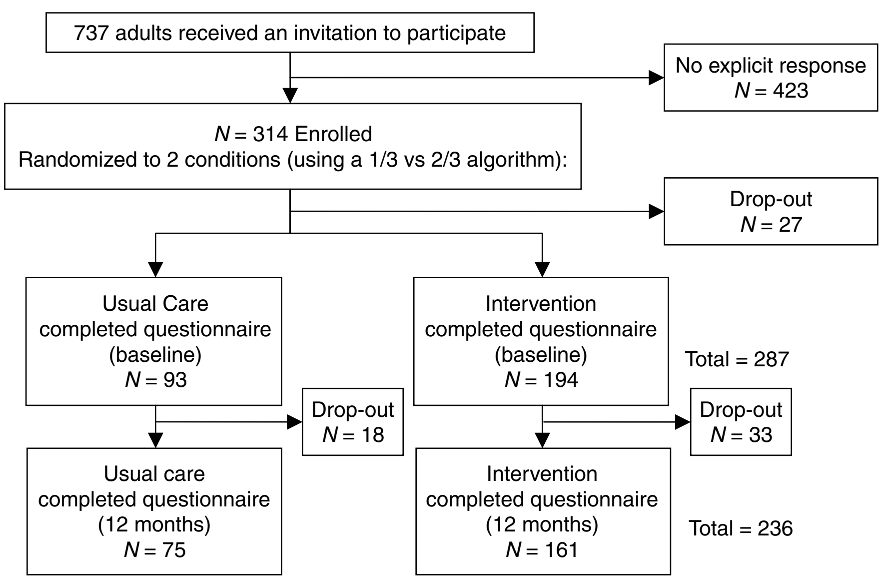

Figure 1. Participants flow diagram.

research integrating these theories in the development, and design, of interventions to change behaviour (Michie & Prestwich, 2010). Research is needed to identify these components and the extent to which participants engage with these components, i.e., their self-selected intervention *intensity* affects the behavioural outcomes.

The present study and hypotheses

The present study is the first randomized controlled trial testing the relations between constructs from the SDT, the TPB, and behaviour change within a theoretically integrated model for different behaviours and intervention intensities. Figure 1 shows the study flow and Figure 2 shows the theoretically integrated model. Autonomous and controlled motivation were hypothesized to be distal predictors of attitudes and self-efficacy (e.g., Hagger *et al.*, 2006a, b). Attitudes and self-efficacy were hypothesized to be proximal predictors of intentions in accordance with the TPB. We hypothesized indirect relations between autonomous and controlled motivation and intentions and between attitudes and self-efficacy (or PBC) and behaviour (Ajzen, 1985; Hagger *et al.*, 2006a). The theoretically integrated model additionally included intervention intensity (or intervention 'dose') as a moderator of all the relations within the model.

Method

Participants

Participants ($N = 287$, 191 male, 96 female, M age = 40.48 years, $SD = 10.55$) completed the measures at baseline after randomization. Seventy per cent ($N = 202$)

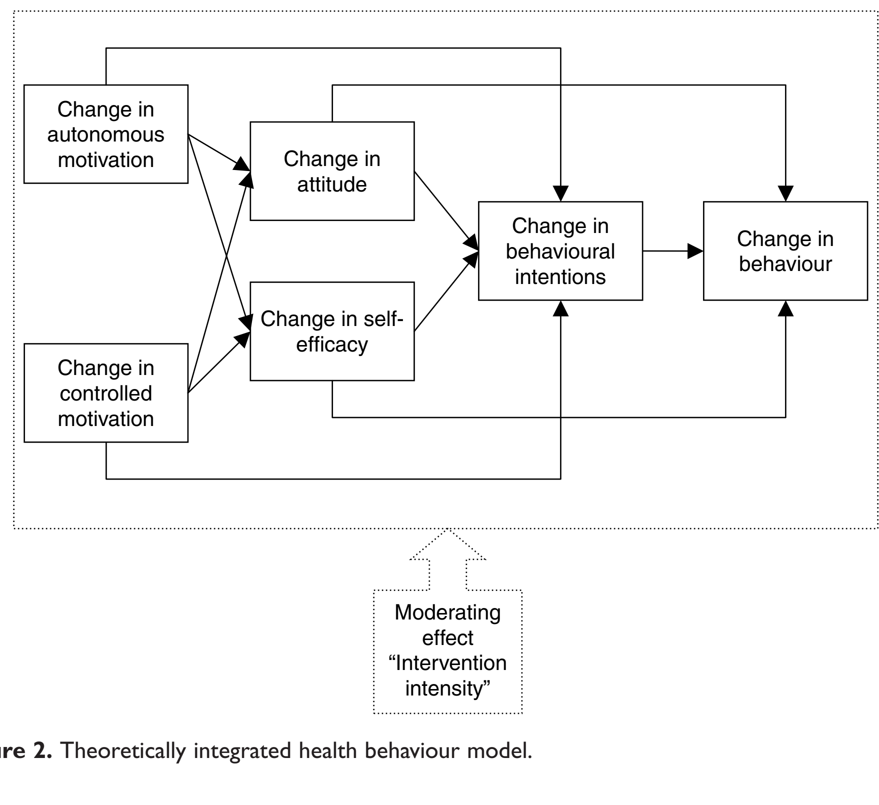

Figure 2. Theoretically integrated health behaviour model.

had a low risk to die of a cardiovascular event in the next 10 years. All participants were highly educated (Master degree). Participants engaged in an average of 237.31 min ($SD = 178.66$) of physical activity per month and their daily fat intake was 106.31 g ($SD = 38.46$) per day. These data suggest that participants in this sample were already quite active. With regard to fat intake, however, they had worse scores compared to the general population (Vandelanotte *et al.*, 2004).

Study design

E-mails requesting study participation were sent to clients ($N = 737$) of an insurer (De Onderlinge Ziekenkas). Three hundred and fourteen adults signed an informed consent form and were randomized to intervention conditions using a 1/3 (receiving 'usual care') versus 2/3 (receiving the intervention) ratio in order to study the dose–response effects of the intervention (Claes & Jacobs, 2007). The randomization was blind and performed by an independent person. The names of the participants were written on papers that were put in sealed envelopes. Next, the envelopes were randomly assigned by hand to baskets for the 'usual care' and intervention conditions.

A power calculation using Nquery Advisor 4.0 showed that 300 participants were required to detect a clinically significant difference of 12 g daily fat intake (common $SD = 34.50$ g) and a difference of 40 min of weekly physical activity (common $SD = 323.00$ min) between the 'usual care' and intervention conditions, with levels of statistical power of 80 and 86%, respectively (two-tailed; $p < .05$). The Hasselt University Ethics Committee approved this study and it was registered (ISRCTN23940498).

After blind randomization, 287 adults completed the baseline measures ($t = 0$) and were asked to complete the measures again at the end of the first intervention year ($t = 1$). To examine the intervention effect, however, it is insufficient to merely compare both study conditions because the participants in the intervention could freely determine their own intervention intensity. This freedom enabled participants who were allocated to the intervention condition to choose for an intervention intensity that was comparable to 'usual care'. A focus on the intervention intensity rather than on the original randomization to 'usual care' and intervention conditions is supported by previous results after 6 months of the intervention (Jacobs, Claes, Thijs, Dendale, & De Bourdeaudhuij, 2009). The latter manuscript dealt with the effects and the dose–response effects of the intervention. No behavioural differences were found between the original study conditions (usual care and intervention condition). The hypothesis was that this was due to people selecting an intervention intensity that was not of a sufficiently high intervention 'dose' to gain health benefits. This hypothesis was confirmed: a higher intervention dose led to better outcomes, independent of the baseline motivation. The present study includes a path analysis of the data after 1 year of intervention, again, taking into account the intervention intensity (or intervention dose).

Intervention

The intervention consisted of an educational website and one-on-one or group coaching sessions in addition to usual care (i.e., medical screening and follow-up). In the present study, we focus on the impact of the coaching aspect of the intervention. The coaching sessions consisted of several techniques to change the psychosocial determinants from TPB and SDT, physical activity and dietary behaviour. The participants were encouraged to increase their level of physical activity by conforming to one of the following recommendations: performing sports at least 3 days a week for 20 min or adopting moderately active pastimes for at least 6 days a week (Graham *et al.*, 2007; Haskell *et al.*, 2007). For dietary behaviour, participants were encouraged to consume less than 30% of their dietary energy from fat and eat at least four portions of fruit and vegetables per day (Vlaams Instituut voor Gezondheidspromotie en Ziektepreventie, Flemish Institute of Health Promotion and Disease Prevention [VIGeZ], 2007; Hoge Gezondheidsraad, Superior Health Council [HGR], 2006). The participants thus could choose to work on multiple behaviours simultaneously.

The intervention comprised behaviour change techniques adopted from a recent taxonomy (Abraham & Michie, 2008). The techniques used were: provide information on the behaviour–health link; provide information on the consequences of not changing; provide information on others' approval; prompt intention formation; prompt barrier identification; provide general encouragement; set graded tasks; provide instruction; model/demonstrate the behaviour; prompt specific goal setting; prompt review of behavioural goals; prompt self-monitoring of behaviour; provide feedback on performance; teach to use prompts/cues; prompt practice; use of follow-up prompts; provide opportunities for social comparison; plan social support; relapse prevention; and motivational interviewing.

An autonomy-supportive interpersonal style was used to change SDT constructs. This was done by providing positive feedback, providing a rationale, avoiding a controlling language, taking the perspective of the individual, acknowledging difficulties associated with changing health behaviours and enhancing a sense of choice (Chatzisarantis & Hagger, 2009; Deci, Eghrari, Patrick, & Leone, 1994). The sense of choice was enhanced by letting the participants in the study freely determine their own intervention intensity and delivery mode and the target behaviour they wanted to work on. Before the intervention (i.e., coaching) started, participants were telephoned by a health psychologist and asked which intervention style they preferred. Participants could determine the delivery mode and intervention intensity of the coaching. Several delivery modes were possible for the coaching: e-mail, regular mail, telephone, and face-to-face. The intervention components adopted to target the constructs from SDT are described in detail elsewhere (Jacobs & Claes, 2008). The coaching was conducted by a health psychologist with the assistance of undergraduate students and all activities were measured using an on-line registration system.

Measures

Motivation

Autonomous and controlled motivation in the physical activity and dietary behavioural contexts were measured using four items selected from the Behavioural Regulation Exercise Questionnaire II (Markland & Tobin, 2004; Mullan, Markland, and Ingledew, 1997) and the Treatment Self-Regulation Questionnaire (Williams, Gagne, Ryan, & Deci, 2002), respectively. The items for autonomous motivation were 'A reason to be physically active every day or to do sports 3 times per week is: (i) because it is fun, and (ii) because I find being physically active a pleasurable activity'. The items for controlled motivation for physical activity were 'A reason to be physically active every day or to do sports 3 times per week is: (i) because I feel ashamed when I miss a physical activity session, and (ii) because others will not be pleased with me if I don't'. Responses to these items were measured on five-point Likert scales (1 = *not true for me* and 5 = *very* *true for me*). The items for autonomous motivation for changing dietary behaviours were ‘A reason to eat a healthy (= low-fat) diet and 5 portions of fruit and vegetables every day (a portion = 80 grams) is: (i) because I have carefully thought about it and believe it is very important for many aspects in my life and (ii) because it is an important choice I really want to make’. The items for controlled motivation for changing dietary behaviours were ‘A reason to eat a healthy (= low-fat) diet and 5 portions of fruit and vegetables every day (a portion = 80 grams) is (i) because I feel pressure from others to do so and (ii) because I want others to approve of me’. Responses to these items were measured on seven-point Likert scales (1 = *strongly disagree* and 7 = *strongly agree*).

Attitudes

General-affective attitudes towards physical activity (two items) and dietary behaviours (two items) were assessed using bipolar adjectives on seven-point Likert scales. For physical activity, participants were asked whether being active everyday for 30 min or do sports three times per week is ‘bad–good’ and ‘stressing–relaxing’. For dietary behaviours, participants were asked whether eating a low-fat diet everyday is ‘not pleasant–pleasant’ and ‘stressing–relaxing’.

Self-efficacy

Self-efficacy was measured by two items for each behaviour on seven-point Likert scales ranging (1 = *strongly disagree* and 7 = *strongly agree*). For physical activity, the following two items were used: ‘I am sure that, when it’s up to me, I am capable to be physically active every day or to do sports 3 times per week, also on days when I’m very busy or family and friends ask time from me’ and ‘I have the feeling that being physically active every day for 30 minutes or doing sports 3 times per week is completely under my control in the coming month’. For dietary behaviours, the following two items were used: ‘I am sure that, when it’s up to me, I am capable to eat 5 portions (1 portion = 80 grams) of fruit and vegetables every day, also on days when I’m very busy or family and friends ask time from me’ and ‘I have the feeling that eating healthy is completely under my control in the coming month’.

Intention

Intentions were measured by one item for each behaviour on seven-point Likert scales (1 = *strongly disagree* and 7 = *strongly agree*): ‘I plan to be active every day or do sports 3 times per week in the coming month’ and ‘I plan to eat a healthy, low-fat diet and eat at least 5 daily portions of fruit and vegetables in the coming month’. The use of more than one item to measure a construct is desirable but this was unfeasible in the present study due to time constraints and questionnaire length (De Bourdeaudhuij *et al.*, 2005).

Behaviour

Physical activity was measured in minutes per week with the International Physical Activity Questionnaire (long version-usual week) which has been found to be a reliable and valid physical activity assessment tool for the general Belgian adult population (Vandelanotte, De Bourdeaudhuij, Philippaerts, Sjöström, & Sallis, 2005; Vandelanotte, De Bourdeaudhuij, Sallis, Spittaels, & Brug, 2005). To correct for over reporting, the household activities (in and outside the house) were left out of the analyses and the scores were multiplied by 0.80 (Rzewnicki, Vanden Auweele, & De Bourdeaudhuij, 2003). Fat intake was measured in grams per day with a computerized fat intake questionnaire with a good reliability and adequate validity (Vandelanotte, Matthys, & De Bourdeaudhuij, 2004).

Intervention intensity
The intervention intensity measure consisted of a registration of the delivery mode, the target behaviour, and the frequency of coaching sessions. The intervention intensity was operationalized as the total frequency of the coaching sessions to promote physical activity or dietary behaviour, respectively. The total frequency was accurately measured using an on-line registration system to gather data for a cost-utility study (Jacobs, Evers, Ament, & Claes, 2010).

Statistical analyses
Preliminary analyses consisted of descriptive statistics, correlation analyses, and an assessment of the psychometric properties of the measures. Residualized change scores have been proposed as a solution to the problem of autocorrelation (regression to the mean) when one wants to measure change (Cronbach & Furby, 1970; Streiner & Norman, 2003, p. 202). Hence, residualized change scores were created by regressing the post-test measures onto the baseline measures and subtracting the predicted value from the post-test value. Next, we standardized the residualized change scores. Standardized residualized change scores were calculated for all the independent and dependent variables in the theoretically integrated model. The standardized residualized change scores for behaviour were then compared for the participants of the original intervention conditions ('usual care' vs. intervention).

The aim of the analyses was to assess the hypothesized relations within the theoretically integrated model depicted in Figure 2. The theoretically integrated health behaviour model should be rejected if the major hypotheses of the model are non-significant. Furthermore, the confirmation of the main effects (e.g., autonomous motivation on TPB constructs, TPB constructs on intention, intention on behaviour) are considered to be more important than the confirmation of the moderation effects because the latter effects were added to the model for the purpose of this specific study including an intervention with a variable, self-selected intensity.

To test these hypotheses, we used partial least squares (PLS) path modelling. PLS path modelling is a variance-based structural equation modelling (SEM) technique that does not rely on distributional assumptions. There are a number of reasons why PLS path modelling was chosen. First, our data exhibited significant deviations from normality (see below and descriptive statistics). Second, the analysis of continuous moderator variables is extremely problematic using covariance-based SEM (e.g., Cortina, 1993; Li *et al.*, 1998). All analyses were conducted with SmartPLS. Based on the empirical work of Andrews and Buchinsky (2002) and MacKinnon, Lockwood, and Williams (2004), the significance of the parameter estimates is assessed by constructing 95% bias-corrected percentile confidence intervals based on a bootstrap procedure with 7,000 replications.

To model the hypothesized moderator effects, we used the PLS approach suggested by Goodhue, Lewis, and Thompson (2007). According to this approach, the moderator effect is modelled as a latent variable with a single indicator that is the product of the summed indicators of the constructs underlying the hypothesized moderator effect. Goodness-of-fit measures evaluate the performance of the entire model with all dependent relationships considered simultaneously. Significance level was set at $\alpha = .05$.

Results

Preliminary analysis

Tables 1 and 2 depict the descriptive statistics and correlation matrices for the relevant variables for physical activity and dietary behaviour, respectively. In both tables, the lower triangle of the correlation matrix contains the coefficients between the variables measured at $t = 0$ and the upper triangle contains the coefficients between the variables measured at $t = 1$. There were no differences between the original study conditions for standardized residualized changes in physical activity ($t = -0.024$; $df = 234$; $p = .98$) or fat intake ($t = 1.17$; $df = 234$; $p = .24$). The mean total frequency of coaching sessions to promote physical activity was 15.52 ($SD = 10.75$) and the mean total frequency of coaching sessions to promote dietary behaviours was 13.71 ($SD = 9.03$).

Running the measurement models with all the available items for each construct revealed inconsistent results for the multiple-item controlled motivation factor. Consequently, in the remainder of this study, the controlled motivation construct was modelled as a single-item variable. The estimation results concerning physical activity and dietary behaviour for both measurement periods are presented in Table 3. The relative goodness-of-fit statistic was .93 for physical activity .94 for dietary behaviours. A relative goodness-of-fit statistic of .90 or higher is indicative of good model performance (Trinchera & Esposito, 2008).

Main analysis

Table 4 provides an overview of the estimates for the different model parameters for the PLS models in both behavioural contexts.

Physical activity

For the physical activity context, changes in autonomous motivation significantly and negatively predicted changes in attitudes towards physical activity ($\beta = -0.38, p < .05$) and changes in controlled motivation positively predicted changes in attitudes towards physical activity ($\beta = 0.23, p < .05$). Concerning an individual's changes in self-efficacy to be physically active results revealed that variance in this construct was significantly explained by changes in autonomous motivation alone ($\beta = 0.30, p > .05$). Changes in autonomous motivation and self-efficacy significantly and positively predicted changes in intentions towards physical activity ($\beta = 0.17$, $p < .05$; $\beta = 0.44$, $p < .05$). Furthermore, the impact of changes in self-efficacy on changes in behavioural intentions was significantly moderated by intervention intensity ($\beta = 0.37$, $p < .05$). More specifically, a higher intervention intensity resulted in a higher positive influence of changes in self-efficacy on changes in behavioural intentions. Finally, changes in behavioural intentions towards physical activity significantly predicted increases in physical activity ($\beta = 0.24$, $p < .05$). The intervention intensity significantly and negatively moderated the relationship between changes in attitudes towards physical

Table 1. Descriptive statistics and correlations for dietary behaviour

	M $t=0$	*SD* $t=0$	SK $t=0$	KU $t=0$	*M* $t=1$	SD $t=1$	SK $t=1$	KU $t=1$	1	2	3	4	5	6	7	8	9	10
AM (item 1)	5.25	1.36	−0.61**	−0.24	4.95	1.49	−0.41**	−0.53	1.00*	.69**	.06	.11	.35**	.32**	.18**	.31**	.35**	−.19**
AM (item 2)	5.21	1.40	−0.53**	−0.17	4.80	1.48	−0.38**	−0.42	.70**	1.00*	.16**	.18**	.41**	.41**	.34**	.45**	.37**	−.16**
CM (item 1)	2.86	1.63	0.44**	−0.89**	2.56	1.58	0.86**	−0.17	.06	.06	1.00*	.58**	.07	.01	.08	.06	.12	.11
CM (item 2)	2.44	1.45	0.74**	−0.33	2.32	1.52	1.01**	0.47	.12	.10	.56**	1.00*	.02	.02	.09	.13	.14	.10
Attitude (item 1)	3.95	1.56	0.04	−0.50	3.78	1.79	0.05	−0.81**	.29**	.39**	−.01	−.04	1.00*	.78**	.33**	.46**	.31**	−.36**
Attitude (item 2)	4.14	1.32	0.07	0.20	4.00	1.49	0.05	−0.03	.32**	.40**	−.03	.00	.75**	1.00*	.30**	.45**	.24**	−.22**
SE (item 1)	4.67	1.78	−0.42**	−0.94**	4.61	1.82	−0.42**	−0.83**	.28**	.44**	.06	.11	.29**	.27**	1.00*	.68**	.64**	−.09
SE (item 2)	4.80	1.43	−0.43**	−0.52	4.67	1.39	−0.31**	−0.27	.27**	.42**	−.08	−.02	.34**	.40**	.59**	1.00*	.48**	−.15**
Intention	5.30	1.47	−0.82**	0.31	4.99	1.8	−0.50**	−0.61**	.39**	.52**	−.02	.04	.32**	.32**	.56**	.44**	1.00*	−.07
FI (g/day)	107	39	0.95**	1.19**	102	42	2.04**	9.41**	−.12	−.15	.21**	.17**	−.20**	−.15**	−.07	−.09	−.12	1.00*

Note. *M*, mean; *SD*, standard deviation; SK, skewness; KU, kurtosis; AM, autonomous motivation; CM, controlled motivation; SE, self-efficacy; FI, fat intake; $^{*}p < .05$; $^{**}p < .05$.

Table 2. Descriptive statistics and correlations for physical activity

	M $t = 0$	*SD* $t = 0$	SK $t = 0$	KU $t = 0$	*M* $t = 1$	*SD* $t = 1$	SK $t = 1$	KU $t = 1$	1	2	3	4	5	6	7	8	9	10
AM (item 1)	3.82	1.01	−0.96**	0.39	2.98	0.77	−0.26	−0.62**	1.00*	.80**	.08	−.04	.31**	.55**	.41**	.51**	.49**	.33**
AM (item 2)	3.84	0.94	−0.96**	0.64**	2.98	0.76	−0.26	−0.49	.81**	1.00*	.08	.05	.36**	.64**	.37**	.48**	.56**	.30**
CM (item 1)	1.78	0.93	1.24**	1.20**	1.58	0.70	1.18**	1.41**	.06	.05	1.00*	.58**	−.08	−.05	.08	.09	.13**	.03
CM (item 2)	1.69	0.88	1.23**	1.12**	1.46	0.62	1.35**	2.21**	−.08	−.07	.56**	1.00*	−.17**	−.16**	.01	.02	−.01	−.05
Attitude (item 1)	6.36	0.87	−1.32**	1.13**	6.24	1.04	−1.95**	5.42**	.40**	.37**	.01	−.09	1.00*	.69**	.22**	.25**	.24**	.16**
Attitude (item 2)	5.94	1.17	−1.05**	0.60	5.82	1.36	−1.26**	1.48**	.66**	.65**	.06	−.05	.59**	1.00*	.40**	.48**	.40**	.25**
SE (item 1)	4.52	1.72	−0.27	−1.07**	4.56	1.81	−0.36**	−0.97**	.40**	.40**	−.04	−.08	.23**	.40**	1.00*	.77**	.57**	.23**
SE (item 2)	4.69	1.78	−0.32**	−1.06**	4.47	1.84	−0.27	−1.08**	.36**	.37**	.00	−.07	.35**	.43**	.76**	1.00*	.57**	.25**
Intention	5.29	1.42	−0.49**	−0.61	5.11	1.69	−0.53**	−0.85**	.46**	.44**	−.03	−.12	.34**	.43**	.62**	.67**	1.00*	.30**
PA (min/week)	242	175	0.92**	0.72**	302	235	2.92**	17.06**	.33**	.36**	.10	.01	.23**	.32**	.28**	.32**	.28**	1.00*

Note. M, mean; *SD*, standard deviation; SK, skewness; KU, kurtosis; AM, autonomous motivation; CM, controlled motivation; SE, self-efficacy; PA, physical activity;
$^{*}p < .05$; $^{**}p < .05$.

Table 3. Psychometric properties

Behaviour	Construct	Construct level statistics $t = 0$	Construct level statistics $t = 1$	Items	CI $t = 0$*	CI $t = 1$*
Dietary behaviour	Autonomous motivation	$\lambda_1 = 1.70$; $\lambda_2 = 0.30$	$\lambda_1 = 1.69$; $\lambda_2 = 0.31$	1	[0.83, 0.83]	[0.85, 0.93]
		$\rho = .92$	$\rho = .91$	2	[0.93, 0.96]	[0.91, 0.95]
		AVE = 0.85	AVE = 0.84			
Dietary behaviour	Attitude	$\lambda_1 = 1.75$; $\lambda_2 = 0.25$	$\lambda_1 = 1.78$; $\lambda_2 = 0.22$	1	[0.90, 0.95]	[0.93, 0.96]
		$\rho = .93$	$\rho = .91$	2	[0.91, 0.96]	[0.91, 0.96]
		AVE = 0.88	AVE = 0.84			
Dietary behaviour	Self-efficacy	$\lambda_1 = 1.59$; $\lambda_2 = 0.41$	$\lambda_1 = 1.68$; $\lambda_2 = 0.32$	1	[0.87, 0.93]	[0.90, 0.94]
		$\rho = .88$	$\rho = .91$	2	[0.80, 0.92]	[0.87, 0.94]
		AVE = 0.79	AVE = 0.84			
Physical activity	Autonomous motivation	$\lambda_1 = 1.81$; $\lambda_2 = 0.20$	$\lambda_1 = 1.80$; $\lambda_2 = 0.20$	1	[0.93, 0.97]	[0.92, 0.96]
		$\rho = .95$	$\rho = .95$	2	[0.92, 0.97]	[0.92, 0.97]
		AVE = 0.90	AVE = 0.90			
Physical activity	Attitude	$\lambda_1 = 1.59$; $\lambda_2 = 0.42$	$\lambda_1 = 1.77$; $\lambda_2 = 0.23$	1	[0.73, 0.90]	[0.78, 0.92]
		$\rho = .88$	$\rho = .91$	2	[0.91, 0.95]	[0.94, 0.97]
		AVE = 0.79	AVE = 0.83			
Physical activity	Self-efficacy	$\lambda_1 = 1.76$; $\lambda_2 = 0.24$	$\lambda_1 = 1.69$; $\lambda_2 = 0.32$	1	[0.91, 0.96]	[0.91, 0.96]
		$\rho = .94$	$\rho = .94$	2	[0.92, 0.96]	[0.92, 0.96]
		AVE = 0.88	AVE = 0.89			

Note. λ_i, *i*th eigenvalue of the item correlation matrix; ρ, composite reliability; AVE, average variance extracted; CI, confidence interval.

Table 4. Structural model parameter estimates

Dependent variable	Independent variables	Dietary behaviour: Mean estimate	Dietary behaviour: Bootstrap *t* value	Dietary behaviour: Bootstrap *p* value	Dietary behaviour: CI	Physical activity: Mean estimate	Physical activity: Bootstrap *t* value	Physical activity: Bootstrap *p* value	Physical activity: CI
Attitude	Autonomous motivation	−0.20	**−2.45**	.02	[−0.34, −0.03]	−0.38	**−4.47**	.00	[−0.53, −0.21]
	Controlled motivation	−0.03	−0.29	.77	[−0.19, 0.19]	0.23	**2.30**	.02	[0.05, 0.43]
	Intervention intensity	0.02	0.33	.74	[−0.12, 0.15]	−0.06	−0.50	.62	[−0.17, 0.05]
	Autonomous motivation × intervention intensity	−0.10	−1.31	.19	[−0.23, 0.05]	0.14	2.00	.05	[0.01, 0.28]
	Controlled motivation × intervention intensity	−0.02	−0.36	.76	[−0.15, 0.11]	−0.18	2.01	.05	[0.01, 0.34]
Self-efficacy	Autonomous motivation	0.32	**4.91**	.00	[0.18, 0.44]	0.30	**5.00**	.00	[0.17, 0.41]
	Controlled motivation	0.04	0.52	.60	[−0.13, 0.17]	0.02	0.25	.80	[−0.12, 0.16]
	Intervention intensity	0.14	**2.34**	.02	[0.02, 0.26]	0.07	1.21	.23	[−0.05, 0.19]
	Autonomous motivation × intervention intensity	−0.05	−0.82	.41	[−0.18, 0.08]	0.02	0.32	.75	[−0.10, 0.12]
	Controlled motivation × intervention intensity	−0.05	−0.69	.49	[−0.20, 0.10]	0.03	0.39	.70	[−0.11, 0.16]
Behavioural intentions	Autonomous motivation	0.15	**2.25**	.03	[0.02, 0.28]	0.17	**2.64**	.01	[0.05, 0.30]
	Controlled motivation	0.04	0.75	.45	[−0.07, 0.14]	−0.01	−0.17	.87	[−0.13, 0.11]
	Attitude	−0.09	−1.48	.14	[−0.03, 0.22]	−0.06	−0.87	.39	[−0.21, 0.06]
	Self-efficacy	0.48	**7.82**	.00	[0.36, 0.60]	0.44	**6.57**	.00	[0.30, 0.56]
	Intervention intensity	0.07	1.02	.31	[−0.06, 0.20]	0.00	0.02	.98	[−0.11, 0.11]
	Autonomous motivation × intervention intensity	−0.06	−0.93	.35	[−0.20, 0.07]	−0.07	−1.23	.22	[−0.18, 0.04]
	Controlled motivation × intervention intensity	−0.01	−0.21	.83	[−0.10, 0.08]	−0.02	−0.30	.76	[−0.14, 0.10]
	Attitude × intervention intensity	−0.07	−0.96	.34	[−0.21, 0.07]	0.12	1.68	.09	[−0.01, 0.27]

Table 4. (*Continued*)

		Dietary behaviour				Physical activity			
Dependent variable	Independent variables	Mean estimate	Bootstrap *t* value	Bootstrap *p* value	CI	Mean estimate	Bootstrap *t* value	Bootstrap *p* value	CI
	Self-efficacy × intervention intensity	−0.08	−1.35	.18	[−0.20, 0.04]	0.21	**2.72**	.01	[0.05, 0.35]
Behaviour	Attitude	0.12	1.96	.05	[0.01, 0.24]	−0.08	−1.46	.15	[−0.18, 0.03]
	Self-efficacy	−0.08	−1.18	.24	[−0.22, 0.05]	0.01	0.05	.96	[−0.18, 0.21]
	Behavioural intentions	0.00	0.01	.99	[−0.13, 0.15]	0.24	**3.50**	.00	[0.09, 0.37]
	Intervention intensity	−0.14	**−2.22**	.03	[−0.26, −0.01]	0.04	0.47	.64	[−0.13, 0.19]
	Attitude × intervention intensity	0.01	0.07	.94	[−0.15, 0.16]	−0.20	**−2.43**	.02	[−0.35, −0.03]
	Self-efficacy × intervention intensity	−0.02	−0.30	.76	[−0.14, 0.11]	−0.14	−1.40	.16	[−0.32, 0.08]
	Behavioural intentions × intervention intensity	−0.10	−1.28	.20	[−0.26, 0.04]	0.07	0.71	.48	[−0.13, 0.24]

Note. Statistics in bold font are significant at $p < .05$; CI, confidence interval.

activity and physical activity behaviour ($\beta = -0.20$, $p < .05$). For physical activity, the hypothesized relationships explained 22% of the variance in attitudes, 10% of the variance in self-efficacy, 30% of the variance in behavioural intentions, and 9% of the variance in changes in physical activity.

Dietary behaviour

For the dietary behaviour context, changes in attitudes towards changing dietary behaviours were significantly and negatively predicted by changes in autonomous motivation ($\beta = -0.20$, $p < .05$). Changes in self-efficacy regarding dietary behaviours were significantly and positively related to changes in autonomous motivation ($\beta = 0.32$, $p < .05$) and intervention intensity ($\beta = 0.14$, $p < .05$). Changes in behavioural intentions towards changing dietary behaviours were significantly and positively predicted by changes in autonomous motivation ($\beta = 0.15$, $p < .05$) and self-efficacy ($\beta = 0.48$, $p < .05$). Finally, desired changes in fat intake (negative sign = reduction of fat intake) were significantly and negatively predicted by the intervention intensity alone ($\beta = -0.14$, $p < .05$). Regarding dietary behaviour the hypothesized relationships explained 13% of the variance in self-efficacy, 32% of the variance in behavioural intentions, and 6% of the changes in fat intake.

Discussion

The purpose of the present study was to test relations within a theoretically integrated health behaviour model of TPB and SDT and to compare the results in two health behaviour contexts related to 'energy balance': physical activity and dietary behaviours. Another aim of the study was to test whether the relations varied due to the intervention intensity. Findings from well-fitting PLS path-analytic models indicated that there were some clear congruences in the variables that predicted changes in the antecedents of both health-related behaviours, namely, the effect of autonomous motivation on attitudes, self-efficacy, and intentions, in both behavioural contexts. Specifically, autonomous motivation was a significant predictor of changes in attitude, self-efficacy, and intentions in both contexts. Self-efficacy was also a significant predictor of changes in intentions in both samples. However, when it came to the prediction of behaviour, there were marked differences in the direct predictors. In the dietary behaviour context, intervention intensity was a significant predictor of behaviour, while changes in behavioural intentions was a significant predictor of behaviour in the physical activity context. There were also some important moderation effects. Findings indicated that the effect of self-efficacy on intentions, and the effect of attitude on behaviour were moderated by intervention intensity in the physical activity behaviour context. There were no interaction effects in the dietary behaviour context. Instead, intervention intensity had a direct effect on changes in fat intake suggesting that more frequent interventions were effective in changing fat intake.

It is important to note that there were a number of consistent patterns of effects that were in accordance with the expected patterns from integrated models adopting the TPB and SDT. Specifically, it seems that, for both behavioural contexts, increases in autonomous forms of motivation led to changes in attitudes and self-efficacy. This is consistent with previous research that has shown significant relations between the immediate antecedents of behavioural intentions from TPB, namely attitudes and PBC, and autonomous forms of motivation from SDT (Hagger & Chatzisarantis, 2009). Such research indicates that people are likely to form future beliefs about outcomes and control over health-related behaviours if their motives are self-determined. A likely mechanism for this is that people with autonomous motives are more likely to pursue personally relevant outcomes and feel competent in pursuing those outcomes. Such outcomes and perceptions of competence are motivationally adaptive, which means it is unsurprising that these variables are likely to be related to intentions to act in the future. An important contribution of the present study is that these patterns of effects are corroborated in terms of change scores, which means that these effects are apparent when controlling for previous perceptions and enables us to better infer causal links between the component theory constructs.

Another set of relations that were consistent across the behavioural contexts in the present study and were consistent with previous research was the effect of changes in self-efficacy and autonomous motivation on changes in intentions. These relations indicate that it is self-efficacy (PBC) from the TPB and autonomous motivation from SDT that are most effective in predicting changes in intentions across the course of the intervention. The effect of increases in self-efficacy on intention change is consistent with previous studies that have shown PBC to have a strong, significant, and consistent effect on intentions in health behaviour (Armitage & Conner, 2001; Hagger *et al.*, 2002). The direct effect of autonomous motive change on increases in intentions has been found in some studies (e.g., Chatzisarantis *et al.*, 2002; Hagger & Chatzisarantis, 2005, 2009). A recent meta-analysis of this integrated model, however, has demonstrated that the direct effects of autonomous motivation on intentions independent of attitudes and PBC are relatively unsubstantial (Hagger & Chatzisarantis, 2009). This means that the direct effect in the present study is contrary to trends in previous research. It must be noted that regardless of whether autonomous motives predict intentions directly or indirectly via attitudes and PBC, these motives are directly implicated in the formation of intentions. This is unsurprising, as research has demonstrated this link consistently (Sarrazin, Vallerand, Guillet, Pelletier, & Cury, 2002) and it represents that motives reflecting the pursuit of behaviours that are personally valued, are consistent with a person's sense of self, and satisfy psychological needs are likely to lead to the formation of intentions to pursue that behaviour again in the future.

There were relations in the present models that were specific to each behavioural context. Many of these differences related to the moderation of the effects in the model by intervention intensity. Specifically, there was an interaction between self-efficacy and intervention intensity on intention for the physical activity behavioural context only. This indicated that more frequent interventions increased the positive effect of self-efficacy on intentions. This demonstrates the value of engaging participants in more intensive forms of the intervention to maximize effects of motivationally relevant outcomes. In addition, controlled motivation predicted attitudes in the physical activity context only.

There were also incongruent patterns of effects of the proximal antecedents of behaviour change on actual dietary and physical activity behaviour change. For the dietary behaviour context, the link between changes in intentions and changes in fat intake was not confirmed. Many authors have identified an 'intention–behaviour gap' in cross-sectional and prospective studies adopting the TPB (Sheeran, 2002). However, the link between intentions and behaviour is seldom zero, and in most studies a significant intention–behaviour link has been documented (Chatzisarantis & Hagger, 2009; Hagger & Chatzisarantis, 2009; Hagger *et al.*, 2006b; Webb & Sheeran, 2006) and has been corroborated by meta-analyses (Armitage & Conner, 2001; Hagger *et al.*, 2002). The problem with the intention–behaviour relationship usually lies in the scale inconsistency. This is likely to result in a modest effect size and a relatively large proportion of the variance in behaviour left unexplained by intentions. The lack of a significant relationship for fat intake in the present study may have been due to a lack of correspondence between the measures. In the present study, participants reported their intentions to change their diet through the adoption of a healthy low-fat diet including five portions of fruits or vegetables per day. Although an explicit reference to fat intake was made, participants also considered the adoption of an alternative behaviour, namely their fruit and vegetable intake. This might have caused the lack of prediction of fat intake by intention due to a lack of scale correspondence.

There was, however, a significant intention–behaviour relationship in the physical activity context. Given the lack of conclusive evidence that intra-individual changes in intention are predictive of behavioural changes the latter finding is very important (Scholz, Nagy, Göhner, Luszczynska, & Kliegel, 2009). Our findings also corroborate previous findings that the intention–behaviour link is usually weaker for dietary behaviour than for physical activity (Hagger *et al.*, 2006b). However, it is important to note the caveat regarding the intention and behaviour measurement correspondence which was far greater in the physical activity measures than in the dietary measures (Hagger *et al.*, 2006b).

Intervention intensity had no moderating effect on the intention–behaviour relation in the present study. Maybe the present intervention would have benefited from techniques designed to convert intentions into behaviour such as implementation intentions and action planning to achieve a moderation effect (Chatzisarantis, Hagger, & Thøgersen-Ntoumani, 2008; Scholz, Schuz, Ziegelmann, Lippke, & Schwarzer, 2008; Sniehotta, 2009; Webb & Sheeran, 2007; Wiedemann, Schüz, Sniehotta, Scholz, & Schwarzer, 2009). However, there is evidence that questions the effectiveness of implementation intentions as moderators of the intention–behaviour relationship (De Vet, Oenema, Sheeran, & Brug, 2009). Perhaps, the moderation effect of the intervention on some relations within the model was thwarted by the large number of choice options. SDT recommendations include advice to enhance a feeling of choice. However, letting participants determine their own intervention intensity and delivery mode might undermine the effectiveness of the intervention because participants can opt to be unexposed to the intervention materials and therefore the options would have not been met with sufficient information. Ryan and Deci (2006) stated that 'one can have many options and not feel autonomy, but instead feel overwhelmed and resentful at the effort entailed in the decision making' (p. 1577). The number of options is not, in itself, enough to stimulate a feeling of autonomy, they need to be meaningful and informed (Ryan & Deci, 2006). The comparison of the original study conditions pointed out that there was no intervention effect when the actual exposure to the intervention (intervention intensity) was not considered. Exposure to the intervention had a direct effect on dietary behaviour by decreasing the fat intake. The actual intervention intensity that the participants received plays a fundamental role in interpreting the effects of the present intervention.

Overall, the original contribution of this study is threefold. First, it corroborates prior research that showed TPB and SDT to be complementary (Hagger *et al.*, 2006b). The important relationships between TPB and SDT constructs were supported (e.g., between autonomous motivation and self-efficacy for dietary behaviour). Second, the most important contribution of this study is the fact that it is the first of its kind to include a measure of intervention exposure. Intervention intensity (frequency) was included as a moderator in the theoretically integrated model but influenced different paths in different behavioural contexts. This is important as it indicates that the intervention can be effective in influencing components from both theories. Not only the 'offered' intervention but the 'used' intervention should be included in future modelling of intervention effects as it is the way interventions are interpreted and utilized 'on the ground' rather than in 'theory' that is important (Michie *et al.*, 2008). The findings of the present study support this point of view. Third, the present study is the first to adopt the theoretically integrated model to evaluate actual behaviour change in the context of dietary behaviour using an experimental design with a long-range evaluation. The study is therefore consistent with calls to adopt experimental and intervention designs to test the model and in behavioural contexts other than physical activity such as dietary behaviour (e.g., Edmunds *et al.*, 2006; Hagger & Chatzisarantis, 2009).

Of course, it would be remiss for us not to identify the limitations of the present study and recommendations for future research. Our data are limited because the intervention was conducted on a sample of highly educated adults who were motivated to change their behaviour. The results might not, therefore, be generalizable to the population. Our model may also omit a number of potentially valuable constructs (e.g., perceived autonomy support and psychological need satisfaction). Measures for these constructs could have given more insight into the experience of the participants with the many choice options available and the extent to which this might have stimulated or thwarted feelings of autonomy or competence. Other interventions made use of manipulation checks or included measures to gain more information on SDT-related constructs that might have been influenced by an intervention (Chatzisarantis & Hagger, 2009; Edmunds *et al.*, 2006). Despite these limitations, present results support the important relations embedded in a theoretically integrated model of TPB and SDT. The theoretically integrated model is useful as it provides a rationale behind the origins of the social cognitive variables of intention, attitude, and self-efficacy within the TPB. The present study showed that this, however, may depend on the type of behaviour and the level of intervention. Future research should focus on the following issues arising from the current study: increasing the number of options and the actual intervention intensity given to participants. The intervention intensity was found to be a moderator of important relations within the theoretically integrated model for physical activity and a direct predictor of a decrease in fat intake. In terms of practical recommendations arising from this research, health promotion interventions should be aimed at increasing autonomous motivation to influence the distal and proximal determinants of behaviour. In doing so, they can follow the SDT recommendation of enhancing choice. The health care professional should explain the options available, guide the decision-making process but not leave the participant alone risking him or her to get overwhelmed by the options available.

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