Title: Interaction effects in the theory of planned behaviour: predicting fruit and vegetable consumption in three prospective cohorts

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Abstract

Objective

The theory of planned behaviour has been criticised for not including interactions between major constructs thought to underlie behaviour. This study investigated the application of the theory of planned behaviour to the prediction of fruit and vegetable consumption across three prospective cohorts. The primary aim of the study was to investigate whether interactions between major constructs in the theory would increase the ability of the model to predict intention to consume fruit and vegetables (i.e., attitude x perceived behavioural control, subjective norm x perceived behavioural control, subjective norm x attitude) and self-reported fruit and vegetable intake (i.e., perceived behavioural control x intention).

Design

Secondary data analysis from three cohorts; one predictive study (cohort 1) and two intervention studies (cohorts 2 and 3).

Method

Participants completed a theory of planned behaviour measure at baseline and a measure of fruit and vegetable intake at 1 week (cohort 1; n=90) or 1 month (cohorts 2 and 3; n=296).

Results

Attitude moderated the impact of perceived behavioural control on intention. Perceived behavioural control moderated the impact of intention on behaviour at 1 week but not 1 month.

Conclusion

The variance accounted for by the interactions was small. However, the presence of interactions between constructs within the theory of planned behaviour demonstrates a need to consider interactions between variables within the theory of planned behaviour in both theoretical and applied research using the model.

Introduction

Inadequate consumption of fruit and vegetables has been linked to increased incidence of cancer, stroke, heart attack and obesity (Dauchet, Amouyel, & Dallongeville, 2009; Dauchet, Amouyel, Hercberg, & Dallongeville, 2006; FAO/WHO, 2003; He, Nowson, & MacGregor, 2006). In light of this the World Health Organisation recommends that adults consume at least 400g of fruit and vegetables in order to maintain optimal health (FAO/WHO, 2003). In Australia, dietary guidelines recommend that adults consume at least two servings of fruit (150g) and five servings of vegetables (75g) each day (National Health and Medical Research Council, 2003). However, despite widespread efforts to increase consumption, most adults do not consume recommended quantities of fruit and vegetables (Australian Bureau of Statistics, 2003, 2009; World Health Organisation, 2004).

The Theory of Planned Behaviour (TPB; Ajzen, 1991; Fishbein & Ajzen, 2010) has been employed as a theoretical basis for identifying cognitions related to fruit and vegetable consumption across a number of contexts (Allom & Mullan, 2011; Guillaumie, Godin, & Vézina-Im, 2010; Kothe, Mullan, & Butow, 2012). These studies indicate that the TPB accounts for 11-45% of variance in fruit and vegetable intake. More broadly, the TPB has been shown to account for an average of 19% of the variance in health behaviour (McEachan, Conner, Taylor, & Lawton, 2011). According to this framework, the most proximal antecedent of behaviour is behavioural intention. This in turn is predicted by three constructs: attitude, subjective norm and perceived behavioural control (PBC). These three components are defined respectively as, the evaluation of the outcomes of the behaviour, the perceived social pressure to engage in the behaviour, and the perceived difficulty of engaging in the behaviour (Fishbein & Ajzen, 2010). According to the model, individuals will intend to consume fruit and vegetables to the extent that they believe the likely outcomes of consumption to be favourable, perceive social pressure from people who are important to them, and feel capable of consuming fruit and vegetables without difficulty.

The TPB is typically formulated as a simple additive model (see Figure 1), where attitude, subjective norm and PBC are all thought to influence behaviour through their effect on behavioural intention. PBC is often also theorised to have a direct effect on behaviour, over and above its influence on intention. According to this formulation of the model, the relationships between constructs are all assumed to be linear (Fishbein & Ajzen, 2010). However critics of the TPB argue that this formulation of the model is problematic (Eagly & Chaiken, 1993).

[Figure 1 about here]

Specifically, it has been argued that the hypothesised relationship between PBC and intention implies that individuals are likely to form an intention to perform a behaviour simply because the behaviour is under their control (Eagly & Chaiken, 1993). In light of this criticism some researchers have argued that PBC may influence intention only above a certain threshold (e.g. Conner & McMillan, 1999; Eagly & Chaiken, 1993), such that the influence of PBC on intention may only be only relevant where individuals hold positive attitudes and supportive subjective norms towards the behaviour. This would imply an interaction between PBC and other components of the model, where PBC is a moderator of subjective norm and/or attitude.

These interactions have rarely been considered in empirical studies (Conner & McMillan, 1999; Umeh & Patel, 2004). Consistent with theoretical arguments, studies which have investigated interactions within the theory in the context of socially undesirable behaviours (i.e. drug use) have found that attitude moderates the relationship between PBC and intention. These studies suggest that the relationship between PBC and intention is only significant among individuals with positive attitudes towards drug use (Conner & McMillan, 1999; Umeh & Patel, 2004). An interaction between normative beliefs and attitude has also been reported in the context of cannabis use (Conner & McMillan, 1999). To date, no study has

investigated interactions between these constructs in the context of a socially desirable behaviour.

The relationship between PBC and behaviour is also a conceptual issue for the theory. According to the linear formulation of the theory of planned behaviour, PBC has a direct influence on behaviour. Such a relationship has been criticised because it would imply that an individual would engage in behaviours that they do not wish to perform simply because they believed that behaviour to be simple or easy to perform. As Conner and McMillan (1999) have argued, this would indicate a boundary condition for the prediction of behaviour, where PBC can only predict behaviour when intention is sufficiently high.

Armitage and Conner (2001) investigated the predictive utility of the PBC x intention interaction term as part of their meta-analytic review of studies using the TPB. They reported that nine of nineteen studies which investigated the interaction term found support for an interaction between the two constructs. However, they noted that this interaction term was not routinely reported in applications of the model – making it difficult to draw conclusions about the true extent of interactions between PBC and intention (Armitage & Conner, 2001).

The majority of studies using the TPB have used the strictly linear formulation of the model reflected in Figure 1. Of the relatively small number of studies that have explored interactions within the model, none have been conducted in the context of nutrition behaviours (Armitage & Conner, 2001; Conner & McMillan, 1999; Umeh & Patel, 2004). Given that the relative influence of model components is known to be behaviour specific, it cannot be assumed that findings from other areas can be directly applied to fruit and vegetable intake.

Aims and hypotheses

The aim of the current study was to extend past research by assessing possible interactions between attitude, subjective norm, and PBC in predicting fruit and vegetable consumption. In

line with previous research in this area it was expected that the TPB would provide a good model of fruit and vegetable intentions and intake in the sample. It was also expected that interactions between TPB constructs would account for a significant proportion of variance over and above their independent effects.

In seeking to address low fruit and vegetable consumption, it is important to develop a detailed understanding of the factors that underpin low consumption in different segments of the community. Data suggest that young adults have the lowest rates of consumption of any age group (Australian Bureau of Statistics, 2009; Joint Health Surveys Unit, 2008; World Health Organisation, 2004), suggesting the value of greater understanding of the determinants of fruit and vegetable consumption in this population. As such, the current study sought to investigate these interaction effects in within this age group.

Method

Ethics Statement

All studies were approved by the University Human Research Ethics Committee.

Participants and Procedure

The data set from this study was drawn from three studies applying the TPB to the prediction of fruit and vegetable consumption (Kothe, 2012). In all studies, data were collected from undergraduate students from a wide range of disciplines who were undertaking a 1st year psychology course at an Australian University. Students enrolled in first year psychology have access to a website that lists all studies which are seeking first year students as participants. Participants received course credit for their participation in research during the semester. In order to avoid coercion students were able to choose from a large number of possible studies and could complete an alternative task if they did not wish to participate in research. All aspects of the studies, including recruitment, occurred online and could be completed from any computer with internet access.

A web based questionnaire was developed for the purpose of these studies. The online questionnaire allowed the administration of a questionnaire at Time 1 which included demographic measures and the TPB questionnaire. Participants from the first data set completed a behaviour measure at one week follow-up. Participants from the second and third data sets completed a behaviour measure at one month follow-up.

Measures

TPB Questionnaire

All studies used in the present analyses used the same questionnaire to assess intention, attitude, subjective norm and PBC. As described elsewhere, the questionnaire was developed using published guidelines for theory of planned behaviour questionnaires (Kothe, et al., 2012). Intention, attitude, subjective norm and PBC were all assessed using a 100 point visual analogue scale with higher scores indicating stronger/more positive evaluations of the target behaviour: consumption of two servings of fruit and five servings of vegetables.

Intention was measured using the mean of three items (e.g. '*I plan to eat 2 servings of fruit and 5 servings of vegetables each day from now on*... strongly disagree – strongly agree'). A higher score indicated a greater intention to consume recommended quantities of fruit and vegetables (Cronbach's alpha = .832). On this scale, a score above 50 indicates an intention to consume fruit and vegetable intake at recommended levels, while a score below 50 indicates intention not to consume fruit and vegetable intake at recommended levels.

Attitude was assessed as the mean of twelve items (e.g. ' *For me to eat 2 servings of fruit and 5 servings of vegetables each day from now on would be*… good – bad'). A higher score indicated a stronger positive attitude towards eating two servings of fruit and five of vegetables (Cronbach's alpha = .890). On this scale, a score above 50 indicates a positive

attitude towards fruit and vegetable intake, while a score below 50 indicates a negative attitude.

Subjective norm was assessed as the mean of six items that measured both injunctive and descriptive norms (e.g. '*Most people who are important to me think that I _____ eat 2 servings of fruit and 5 servings of vegetables each day from now on...* should – should not' and '*Many people like me eat 2 servings of fruit and 5 servings of vegetables each day from now on...* extremely likely – extremely unlikely'). A higher score indicated greater perceived social pressure to consume two servings of fruit and five servings of vegetables (Cronbach's alpha = .765). On this scale, a score above 50 indicates perceived social pressure to consume fruit and vegetables, while a score below 50 indicates perceived social pressure to restrict consumption of fruit and vegetables.

PBC was measured as the mean of four items (e.g. '*It is mostly up to me whether or not I eat 2 servings of fruit and 5 servings of vegetables from now on* …. strongly agree – strongly disagree'). Higher scores indicated greater perceived control over behaviour (Cronbach's alpha = .717). On this scale, a score above 50 indicates a perception that fruit and vegetable consumption is under the individuals' control, while a score below 50 indicates a perception that fruit and vegetable consumption is not under the individuals' control,.

Behaviour

Fruit and vegetable consumption was measured using a brief self-report measure of previous day fruit and vegetable consumption. The 2-item measure of previous-day fruit and vegetable consumption is similar to the measure of fruit and vegetable consumption used in the National Health Survey and in evaluations of the success of the *Go for 2&5* health-promotion campaign (Australian Bureau of Statistics, 2009; Kothe, et al., 2012; Woolcott Research, 2007). The measure asks participants to indicate the number of servings of fruit and the number of servings of vegetables they consumed in the previous day. Although multiple 24

hour dietary recalls at multiple time points remain the gold standard, this type of measure has been shown to be well correlated with estimates of fruit and vegetable consumption obtained from 24 hour dietary recall (Peterson et al., 2008). Short dietary instruments are also less likely to be subject to over-reporting of fruit and vegetable consumption than longer food frequency questionnaires (Peterson, et al., 2008).

Results

The combined data set for this study consisted of 460 participants. Of these, 104 participants were drawn from the first data set. Ninety participants from the first data set went on to complete Phase 2 of the study at 1-week follow-up. This represents a loss to follow-up of 13.5% across the duration of the study. The remaining 354 participants were drawn from the second and third data sets. Of those, 296 went on to complete 1-month follow-up. This represents a loss to follow-up of 16% over the duration of the one month follow-up. Age in years in the combined sample ranged from 18 to 25, with a mean age of 18.98 years (SD = 1.40). The majority of participants (78.7%) were female and lived at home with their parents (77.6%). The most commonly identified ethnicity was Australian (45%). Mean fruit and vegetable consumption at baseline was 4.5 servings per day (SD = 2.25).

The correlations between TPB variables and behaviour at one week and one month are presented in Table 1. The Table also includes means and standard variations for each variable.

[Table 1 about here]

Independent sample t-tests and chi square tests of independence were conducted to investigate the potential for differential attrition. Individuals who completed baseline and follow-up (completers) were compared to those that completed baseline only (drop-outs). There were no differences between the groups on baseline behaviour, attitude, subjective norm, perceived behavioural control and intention (see Table 2). There were also no differences between drop-

outs and completers for any demographic variable (age, gender, living situation, and ethnicity).

[Table 2 about here]

A hierarchical linear regression analysis was used to examine the effect of theory of planned behaviour constructs (attitude, subjective norm, and perceived behavioural control) on intention to consume recommended quantities of fruit and vegetables. Attitude, subjective norm, and perceived behavioural control were entered simultaneously into block one. Interaction terms, derived by the cross-product of mean centered subjective norm, attitude, and perceived behavioural control, were entered in block 2.

The final model was significant and accounted for 45.5% of the variance in intention (R^2 =. 455; $F_{6, 452}$= 62.798 p < .001). As shown in Table 3, attitude, subjective norm and PBC were all significant predictors of intention in block 1. The attitude x PBC was also a significant predictor of intention. Attitude was no longer significant once the interaction term had been entered into the analysis, however PBC and subjective norm remained significant. The addition of the interaction terms in block 2 represented a significant R^2 change ($R^2\Delta$ = .022; $F\Delta_{3,452}$ = 6.018 p < .001). Simple slopes analyses were conducted to examine the attitude – PBC relationship at 1SD above and below mean attitude. These analyses demonstrated that the moderating effect of attitude was such that the relationship between intention and PBC was significant at higher levels of attitude (attitude =100, t=4.44, p<.001) but not at lower levels of attitude (attitude= 76, t=-.177, p=.860). This relationship is presented in Figure 2.

[Table 3 about here]

[Figure 2 about here]

Hierarchical linear regression analyses were also used to examine the effect of intention and perceived behavioural control on self-reported fruit and vegetable intake. Separate analyses

were conducted for the one week and one month behavioural outcomes. In each analysis, intention and perceived behavioural control were entered in block 1, and the PBC x intention interaction term entered in block 2.

The final model was significant and accounted for 32.9% of the variance in consumption at one week (R^2 =. 329; $F_{3, 86}$= 16.09 p < .001). As shown in Table 4, intention was the only significant predictor of behaviour in the first step. However, PBC, intention, and the PBC – intention interaction were all significant predictors of fruit and vegetable consumption at one week in the final block. The addition of the interaction terms in block 2 represented a significant R^2 change ($R^2\Delta$ = .047; $F\Delta_{1,85}$ = 5.845 p = .014). The interaction between intention and PBC was such that the relationship between PBC and behaviour was not significant at when intention was weakly negative (intention= 44.7, t=1.97, p=.052); but was significant when intention was strongly positive (intention= 86.8, t=2.083, p=.040). This relationship is presented in Figure 3.

[Table 4 about here]

[Figure 3 about here]

The final model explained 12.1% of the variance in fruit and vegetable consumption at one month (R^2 =.121; $F_{3, 291}$= 13.35, p < .001). As shown in Table 5, intention was the only significant predictor of behaviour in the final step. Neither the PBC nor PBC x intention interaction were significant predictors of fruit and vegetable consumption at one month follow-up.

[Table 5 about here]

Discussion

Consistent with expectations, the TPB accounted for a substantial proportion of fruit and vegetable intake and intentions to consume fruit and vegetables. Together, intention was well

predicted by attitude, subjective norm and PBC; while fruit and vegetable intake was predicted by intentions but not PBC. Overall, the linear formulation of the theory predicted 43% of intention to consume fruit and vegetables. Intention and PBC accounted for 27% of variance in fruit and vegetable consumption at one week, and 12% of variance in fruit and vegetable consumption at one month. These results are broadly consistent with previous applications of the model to the prediction of fruit and vegetable consumption (Allom & Mullan, 2011; Collins & Mullan, 2011; Guillaumie, et al., 2010; Kothe, et al., 2012), where the model is typically found to account for a higher proportion of variance in intention than in behaviour. The proportion of variance in fruit and vegetable consumption is lower than in a meta-analytic review of the use of social cognition models which excluded studies with student samples (Guillaumie, et al., 2010). However, the findings are more similar to studies within Australian students which have found that the theory accounts for 11-24% of variance in behaviour (Allom & Mullan, 2011; Kothe, et al., 2012). The majority of students in the present study lived at home, which may have reduced the extent to which fruit and vegetable consumption was under the influence of the participants and limited the extent to which TPB variables could account for variability in consumption because of limited actual behavioural control and less influence of subjective norm or students' personal attitudes. The finding that the model was better able to predict fruit and vegetable consumption at one week than one month is consistent with studies suggesting that larger estimates of predictive utility are found when using short-term follow-up (McEachan, et al., 2011)

Contrary to expectations, PBC was not a significant predictor of behaviour at either time point. Although PBC did become significant once the PBC – intention relationship was added to the regression within the week one sample, this result should be carefully interpreted given that the inclusion of the interaction terms changes interpretation of constitutive terms within the regression analyses (discussed in further detail below; Brambor, Clark, & Golder, 2006). This was an unexpected finding, since meta-analyses suggest that the addition of PBC

typically accounts for a significant proportion of variance in behaviour over and above the influence of intention (Armitage & Conner, 2001). Interestingly, within this study PBC was significantly correlated with behaviour. As such, failure of PBC to account for behaviour within the regression model may indicate that the PBC to behaviour relationship is fully mediated by intention. Ajzen & Madden (1986) suggested a direct path between PBC and behaviour on the basis that PBC would act as a proxy for actual control (Ajzen & Madden, 1986). Previous studies have found that the influence of PBC on behaviour is weaker when PBC is a less accurate indicator of actual control and that individuals are sometimes inaccurate when reporting their measure of actual control (Sheeran, Trafimow, & Armitage, 2003). It may be that individuals in the current study formed inaccurate perceptions of their actual control over fruit and vegetable consumption and that this led to a failure for PBC to account for behaviour over and above intention. Further research on the accuracy of PBC as an indicator of actual control in the context of fruit and vegetable consumption is needed in order to examine this finding and aid in the interpretation of this relationship.

It was expected that interactions between TPB variables would account for a significant proportion of variance over and above their independent effects. Four interaction terms were investigated in the present study (subjective norm – PBC, attitude – PBC, subjective norm – attitude, and PBC – intention). These results suggest that the inclusion of interaction increased the variance in fruit and vegetable consumption and intention accounted for by TPB variables. These interaction terms are of interest because they address major criticisms of the linear formulation of the model.

The attitude – PBC interaction

An interaction between attitude and perceived behavioural control was found. The moderating effect of attitude was such that the relationship between PBC and intention was only significant for those with strongly positive attitudes. This supports the argument that attitude should form a boundary condition for PBC (Eagly & Chaiken, 1993). Previous research has

found that the moderating effect of attitude on the PBC – intention relationship is most pronounced for those with strong negative evaluations of behaviour (Conner & McMillan, 1999). The simple slopes analysis showed that PBC was not a significant predictor of intention for individuals whose attitudes were 1SD below the mean. It is important to note that these participants still reported positive attitudes towards behaviour, since on this scale scores above 50 reflect positive attitudes towards fruit and vegetable consumption. This suggests that the boundary conditions for attitude with regard to the PBC – intention relationship is not characterised simply by the absence of a negative evaluation of fruit and vegetable consumption. Instead, this suggests that even for individuals with positive evaluations of fruit and vegetable consumption, attempts to increase intentions by targeting PBC may fail if attitudes are not sufficiently high. It should also be noted that once this interaction term was included in the regression model, the relationship between attitude and intention was no longer significant. While the precise nature of this boundary is unclear these findings would suggest that interventions should not seek to increase intention to consume fruit and vegetable purely by targeting PBC. Interventions targeting intention via PBC would appear to be more likely to be successful if attitude is also addressed.

The subjective norm – PBC interaction

Contrary to expectations, the relationship between PBC and intention did not differ as a function of social pressure to consume fruit and vegetables. This suggests that within this population, the influence of PBC is independent of subjective norm; such that even an individual who perceived negative social pressure to eat fruit and vegetables may form an intention purely on the basis of the belief that the behaviour was easy to perform and within their control. However, the relationship between PBC and attitude is relevant when considering the implications of these findings because while individuals with high PBC may form an intention to consume fruit and vegetable in spite of perceived negative social pressure, it would appear that this would only occur if they also held strongly positive attitudes.

The subjective norm – attitude interaction

The interaction between subjective norm and attitude in the prediction of intention was also investigated. As with the subjective norm – PBC interaction discussed above, the results of this study indicate that these two factors operate independently of one another in determining intention. This is consistent with the assumption within the TPB that attitude and subjective norm represent distinct constructs (Fishbein & Ajzen, 2010) that have independent relationships with intention.

The PBC – intention interaction

It was expected that intention would moderate the intention behaviour relationship, such that PBC would only predict fruit and vegetable consumption if intention was positive. This hypothesised relationship was supported at one week follow-up, but not at one month follow-up. These results suggest that while intention may form a boundary condition for PBC in some circumstances, this effect is only meaningful when there is a relatively short time period between intention and behaviour. The mixed results found in the present study are broadly consistent with previous studies investigating the influence of PBC on the intention behaviour relationship (Armitage & Conner, 2001). The findings that the PBC – intention interaction were significant at one week but not one month may suggest that factors external to the participant (e.g. changes in the environment) may have influenced behaviour. This effect is likely to be attenuated as length of follow-up increases.

Methodological issues

There are a number of methodological considerations that should be taken into account when interpreting the findings discussed above. First, this study examined interactions within the TPB using a volunteer student sample. Research suggests that use of such samples may overestimate the utility of the TPB compared to when applied to community or clinical samples (McEachan, et al., 2011). This should be considered when interpreting the proportion

of variance accounted for by the model in the current analyses. However, the relative lack of diversity in the sample may lead to overestimation of the utility of the model which may also make it difficult to detect real interaction effects within the model due to range restriction for some key variables. As such, estimates of the influence of interaction terms may be lower than would be observed in a community sample. Although the magnitude of interactions cannot be confirmed on the basis of a single set of analyses, this research does suggest several interesting avenues for future research in more diverse samples in order to confirm the size of these effects. These include further investigation of the PBC x attitude interaction and consideration of changes in the PBC x intention relationship over time.

Second, the behaviour measures employed in the present study were all self-report. The use of objective measures of fruit and vegetable consumption would be useful in determining the magnitude of the PBC – intention interaction for objectively measured fruit and vegetable intake. Even in the absence of objective measures, the use of more reliable estimates of fruit and vegetable consumption such as multiple 24 hour dietary recalls at multiple time points would have been advantageous in this context. However, it is important to note that such measures have limited feasibility in many larger studies due to cost and time constraints, and that meta-analyses do suggest that the TPB does successfully predict objectively measured behaviour (Armitage & Conner, 2001). Given the outcome of previous analyses (Armitage & Conner, 2001), it could reasonably be expected that the PBC – intention interaction would remain significant in studies of objectively measured behaviour but that the overall model would account for a lower proportion of the variance in fruit and vegetable consumption. Even so, future studies should investigate whether these relationships hold if the measurement of fruit and vegetable consumption is improved.

The current paper compared the linear and multiplicative TPB models on the basis of regression analyses. This has been the analytical approach used in previous studies of interaction terms with the TPB (Armitage & Conner, 2001; Conner & McMillan, 1999; Umeh

& Patel, 2004), and in studies which have sought to justify adding variables to the TPB (Conner & Armitage, 1998). However, the use of analytical methods that allow for consideration of model fit such as structural equation modelling, would have been preferable in terms of demonstrating the additional explanatory power associated with the inclusion of interaction terms. Unfortunately, such analyses require larger sample sizes than was obtained in the current study in order to be adequately powered (Barrett, 2007; Preacher & Coffman, 2006). Although the use of secondary data sets meant that it was not feasible in the present context, future studies which seek to explore the role of interaction terms should conduct thorough *a priori* power analyses (including Monte Carlo simulations where possible) in order to ensure that such model fit analyses can be assessed (Preacher & Coffman, 2006).

Finally, readers should be cautious in interpreting independent effects of TPB constructs on intention and behaviour on the basis of the beta-weights reported in the final step of the regression models reported in Tables 3-5. The interpretation of direct effects within regression models that include interaction terms has been the subject of substantial concern within statistical literature. For example, in evaluating the use of interaction models Barbour et. al. argue that, although common, the interpretation of constitutive terms as unconditional marginal effects is a major error within the interpretation of regression models that include interaction terms (Brambor, Clark, & Golder, 2006). They write: "scholars should refrain from interpreting the constitutive elements of interaction terms as unconditional or average effects—they are not… the coefficient on the constitutive term X *must not* be interpreted as the average effect of a change in X on Y as it can in a linear-additive regression model [emphasis in original]" (Brambor, et al., 2006, p. 71). In discussing the manner in which these effects can be interpreted Barbour et. al. note that "absent any knowledge about the distribution of condition Z, the only clear way to gauge the average effect of X on Y is to run an unconditional model in which X is not included in a multiplicative interaction term." (Brambor, et al., 2006, p. 72). As such, researchers who require an estimate of the average effect TPB constructs on behaviour and/or intention should ensure that they interpret the

coefficients from the step of the regression model that does not include the interaction term (i.e. Block 1). However, given that presence of significant interaction terms within the current study we would argue that such an interpretation may miss important boundary conditions for these relationships.

Conclusions

The analyses presented in this paper add to the body of knowledge showing that the TPB can be used to predict fruit and vegetable intake, and demonstrate the importance of considering interactions between TPB components. Attention to these interactions is important for extending the understanding of the processes by which TPB factors determine behaviour and in understanding the limits of the relationships between variables. This study is the first to investigate the role of interactions between pre-intentional TPB variables in the context of socially desirable health behaviours. This adds to the previous findings from the drug use literature (Conner & McMillan, 1999; Umeh & Patel, 2004). The similarities between this study and previous studies are conceptually interesting since they indicate a broadly consistent pattern of results for positive and negative health behaviours.

These interactions may have practical implications for the development of interventions to target fruit and vegetable consumption as it would appear that attempts to increase intention through increased PBC are likely to be most effective when attitude is high – suggesting a need to target both factors in order to achieve maximum effect within intervention studies. Similarly, the non-significant relationship between PBC and behaviour when intention is low would suggest that interventions that seek to increase feelings of control will have limited effectiveness if intention is not also considered.

Given the high predictive utility of the linear model it is unclear whether interaction effects are of significant magnitude across a range of behaviours to justify reformulation of the TPB in order to take such interactions into account. However, it should be noted that the proportion

of variance accounted for by considering these interactions is comparable to increases seen when factors such as moral norm are added to the model (Conner & Armitage, 1998) but do not require any additional data collection. Replication of these effects in studies of other behaviours and in more diverse samples is needed to gain a more detailed understanding of the magnitude and generalizability of interactions within the model before such conclusions should be drawn. More routine testing and reporting of interactions would greatly increase the understanding of these relationships, and the depth and quality of the research in this domain.

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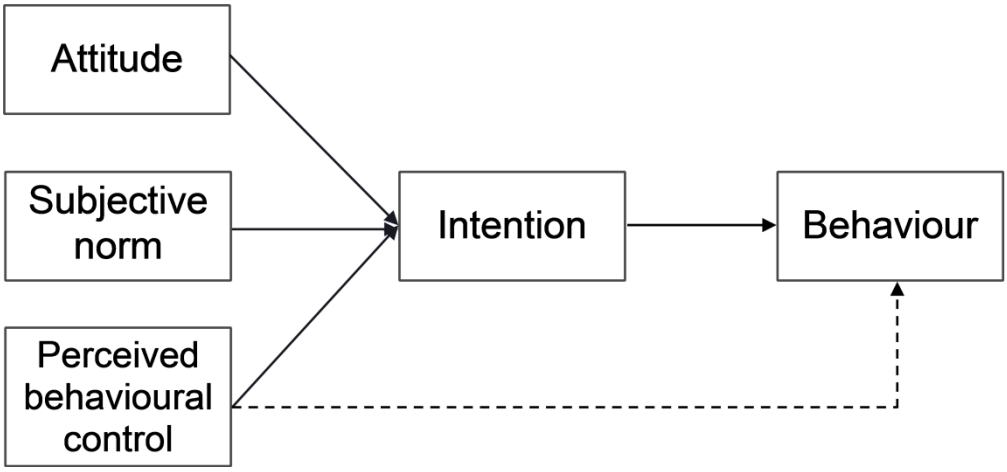
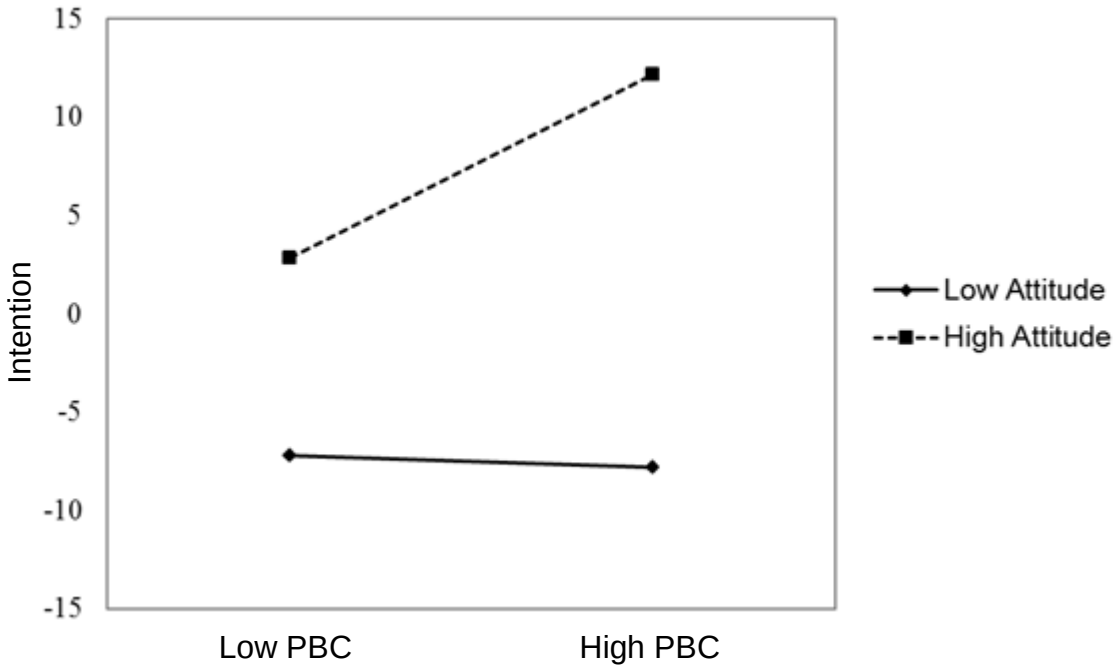
Figure Legends

Figure 1. Standard linear formulation of the theory of planned behaviour

Figure 2. The relationship between PBC and intention as moderated by attitude

Figure 3. The relationship between PBC and behaviour as moderated by intention


Attitude
Subjective norm
Perceived behavioural control
Intention
Behaviour


15
10
5
0
-5
-10
-15
Intention
Low PBC
High PBC
Low Attitude
High Attitude

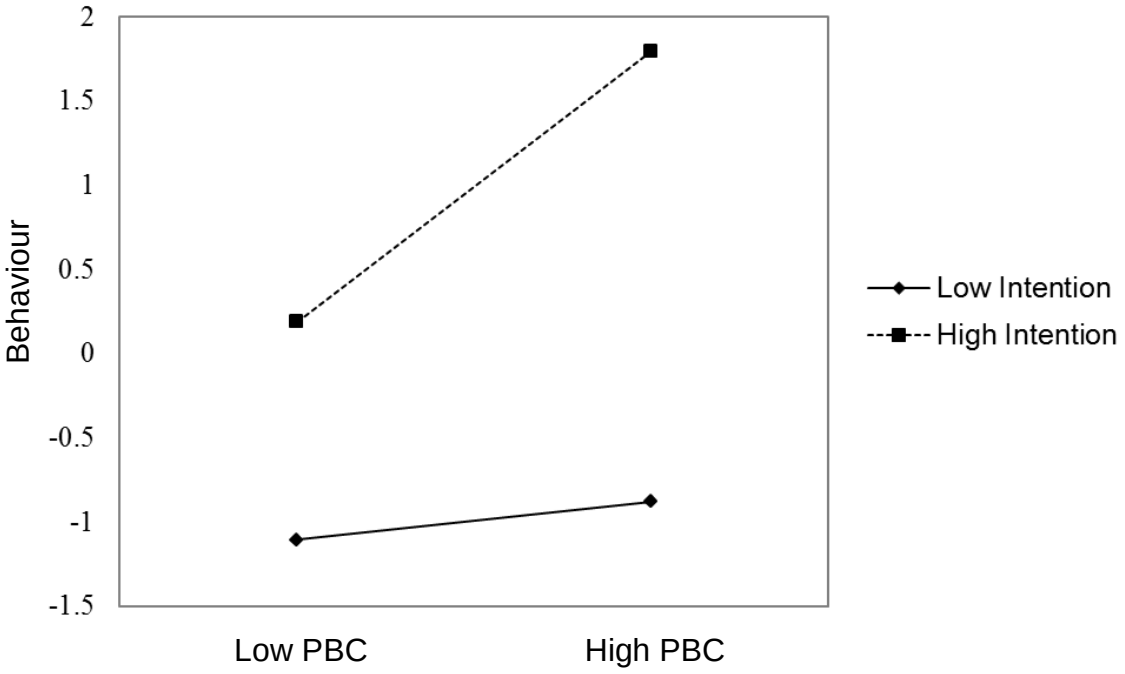

2
1.5
1
0.5
0
-0.5
-1
-1.5
Behaviour
Low PBC
High PBC
Low Intention
High Intention

Table 1. Descriptive statistics for TPB variables and behaviour

	Intention (n=460)	Attitude (n=459)	PBC (n=459)	Subjective Norm (n=459)	Behaviour at one week (n=89)	Behaviour at one month (n=295)
Intention	1	.388**	.502**	.582**	.503**	.340**
Attitude		1	.361**	.416**	.154	.102
PBC			1	.403**	.386**	.230**
Subjective Norm				1	.339**	.347**
Behaviour at one week					1	N/A
Behaviour at one month						1
Mean ± SD	64.9 ± 22.3	88.1 ± 11.9	79.8 ± 16.1	66.0 ± 15.5	4.8±2.2	5.2±2.2

Note: * denotes statistical significance at the <.05 level; ** denotes statistical significance at the <.01 level

Table 2. Comparison of TPB variables at baseline between dropouts and completers

	Dropout (Mean ± SD)	Completers (Mean ± SD)	t	*p*
Behaviour at baseline	4.66 ± 2.44	4.48 ± 2.22	.629	.530
Intention	64.42 ± 22.39	64.96 ± 22.31	-.191	.849
Attitude	88.45 ± 14.91	88 ± 11.3	.300	.764
PBC	81.6 ± 16.25	79.44 ± 16.04	1.066	.287
Subjective Norm	65.66 ± 15.47	66.03 ± 15.51	-.191	.849

Table 3. Baseline TPB Constructs Regressed on Intention (n=459)

Model	B	SE	95% CI	β	t	*p*	$R^2\Delta$
Block 1							.434**
Attitude	.074	.054	0.345, 0.2	.107	2.689	.007**	
Subjective norm	.058	.485	0.714, 0.599	.418	10.278	<.001**	
PBC	.055	.300	0.515, 0.407	.295	7.435	<.001**	
Block 2							.022**
Attitude	.088	.010	0.357, 0.183	.099	2.077	.745	
Subjective norm	.059	.460	0.69, 0.575	.401	9.827	<.001**	
PBC	.058	.353	0.581, 0.467	.338	8.026	<.001**	
Attitude x PBC	.004	.004	0.021, 0.013	.119	3.014	.003**	
Subjective norm x PBC	.004	.000	0.014, 0.007	.077	1.864	.064	
Subjective norm x attitude	.005	-.018	0.001, -0.009	-.078	-1.783	.075	

Note: Dependent variable = intention * denotes statistical significance at the <.05 level; ** denotes statistical significance at the <.01 level

Table 4. Intention and PBC regressed on behaviour at one week (n=89)

Model	B	SE	95% CI	β	t	Sig.	$R^2\Delta$
Block 1							0.28**
Intention	.039	.010	0.19, 0.59	.417	3.866	<.001**	
PBC	.023	.015	-0.007, 0.53	.173	1.601	.113	
Block 2							.049*
Intention	.029	.015	0.023, 0.063	.462	4.345	<.001**	
PBC	.043	.010	-0.001, 0.59	.215	2.023	.046*	
PBC x Intention	.001	.000	0.000, 0.002	.235	2.521	.014*	

* denotes statistical significance at the >.05 level; ** denotes statistical significance at the >.01 level

Table 5. Intention and PBC regressed on behaviour at one month (n=295)

Model	B	SE	95% CI	β	t	Sig.	$R^2\Delta$
Block 1							.120**
Intention	.030	.006	0.017, 0.042	.299	4.710	<.001**	
PBC	.011	.009	-0.006, 0.28	.080	1.263	.208	
Block 2							.001
Intention	.031	.006	0.018, 0.043	.308	4.741	<.001**	
PBC	.009	.009	-0.009, 0.027	.064	.949	.344	
PBC x Intention	.000	.000	-0.001, 0.000	-.039	-.665	.507	

* denotes statistical significance at the >.05 level; ** denotes statistical significance at the >.01 level