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Promoting fruit and vegetable consumption: Testing an intervention based on the theory of planned behaviour

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Abstract

This study evaluated the efficacy of a theory of planned behaviour (TPB) based intervention to increase fruit and vegetable consumption. The extent to which fruit and vegetable consumption and change in intake could be explained by the TPB was also examined. Participants were randomly assigned to two levels of intervention frequency matched for intervention content (low frequency n = 92, high frequency n = 102). Participants received TPB-based email messages designed to increase fruit and vegetable consumption, messages targeted attitude, subjective norm and perceived behavioural control (PBC). Baseline and post-intervention measures of TPB variables and behaviour were collected. Across the entire study cohort, fruit and vegetable consumption increased by 0.83 servings/day between baseline and follow-up. Intention, attitude, subjective norm and PBC also increased ($p < .05$). The TPB successfully modelled fruit and vegetable consumption at both time points but not behaviour change. The increase of fruit and vegetable consumption is a promising preliminary finding for those primarily interested in increasing fruit and vegetable consumption. However, those interested in theory development may have concerns about the use of this model to explain behaviour change in this context. More high quality experimental tests of the theory are needed to confirm this result.

Keywords: theory of planned behaviour; fruit and vegetable consumption; behaviour change

Fruit and vegetable consumption has wide ranging implications, including decreased risk of cancer, heart attack, and stroke (Dauchet, Amouyel, & Dallongeville, 2009; Dauchet, Amouyel, Hercberg, & Dallongeville, 2006; FAO/WHO, 2003; He, Nowson, & MacGregor, 2006). The Australian Government recommends that Australians consume 2 pieces of fruit and 5 servings of vegetables each day (National Health and Medical Research Council, 2003). However, few adults meet recommended daily intakes of fruit and vegetables, with young adults the least likely of any age group to consume fruit and vegetables (Australian Bureau of Statistics, 1995; Joint Health Surveys Unit, 2008). Low consumption rates amongst young adults suggest the need for programs designed specifically for this population.

Major reviews of behaviour change and methods of intervention design recognise the importance of theory in the development and evaluation of interventions (e.g. Bartholomew, Parcel, Kok, & Gottlieb, 2001; House of Lords: Science and Technology Committee, 2011). A recent meta-analytic review of the use of theory in intervention design concluded that more extensive use of theory was associated with larger intervention effects (Webb, Joseph, Yardley, & Michie, 2010). However, despite this widespread recognition of the importance of theory, many studies within health behaviour research are still atheoretical (Painter, Borba, Hynes, Mays, & Glanz, 2008). The challenge for researchers working in the area of fruit and vegetable consumption is to develop effective theory-driven interventions which target variables likely to influence consumption. The present study adopts the theory of planned behaviour (TPB; Ajzen, 1991) as a framework for addressing this issue since it proposes determinants of behaviour which are potentially amenable to change through psychosocial interventions.

TPB

The TPB posits that intention and perceived behavioural control (PBC) are the most proximal determinants of behaviour; intention in turn is determined by attitude towards the behaviour,

subjective norm and PBC (Ajzen, 1991). Attitude refers to the individual's evaluation of a given behaviour as favourable or unfavourable and formed on the basis of the individual's beliefs about the outcomes of behaviour and their evaluations of those outcomes (Ajzen, 1991; Fishbein & Ajzen, 2010). Subjective norm refers to perceived social pressure to perform (or not perform) of the behaviour. Subjective norm is formed as a result of the individual's beliefs about the extent to which important others would approve or disapprove of their performance of the behaviour mediated by the individual's motivation to comply with others' views (Ajzen, 1991; Fishbein & Ajzen, 2010). The final predictor of intention measured in this study, PBC, reflects the extent to which an individual believes the performance of the behaviour is within their control (Ajzen, 1991; Fishbein & Ajzen, 2010). Like attitude and subjective norm, PBC is thought to influence behaviour through its influence on intention. It is also thought to have a direct influence on behaviour over and above its influence on intention. The extent to which PBC has a direct influence on behaviour is often thought to reflect an individual's actual behavioural control over the target behaviour (Fishbein & Ajzen, 2010). Given the difficulty in directly assessing actual behaviour control for most health related behaviours, PBC is used as a proxy for actual behaviour control the majority of TPB based studies (Armitage & Conner, 2001; Fishbein & Ajzen, 2010; Godin & Kok, 1996).

A large number of studies provide support for the utility of the model in the prediction of behaviour (Armitage & Conner, 2001; Godin & Kok, 1996). In the context of fruit and vegetable intake, the model has been reported to account for an average of 41% of the variance in intention and 45% of the variance in behaviour (Guillaumie, Godin, & Vézina-Im, 2010). In their meta-analytic review of psychosocial predictors of fruit and vegetable intake, Guillaumie, Godin, and Vézina-Im argued that the TPB is the most strongly supported model of intention and behaviour (Guillaumie, et al., 2010), and therefore there is sound justification

for the use of the model in interventions designed to increase intake of fruit and vegetables (Guillaumie, et al., 2010).

TPB and behaviour change

Although the predictive utility of the TPB model has been well established, there are relatively few studies which manipulate the cognitions specified in the model in order to assess whether changes in the supposed predictors of behaviour do in fact lead to behaviour change (Elliott & Armitage, 2009; Hardeman et al., 2002). While a number of studies have successfully changed behaviour using interventions modelled on the TPB (for a review see: Hardeman, et al., 2002) – few studies have investigated the extent to which change in behaviour occurs through theorised pathways (Elliott & Armitage, 2009; Hardeman, et al., 2002). Researchers have specifically called for studies which explore the mediation of behaviour change outcomes by theory specific cognition changes (Michie & Abraham, 2004). While a small number of studies have explored this in recent years (e.g. Elliott & Armitage, 2009; Kelley & Abraham, 2004; Kothe, Mullan, & Amaratunga, 2011) results have been inconsistent and none have looked at fruit and vegetable intake.

Aims and hypotheses

The TPB was used in this study to develop and test an intervention to promote fruit and vegetable consumption amongst young adults. The aims of the study were to evaluate the impact of the intervention on TPB variables and behaviour; to investigate the extent to which intervention effects could be explained using pathways implied by the TPB; and to examine the efficacy of the Fresh Facts 30 day program, described below, at different levels of email frequency.

It was hypothesised that exposure to the intervention would result in changes in attitude, subjective norm, PBC, intention and behaviour. It is expected that the TPB would provide a good model of intention and behaviour at both baseline and follow-up. With

regards to the modelling of behaviour change, it was hypothesised that change in behaviour could be explained by change in intention and PBC and that change in intention could be explained by change in attitude, subjective norm, and PBC.

In light of work linking intervention intensity to efficacy (Kroeze, Werkman, & Brug, 2006), it was expected that higher frequency emails would result in greater change in behaviour.

Method

Participants

Data were collected from undergraduate students from a wide range of disciplines who were undertaking a 1st year psychology course at an Australian University in May 2011. All aspects of the experiment, including recruitment, occurred online and could be completed from any computer with internet access. Participants received course credit for their participation. Details of the final sample are given in the results section.

The Fresh Facts 2011 Intervention

The intervention ('Fresh Facts 2011') was designed to increase fruit and vegetable intake of young adults. The intervention was developed using the Theory of Planned Behaviour (Ajzen, 1991), and consisted of a 30 day program designed to target attitude, subjective norm and PBC. The intervention materials consisted of a series of automated emails sent to participants over the course of the intervention period. Participants were randomised to two levels of email frequency – participants in the high frequency group received 27 intervention emails (each containing one intervention message) over the study period, while participants in the low frequency group received 9 longer emails (each containing three intervention messages) over the same time period. The email content was matched across the two groups so that all participants received identical intervention content regardless of group.

The content of the automated emails was designed using the taxonomy of behaviour change techniques (Abraham & Michie, 2008). All techniques used in the present study have previously been identified as potentially being linked to attitude, subjective norm, and/or PBC (Abraham, Kok, Schaalma, & Luszczynska, 2010). For a summary of the intervention techniques used in the present study see Table 1.

Table 1

Summary of behaviour change techniques used in FreshFacts 2011

TPB variable targeted	Behaviour change technique	Definition
Attitude	Provide general information on behaviour-health link	Information about the relationship between the behaviour and health.
	Provide general information on the material consequences of behaviour	Information focusing on what will happen if the person performs the behaviour including the benefits and costs (or negative consequences) of action or inaction, including perceived severity of symptoms
Subjective Norm	Provide information about others' behaviour	Information about what other are doing i.e., indicates that a particular action or sequence of actions is common or uncommon amongst a group.
	Provide information about others' approval	Information about how other people/ specific others judge/ approve of the participant's behaviour.
	Provide opportunities for social comparison	Provide a setting in which social comparison can occur.
PBC	Arguments to bolster self efficacy	Involves telling the person that they can successfully perform the behaviour, arguing against self doubts and asserting that they can and will succeed.
	Provide instruction	Telling participants how to perform a behaviour or preparatory behaviours e.g., instructions providing "tips".

Procedure

This study was approved by the University Human Research Ethics Committee and carried out in accordance with universal ethical principles. After completing a consent form online, participants completed a baseline questionnaire at Time 1, which included demographic measures, a measure of behaviour, and a TPB questionnaire. Once they had completed the baseline survey, participants were randomised and then added to the study mailing list and began receiving intervention messages via email. All participants received an invitation to complete the follow-up questionnaire on Day 30. The Time 2 questionnaire included a second administration of the behaviour measure and TPB items.

Measures

TPB Questionnaire

A purpose designed questionnaire was used to assess intention, attitude, subjective norm and PBC. The questionnaire was designed using guidelines for TPB questionnaire construction (Francis et al., 2004). Intention, attitude, subjective norm and PBC were all assessed using a 100 point visual analogue scale at both baseline and post-intervention follow-up.

Intention to eat 2 servings of fruit and 5 servings of vegetables was measured by three items, each relating to an individual's plans and intentions regarding future fruit and vegetable consumption (e.g. *I plan to eat 2 servings of fruit and 5 servings of vegetables each day from now on...* strongly disagree – strongly agree). Consistent with previous research, the overall intention score was derived from the mean of the three items, with a higher score indicating greater intention. (Francis, et al., 2004). Cronbach's α for the three items was .813 at baseline, and .819 at follow-up.

Attitude was assessed as the mean of six items, each measured on a semantic differential scale using bipolar adjective pairs (e.g. *For me to eat 2 servings of fruit and 5*

servings of vegetables each day from now on would be... good – bad). In order to minimise response biases (Francis, et al., 2004), items were arranged so that the ends of the scales were a mix of positive and negative endpoints, scores were reverse coded before analysis as needed. A higher score indicates a stronger positive attitude towards eating 2 servings of fruit and 5 of vegetables. The six items had high internal consistency (Cronbach's $\alpha = .906$ at baseline, $\alpha = .929$ at follow-up).

The six item subjective norm scale was made up of items measuring both injunctive and descriptive norms (Fishbein & Ajzen, 2010). Injunctive norm items related to the individual's perception of the extent to which important others believe that they should or should not consume fruit and vegetables (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*). Descriptive norm items related to the individual's perception of the fruit and vegetable consumption of others (e.g. *Many people like me eat 2 servings of fruit and 5 servings of vegetables each day... extremely likely – extremely unlikely*). Items assessing both injunctive and descriptive norm were combined into a single measure of subjective norm using the mean of the six items (Francis, et al., 2004). A higher score indicates greater perceived social pressure to consume 2 servings of fruit and 5 of vegetables. The six item combined scale had adequate internal consistency ($\alpha = .771$ at baseline, $\alpha = .788$ at follow-up).

PBC was measured by four items; two items measured the extent to which the individual believed that fruit and vegetable consumption was under his/her control (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*) and two items measured the perceived ease or difficulty of adequate fruit and vegetable consumption (e.g. *If I wanted to I could eat 2 servings of fruit and 5 servings of vegetables from now on definitely true – definitely*

false). The overall PBC score was derived from the mean of the four items, with a higher score indicating greater perceived control over behaviour (Francis, et al., 2004). Cronbach's α for the three items was .718 at baseline, and .823 at follow-up.

Behaviour

A short self-report measure of previous day fruit and vegetable consumption was used to measure behaviour. Two items were used to assess consumption at each time point: 'How many servings of fruit did you eat yesterday?' and 'How many servings of vegetables did you eat yesterday?' Scores from the two items were summed to create a composite score of the previous day fruit and vegetable consumption.

Design and Data analysis

This study investigated the effects of the Fresh Facts intervention using a pre-post design. This design was chosen since it maximises statistical power (Howell, 2006) and is an important first step in investigating the effects of an intervention before embarking on a larger and more expensive randomised controlled trial.

Analysis of intervention effects and all descriptive analyses were conducted in SPSS 17.0. Paired-samples t-tests were used to investigate changes in TPB variables and behaviour between the two time points.

Structural equation modelling (SEM) with Amos 19.0 using the maximum likelihood estimation was used to test the TPB models. Separate structural equation models were tested in cross-sectional analyses of the TPB at baseline and follow-up, and in analyses of change in TPB variables between Time 1 and Time 2. Each model was evaluated by examining the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root-mean-square-error of approximation (RMSEA) and χ^2 divided by degrees of freedom (χ^2/df). A good model fit was indicated by a high CFI or TLI (>0.90), a low RMSEA (<0.10) and a χ^2/df between 1 and 3 (Kline, 2005). For the cross-sectional models (Model 1 and Model 2), structural pathways

were drawn from attitude, subjective norm, and PBC to intention; and from intention and PBC to previous day fruit and vegetable intake. Covariances were drawn between all independent variables. For the modelling of change between Time 1 and Time 2 (Model 3), pathways were drawn between attitude change, subjective norm change, and PBC change to intention change, and from intention change and PBC change to behaviour change. As with the cross-sectional models, covariances were drawn between all independent variables.

Results

One-hundred and ninety-four participants completed baseline data collection and were sent intervention emails. Age in years in the present sample ranged from 18-25, with a mean age of 18.94 years ($SD=1.41$). The majority of participants (74.7%) were female (see Table 2). Given this sample size, the study was sufficiently powered to detect within group changes with an effect size of $d \geq 0.20$. This is typically classified as a ‘small’ effect (Cohen, 1988).

Table 2

Demographic characteristics of the baseline sample

Demographic Characteristic	N	%
Gender		
Female	145	74.7
Male	47	24.2
Living Situation		
With parents	147	75.8
With friends	14	7.2
Residential college	14	7.2
Alone	11	5.6
With partner	5	2.6
Ethnicity		
Australian	73	37.6
North-East Asian	52	26.8
South-East Asian	23	11.9
Southern and Eastern European	15	7.7
Southern and Central Asian	12	6.2
North-West European	6	3.1
North African and Middle Eastern	6	3.1
New Zealander or Pacific Islander	3	1.5
Sub-Saharan African (e.g. South African, Zimbabwea		.5

Tests of representativeness

A series of independent samples t-tests and chi squared tests of independence were conducted to ensure that the two groups were equivalent at baseline. The two groups were compared on all demographic variables and on baseline TPB and behaviour measures. The results showed that there were no significant between group differences on any measure (all p 's > .05). Therefore it was concluded that randomisation was successful.

Of participants enrolled in the study, 166 completed the post-intervention questionnaire on Day 30. This represents a loss to follow-up of 15.3% over the course of the study. A series of independent samples t-tests were conducted to ensure that the participants who dropped out of the study at follow-up were representative of those responding at two time points. Participants who dropped out of the study were compared to completers on baseline TPB and behaviour measures. The results showed that there were no significant differences between completers and drop-outs on any measure ($t_{190-191} = 0.41-1.32$, all p 's > .05). Therefore it was concluded that selective attrition was not likely to be a factor in this study.

Descriptive statistics

Means and standard deviations for each variable at each time point are shown in Table 3. Across both time points, participants generally intended to consume the recommended quantity of fruit and vegetables each day. This was accompanied by evaluations of the behaviour as positive, within their control, and socially acceptable at both baseline and follow-up.

Fruit and vegetable consumption in this population was generally low. At baseline, 83.3% of participants reported consuming less than the recommended daily intake of fruit and vegetable on the day before data collection; 51.6% ate less than 2 servings of fruit, and 87.5% ate less than 5 servings of vegetables.

Testing intervention effects

Differences between the low frequency and high frequency intervention were tested using independent sample t-tests. There were no differences between the two groups on any of the primary and secondary outcomes (p 's $>.05$). In light of this lack of differences, the two groups were analysed and reported together for the remaining analyses in this report.

Combined intervention effects were formally tested using a series of paired-sample t-tests, which examined change in primary and secondary outcome measures between the two time points. The results of these analyses are summarised in Table 3.

Table 3

Means (standard deviations) and tests of effects on TPB variables and behaviour

	Time 1	Time 2	<i>t</i>	<i>df</i>	<i>p</i>	<i>d</i>
Fruit and vegetable servings/day	4.40 (2.26)	5.24 (2.28)	-4.806	163	<.001	0.37
Intention	62.17 (22.54)	74.20 (17.42)	-8.276	163	<.001	0.60
Perceived behavioural control	77.92 (16.78)	80.09 (15.43)	-2.054	162	.042	0.13
Attitude	84.01 (11.32)	87.21 (12.54)	-3.795	162	<.001	0.27
Subjective Norm	65.48 (16.00)	72.19 (14.61)	-6.817	162	<.001	0.44

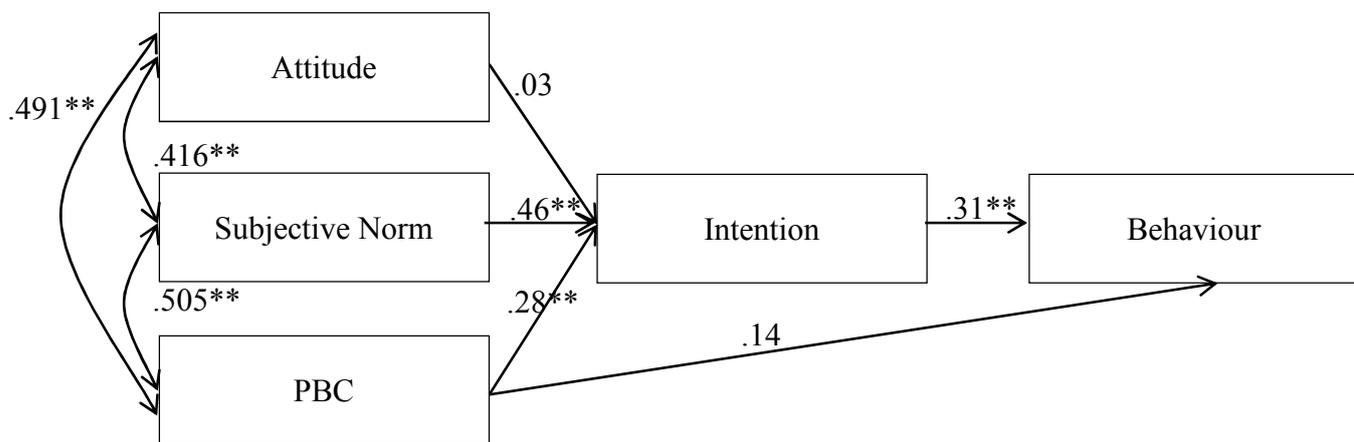
Participants consumed an average of 4.4 servings of fruit and vegetables on the day before baseline testing; at follow-up participants reported consuming an average of 5.2 servings of fruit and vegetables on the day before testing. This represents a significant increase in fruit and vegetable consumption between the two time points.

Intention increased significantly between Time 1 and Time 2, indicating that participants had a greater intention to consume recommended quantities of fruit and vegetables at follow-up than they did pre-intervention. PBC increased an average of 2.17 points between Time 1 and Time 2; this effect was significant. This indicates an increase in

the perception that consumption of fruit and vegetable was achievable and/or controllable. Subjective norm also increased, by an average of 6.7 points, between Time 1 and Time 2. This effect was significant. This indicates an increase in perceived social pressure to consume fruit and vegetables between baseline and post-intervention follow-up. There was a significant difference in reported attitudes between baseline and follow-up, with positive evaluations of fruit and vegetable consumption increasing between Time 1 and Time 2.

Cross-sectional prediction of fruit and vegetable consumption using the TPB

The first cross-sectional model (Figure 1) tested associations between attitude, subjective norm, PBC, intention and fruit and vegetable consumption at baseline. Fit indices indicate that the model provided a good fit to the data (see Table 4).



Note. Path coefficients are standardized. ** p<.001, *p<.05; Intention R²=0.445; Behaviour R²=0.168

Figure 1. Structural equation model of theory of planned behaviour at baseline (Model 1, N = 194).

Table 4

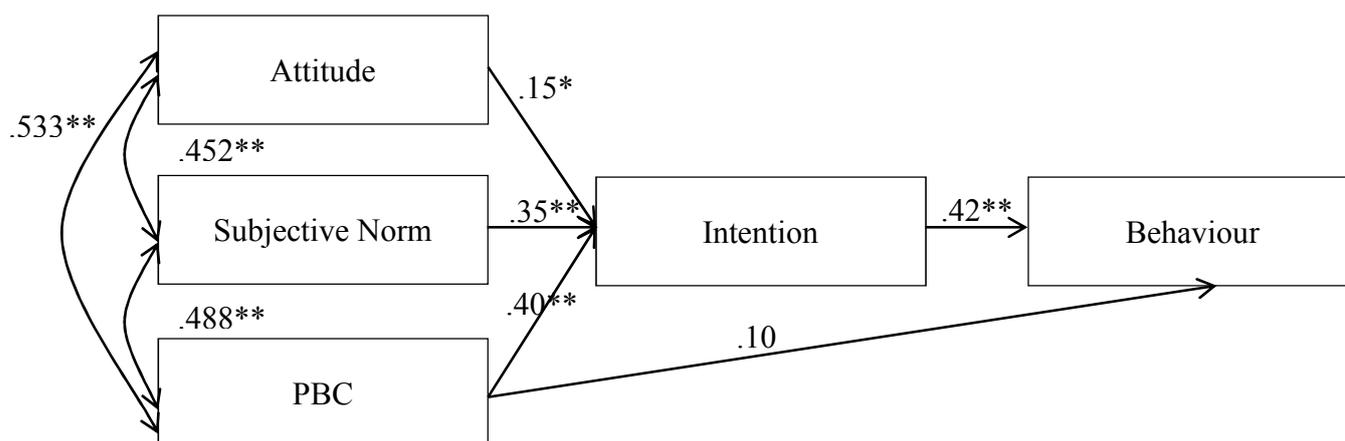
Model fit indices

	TLI	CFI	RMSEA	χ^2/df
Model 1 – Baseline cross-sectional model	.980	.997	.041	1.33
Model 2 – Follow-up cross-sectional model	.935	.991	.079	2.20
Model 3 – Change model	1.03	1.00	.000	0.82

TLI = Tucker-Lewis index, CFI = comparative fit index, RMSEA = root-mean-square-error of approximation.

Subjective norm and PBC, but not attitude, were significant predictors of intention. Intention, but not PBC, was a significant predictor of fruit and vegetable consumption at baseline. The model accounted for 44.5% of the variance in intention, and 16.8% of the variance in behaviour, at baseline.

The second cross-sectional model (Figure 2) tested associations between attitude, subjective norm, PBC, intention and fruit and vegetable consumption immediately post-intervention. As with the previous model, fit indices indicate that the model provided a good fit to the data.



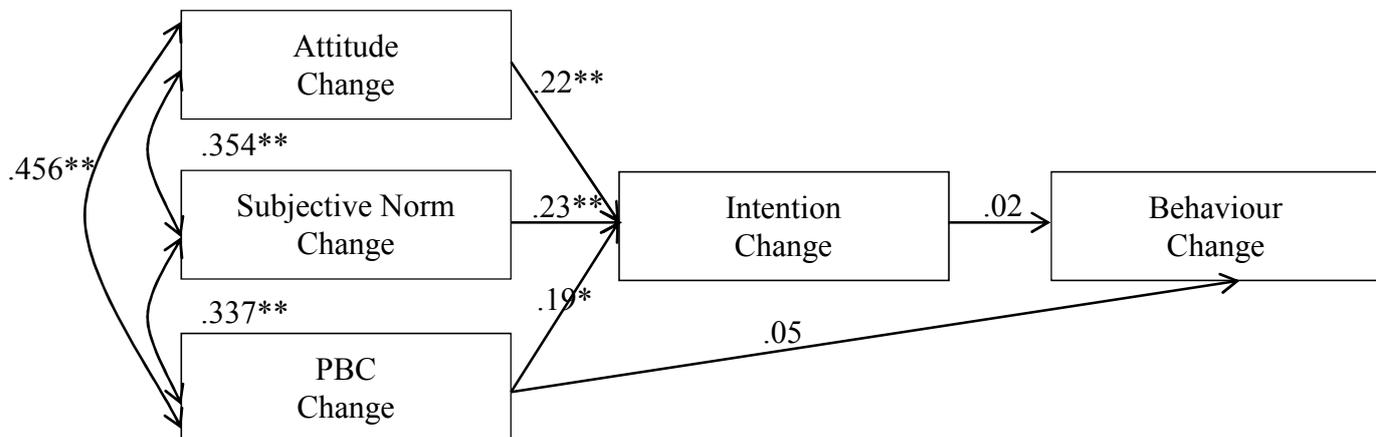
Note. Path coefficients are standardized. ** p<.001, *p<.05; Intention R²=0.551; Behaviour R²=0.243

Figure 2. Structural equation model of theory of planned behaviour at follow-up (Model 2, N = 166).

Subjective norm, attitude and PBC, were significant predictors of intention. Intention, but not PBC, was a significant predictor of fruit and vegetable consumption at Time 2. The model accounted for 55.1% of the variance in intention, and 24.3% of the variance in behaviour, at follow-up.

Prediction of change in fruit and vegetable consumption using the TPB

The third structural model (Figure 3) investigated associations between change in attitude, subjective norm and PBC, and change in intention and behaviour.



Note. Path coefficients are standardized. ** $p < .001$, * $p < .05$; Intention Change $R^2 = 0.245$; Behaviour Change $R^2 = 0.0002$

Figure 3. Structural equation model of change in theory of planned behaviour cognitions and behaviour between baseline and follow-up (Model 3, $N = 166$).

Fit indices indicate adequate model fit, but the results represent a significant departure from theory. Attitude change, subjective norm change, and PBC change were all predictors of intention change. However, intention change and PBC change did not predict change in fruit and vegetable consumption between baseline and follow-up. The model accounted for 24.5% of the variance in change in intention, but just .02% of the variance in change in behaviour. It was not possible to formally test for mediation since change in intention and change in behaviour were not significantly correlated (Baron & Kenny, 1986).

Discussion

The intervention led to increased consumption of fruit and vegetables amongst this sample of Australian young adults. Average self-reported fruit and vegetable intake rose by 0.83 servings between baseline and immediate post-intervention follow-up. Importantly, some

have argued that a change in fruit and vegetable intake of this size is likely to be clinically significant (see Ciliska et al., 2000 for a review of clinical significance in fruit and vegetable consumption). The results also indicate that the Fresh Facts intervention successfully increased PBC, subjective norm and attitudes towards fruit and vegetable intake. The intervention also increased reported intention to consume fruit and vegetables at recommended levels. These results broadly support the first set of hypotheses: that the intervention would result in changes in attitude, subjective norm, PBC, intention, and self-reported behaviour. These are promising findings, suggesting that an intervention based on automated emails could promote fruit and vegetable consumption in Australian young adults. Given the short-term follow-up used in the current study it is difficult to determine the likely long-term effects of the Fresh Facts program. However, it is interesting to note that several interventions used to promote fruit and vegetable consumption among healthy individuals have been able to maintain intervention effects over the medium to long term (Ammerman, Lindquist, Lohr, & Hersey, 2002; Knai, Pomerleau, Lock, & McKee, 2006; Pomerleau, Lock, Knai, & McKee, 2005). Further research is needed to determine whether the increases in fruit and vegetable consumption observed in the current study could also be maintained over time.

It was expected that higher frequency emails would result in larger changes in fruit and vegetable consumption and related cognition. This result was not supported, there were no between group differences observed for any of the primary or secondary outcome measures. However, it is important to note that since the two groups were matched for overall intervention content this does not reflect a failure to detect a dose response relationship. Rather, on the basis of these findings it would appear that practitioners should feel free to select message frequency on the basis of feasibility and acceptability in a given context rather than based on the concern that it may impact intervention efficacy.

This study also served as an experimental test of the TPB. Results indicate that the model can be successfully applied to cross-sectional prediction of behaviour. This is consistent with reviews of the TPB across a range of behaviours (Armitage & Conner, 2001; Godin & Kok, 1996) and with previous studies which have applied the model to the prediction of fruit and vegetable intake in other populations (Guillaumie, et al., 2010). Interestingly the model was more effective at predicting behaviour at post-intervention. This may reflect an increase in temporal stability and a more coherent understanding of fruit and vegetable consumption at post-intervention (Hardeman, Kinmonth, Michie, & Sutton, 2011). The predictive utility of the model when applied to intention to eat fruit and vegetables compared favourably with previous studies of the TPB as applied to fruit and vegetable consumption (Guillaumie, et al., 2010). These findings are also broadly consistent with recent studies which have applied the TPB to the prediction of other eating behaviours in Australian young adults. The theory has previously been found to account for 33% of the variance in breakfast consumption (Kothe, et al., 2011) and 29% of the variance in snacking behaviour (Collins & Mullan, 2011). These findings support the ongoing use of this model to predict fruit and vegetable consumption and add to the literature seeking to explain fruit and vegetable intentions in young adults.

However, the model performed less well when used to predict behaviour. This is inconsistent with the findings from previous studies using the TPB to explain fruit and vegetable consumption (Guillaumie, et al., 2010), where the TPB has been found to predict behaviour as well as it predicts intention. The large gap between the predictive utility of the model when applied to behaviour rather than intention is more consistent with general reviews of the TPB which have found similar reductions in the predictive utility of the model when applied to behaviour (Armitage & Conner, 2001; Godin & Kok, 1996). This gap is known as the intention-behaviour gap (Armitage & Conner, 2001). Some researchers have argued that the intention-behaviour gap may indicate missing variables in the model that

moderate or mediate the intention-behaviour relationship, or variables that determine behaviour without influencing intention (e.g. Conner & Armitage, 1998). Data from this study would suggest that, at least in young adults, the inclusion of other variables known to bridge the intention-behaviour gap may be useful in improving the prediction of fruit and vegetable consumption. Previous research investigating food choice in young adults has indicated a range of variables that may help to explain the intention-behaviour gap. These include planning (Wong & Mullan, 2009), habit (Allom & Mullan, 2011), and self-regulatory capacity (Allom & Mullan, 2011; Collins & Mullan, 2011).

One common interpretation for the intention-behaviour gap is the possibility that individuals have difficulty in enacting their intentions due to limited control over their behaviour. Like most studies using the TPB, the current study used PBC as a proxy for actual behavioural control. The lack of a significant relationship between PBC and behaviour when controlling for intention at both baseline and follow-up would suggest that actual behavioural control does not limit fruit and vegetable consumption in the present population. This is consistent with studies of other eating behaviours which have found that PBC does not predict behaviour over and above its influence on intention amongst Australian young adults (Kothe, et al., 2011; Wong & Mullan, 2009). However, interpretation of these effects is limited by the fact that actual behavioural control has not been directly measured, future researchers may wish to consider ways to measure actual behavioural control in order to further clarify the role of actual behavioural control in determining fruit and vegetable consumption in this, and other, populations.

In addition to testing the predictive utility of the model when used cross-sectionally this study also sought to investigate the extent to which changes in behaviour could be explained using the behaviour change processes implied by the TPB. It was predicted that change in intention would predict change in behaviour, and the effect of change in attitude,

subjective norm and PBC on behaviour would be mediated by intention change. However this hypothesis was not supported. While changes in attitude, subjective norm, and PBC were found to predict intention change, behaviour change was not predicted by intention change or PBC change. The lack of significant association between intention and PBC change and behaviour means that tests of mediation were not appropriate (Baron & Kenny, 1986). These data suggest that changing intention and PBC is not always enough to change behaviour, and that the behaviour change exhibited in this study may be due to changes in determinants of behaviour other than those specified by the TPB. This finding may challenge theoretical assumptions that form the justification for the use of the TPB in intervention design.

It is possible that the lack of relationships between changes in theory-relevant cognitions and targeted behaviour may be specific to the processes underlying behaviour change in the Fresh Facts intervention. For example, Kelley & Abraham (2004) argued that goal setting, an important component of their intervention, may explain behaviour change in their intervention targeting physical activity in older adults, and would not be detected by measurement of TPB relevant cognitions (Kelley & Abraham, 2004). It may be that a similar process underlies the behaviour change observed in the current study. The inclusion of behaviour change techniques in this study was guided by the taxonomy of behaviour change techniques and work linking specific techniques to theoretical models (Abraham, et al., 2010). However, many of the techniques used in this intervention may have had multiple pathways through which to affect behaviour. For example, one of the techniques used to increase PBC was “providing instruction;” this technique includes telling participants how to perform preparatory behaviours (Abraham, et al., 2010). Fresh Facts intervention materials designed to use this technique provided a number of suggestions for preparatory behaviour, such as carrying fruit and vegetables. These techniques may have led to increases in habitual performance of behaviour, a factor which would not be captured by measures designed to

assess change in TPB variables, but which would be expected to lead to increased fruit and vegetable consumption (Guillaumie, et al., 2010; Shaikh, Yaroch, Nebeling, Yeh, & Resnicow, 2008).

A second interpretation of the current findings would be that the TPB may not in fact adequately model changes in behaviour, regardless of the intervention used. The lack of support for behaviour change processes from the TPB found in this study is consistent with findings from a number of other studies which have investigated the processes by which TPB based interventions lead to increases in desired behaviours (Hardeman, et al., 2011; Kelley & Abraham, 2004). However, it is important to note that other studies which have found limited associations between TPB change and behaviour change have also found that the TPB did not model behaviour cross-sectionally (Hardeman, et al., 2011). As such the lack of support for the behaviour change processes implied by the TPB found in those studies may indicate problems with the application of the model in a given context, rather than lack of support for behaviour change processes of the model more specifically. This study is the first to suggest that the TPB may not adequately model behaviour change even if it does model behaviour. This would be consistent with arguments that the intention-behaviour gap in the model when used cross-sectionally or prospectively reflects missing variables within the model (Armitage & Conner, 2001). Researchers investigating behaviour change processes underlying interventions such as Fresh Facts may wish to consider whether behaviour change could be more effectively modelled using theories which have been developed to extend the TPB, such as the Health Action Process Approach (Schwarzer, 1992) or through the addition of variables such as goal-setting to explanatory models.

Limitations

While the within-subjects design of the present study allowed for increased power and was important for demonstrating possible effects of the Fresh Facts intervention, it is also possible that these findings reflect limitations in the study methodology. While participants in the study reported increases in both theory-relevant constructs and fruit and vegetable intake, it is difficult to determine whether these reported changes reflect actual changes in intake as a result of the intervention, or whether they reflect an artefact of the experimental design. This issue could be resolved by replication of these findings using a randomised controlled trial design where participants are randomised into a no intervention control group and active intervention group rather than the two levels of message frequency used as the basis of randomisation in the present study. The pre-post analyses used in the present study also limits interpretations of intervention effects. While this study provides preliminary evidence that the Fresh Facts intervention increases fruit and vegetable consumption, replication of this finding using a no-intervention comparison group would provide clearer evidence of intervention effects.

The use of a student sample in the present study should also be taken into account while interpreting results as the use of university undergraduates may limit the generalisability of intervention effects. However, given that fruit and vegetable intake is particularly low in young adults, this population represents an important sub-group. It should also be noted that while researchers have criticised the use of student samples in TPB based studies (Elliott & Armitage, 2009; Michie & Abraham, 2004), they have typically done so on the basis that student samples are likely to over-estimate the utility of the TPB. As such, the use of a student based sample may represent a best-case application of the model. However, the present study failed to find support for the use of the model in the explanation of behaviour change. If the theory can not be applied to behaviour change under ideal

circumstances this may raise even larger doubts for the application of the model to behaviour change in the wider population.

Conclusion

For clinicians and researchers primarily interested in increasing fruit and vegetable consumption these results provide preliminary evidence that the Fresh Facts intervention could increase fruit and vegetable consumption relative to baseline, at least for university based samples. This is a promising finding, especially considering the low levels of ongoing support required for interventions of this kind. Email-based interventions like Fresh Facts can be widely distributed and easily expanded to include a large number of participants. Once the intervention has been developed individuals can participate in the intervention with virtually no additional resources – meaning that interventions like Fresh Facts can be made available to large groups of individuals at very low cost. This finding should be encouraging for health promotion professionals seeking methods to influence large numbers of participants with limited resources.

However, for researchers interested in theory development, the results are less encouraging. This study also investigated the use of the TPB as applied to fruit and vegetable intake. The findings are consistent with previous research showing that the TPB can be used to predict fruit and vegetable consumption. However, the current study also adds to the body of research by empirically examining the assumption that the TPB can be supported as a model of behaviour change in fruit and vegetable consumption. Findings from this study suggest that, at least in the case of the Fresh Facts intervention, the TPB does not provide a good model of behaviour change. This has implications not just for theory based interventions designed to increase fruit and vegetable intake, but also for the use of the TPB in explaining behaviour change more broadly. On the basis of these findings, it would appear

that researchers should be cautious in interpreting a model's strong predictive power as evidence that the model will provide a good model of behaviour change.

It is important to note that on the basis of current evidence it is impossible to determine whether results in this study reflect an overall failure of the TPB to explain change in behaviour, or whether it would simply be a function of the behaviour change processes underlying the Fresh Facts intervention. This is also true of previous studies which have tested the TPB as a model of behaviour change (e.g. Elliott & Armitage, 2009; Kelley & Abraham, 2004; Kothe, et al., 2011). A larger body of research specifically investigating the pathways between intervention efficacy and TPB change is needed before such a distinction can be made.

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