Using Meta-Analytic Path Analysis to Test Theoretical Predictions in Health Behavior: An Illustration Based on Meta-Analyses of the Theory of Planned Behavior

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Abstract

Objective. Synthesizing research on social cognitive theories applied to health behavior is an important step in the development of an evidence base of psychological factors as targets for effective behavioral interventions. However, few meta-analyses of research on social cognitive theories in health contexts have conducted simultaneous tests of theoretically-stipulated patterns effects using path analysis. We argue that conducting path analyses of meta-analytic effects among constructs from social cognitive theories is important to test nomological validity, account for mediation effects, and evaluate unique effects of theory constructs independent of past behavior. We illustrate our points by conducting new analyses of two meta-analyses of a popular theory applied to health behaviors, the theory of planned behavior.

Method. We conducted meta-analytic path analyses of the theory in two behavioral contexts (alcohol and dietary behaviors) using data from the primary studies included in the original meta-analyses augmented to include intercorrelations among constructs and relations with past behavior missing from the original analysis.

Results. Findings supported the nomological validity of the theory and its hypotheses for both behaviors, confirmed important model processes through mediation analysis, demonstrated the attenuating effect of past behavior on theory relations, and provided estimates of the unique effects of theory constructs independent of past behavior.

Conclusions. Our analysis illustrates the importance of conducting a simultaneous test of theory-stipulated effects in meta-analyses of social cognitive theories applied to health behavior. We recommend researchers adopt this analytic procedure when synthesizing evidence across primary tests of social cognitive theories in health.

Keywords: meta-analysis; structural equation modeling; causal models; path analysis; past behavior; theory of planned behavior; nomological validity; social cognitive models; indirect effects; past behavior

Using Meta-Analytic Path Analysis to Test Theoretical Predictions in Health Behavior: An Illustration Based on Meta-Analyses of the Theory of Planned Behavior

Behavioral risk factors are associated with increased incidence of many chronic illnesses such as cardiovascular disease, diabetes, and certain types of cancer (World Health Organization, 2008). Epidemiological data has demonstrated links between behaviors such as regular vigorous physical activity, following a healthy diet, refraining from smoking tobacco, and keeping alcohol consumption within guideline levels and reduced all-cause mortality (Ford et al., 2011; Khaw et al., 2008). Identifying the factors associated with behaviors known to reduce disease risk is a key goal for behavioral scientists because it may provide an evidence base of potentially manipulable factors as targets for interventions to promote health related behavior and prevent chronic disease. The application of social cognitive theories to predict and explain health behavior has been at the forefront of this endeavour (Conner and Norman, 2015; Hagger, 2010). The theories help identify the psychological constructs that relate to health behavior and map the processes by which the constructs relate to behavior (Kok et al., 2015). Confirmation of theory predictions specified a priori across multiple tests enables the development of an evidence base of constructs and processes likely related to health behavior. The evidence may inform the development of interventions that are optimally effective in promoting health behavior change (Michie and Johnston, 2012; Wallace et al., 2014).

An important goal of research applying social cognitive theories in health behavior contexts is to confirm whether a stipulated pattern or network of effects among theory constructs comprising multiple hypotheses holds in an omnibus empirical test. Simultaneous tests of the proposed pattern of effects against observation permit confirmation or rejection of the theory, referred to as nomological validity (Bagozzi, 1981; Cronbach and Meehl, 1955). Nomological validity is often evaluated using multivariate analyses based on regression such as, path analysis and structural equation modeling. Such analyses are fit-for-purpose in testing social psychological theories as they are confirmatory rather than exploratory, and directly address the issue of whether the theoretically-stipulated pattern among constructs specified

a priori is an optimal fit with observations collected. There have been suggestions that many theory tests have failed to find support for key effects within a theory-stipulated nomological network and yet have claimed support for the theory raising questions of falsifiability (Ogden, 2003, 2015). A priori specification of the fundamental hypotheses and predictions of a theory (Sniehotta et al., 2015) accompanied by simultaneous tests of the predictions (Bagozzi, 1981; Hagger and Chatzisarantis, 2016) are necessary if theories are to be adequately evaluated in health behavior contexts.

A second important goal of research applying psychological theories to health behaviors is the importance of high-quality replications of proposed patterns of effects across multiple samples, behaviors, and contexts. Meta-analytic syntheses of such applications are essential in this endeavor as they provide cumulative evidence for theory effects while statistically correcting for methodological artefacts like sampling and measurement error. The syntheses provide more accurate estimations of the true effect among the constructs across the literature and evaluate the extent of variability of the effect after taking into account the corrected artefacts. There has been a proliferation in meta-analytic syntheses of the evidence for these theories including the theories of reasoned action and planned behavior (e.g., McEachan et al., 2012; Rich et al., 2015), self-determination theory (e.g., Chatzisarantis et al., 2003; Ng et al., 2012), social cognitive theory (e.g.,Young et al., 2015), and the prototype willingness model (e.g., Todd et al., 2016; van Lettow et al., 2016) in the context of health behavior. Such analyses are important because they add to the cumulative evidence for the theories and may inform means to intervene and change behavior through strategies targeting the salient theoretical factors and processes.

However, few of the meta-analytic cumulations have combined analyses that test the validity of an a priori pattern of relations and processes stimulated by the theory with synthesized data from a meta-analysis. The application of path analysis, or even structural equation modeling, to test the pattern of effects in a theory-based nomological network of constructs using the corrected matrix of correlations derived from meta-analysis is not a new phenomenon, and has been applied to tests of

models in health behavior for many years (e.g., Carraro and Gaudreau, 2013; Hagger and Chatzisarantis, 2009; Hagger et al., 2002; Rich et al., 2015; Yu et al., 2007). To date such tests are relatively rare to the detriment of the advancement of science. Omitting this final step limits the impact of meta-analytic tests of social psychological theories in health contexts and precludes valid tests of relations among theory constructs. It prevents the researcher from definitively testing the theory itself and, therefore, evaluating whether the predictions of the theory are supported or rejected and need to be modified. Exclusive reliance on corrected zero-order correlations without a path analysis to test the validity of theory predictions is equivalent to conducting a primary test of a theory and merely reporting the zero-order correlations among the psychological variables without conducting a multivariate test. A 'test' of a theoretical model relying only on zero-order relations would likely be given short shrift by a journal editor as it would not be fit-for-purpose as a test of the theory.

Furthermore, relying solely on zero-order relations among constructs from a theory without a simultaneous test will likely give inaccurate information on the true size of the effects. Just as in primary research, a multivariate analysis is essential when testing theory effects because constructs with the theory are frequently correlated, perhaps due to measurement error or genuine conceptual overlap, and including all variables in the prediction of behavior or other outcomes in the theory is necessary for the unique effects of each construct to be ascertained. The inclusion of demographic factors as covariates that may affect relations in the model is also important and they can be included as predictors of each variable in path analyses to control for the effects. Controlling for the effects of past behavior is particularly important in testing theory predictions because it acts as a proxy measure of the extent to which individuals have made decisions to act in the past (Albarracín and Wyer, 2000; Hagger and Chatzisarantis, 2014) and the extent to which the behavior is under habitual control (Gardner, 2015; Ouellette and Wood, 1998). In fact, the inclusion of past behavior in the prediction of prospectively-measured behavior in social cognitive theories models the stability of the behavior over time. If the theory constructs fail to account for behavioral stability and to predict unique variance behavior over

time then it is redundant as a means to explain behavior. Even if constructs from theories have also been shown to account for unique variance in behavior, the size of the effect of past behavior may be such that it renders the effects of these constructs trivial[1] by comparison, limiting the effectiveness of the theory. For example, previous tests of the theory of planned behavior based on meta-analyses have demonstrated that relationship between intentions and behavior, a critical link in the model and central to whether it is considered effective as an account of health behavior, was reduced from a substantial to a relatively trivial effect size with the inclusion of past behavior (Hagger et al., 2002; McEachan et al., 2012). Failure to account for control variables like past behavior in path analytic meta-analyses of theories applied in health contexts places considerable limits on researchers' capacity to arrive at a definitive decision on the effectiveness of the model to explain behavioral outcomes.

Conducting a simultaneous analysis of theory-stipulated effects among constructs in a meta-analytic path model also adds value to meta-analytic tests of theories because it enables the evaluation of theory-stipulated mediation effects. Mediation analyses allow researchers to test the mechanisms by which distal variables in a nomological network are related to behavioral outcomes, usually through more proximal predictors. Examples of mediation processes in social cognitive models applied in health contexts abound. In the common sense model of illness, for example, impact of illness beliefs such as serious consequences or perceived control on illness outcomes such as illness status or functioning is proposed to be mediated by coping procedures to manage the illness threat (Hagger and Orbell, 2003; Leventhal et al., 2011). In the theory of planned behavior, an individual's intention to engage in a health behavior is proposed to mediate the effects of attitudes (personal beliefs about outcomes), subjective norms (normative beliefs regarding behavioral engagement), and perceived behavioral control (beliefs about capacity to engage in the behavior) on actual behavioral engagement (Ajzen, 1991; Armitage and

[1]Confidence intervals of effect sizes in meta-analysis that encompass zero are indicative of a null effect while effect sizes that do not encompass zero, but are sufficiently small to have little theoretical or practical significance are considered trivial. Seaton et al. (2010) suggest that effect sizes larger than .10 to be the minimum considered for the effect to have "substantive value" and very small effects ($\beta < .075$) should be regarded as trivial.

Conner, 2001). Path analysis and structural equation modeling enable researchers to establish whether effects of distal constructs on outcomes are transmitted through other constructs, and provide evidence for important pathways by which psychological factors are related to behavior. It stands to reason, therefore, that such analyses should be applied to data derived from meta-analytic syntheses of data in order to test whether the processes proposed in a model hold in data accumulated from multiple tests.

In summary, relying solely on zero-order effects in a meta-analysis of relations between constructs in a theory is not fit-for-purpose as a means to test a theory and can lead to misleading conclusions as to its effectiveness. Specifically, a meta-analysis of a theory based on zero-order effects rather than path analytic tests (1) fails to provide an omnibus test of the proposed nomological network of relations among the theory constructs; (2) does not account for the effects of other factors that may attenuate or change the predictions of the model, particularly past behavior; and (3) does not enable researchers to test for key mediation effects in the model. Despite this, meta-analytic syntheses of relations among constructs from a given theory that use path analysis to test the pattern of effects among its constructs are still relatively rare. For example, two recent meta-analyses of the theory of planned behavior in two health-related behaviors alcohol (Cooke et al., 2014) and dietary (McDermott et al., 2015) behaviors, respectively, reported zero-order meta-analytically derived correlations among the variables but did not conduct a path analysis to test model predictions. In both articles the initial stages of the analyses were competently conducted and included an informative search and analysis of candidate moderators to resolve heterogeneity in the effects. However, the inclusion of a path-analysis to simultaneously test theoretical predictions would have greatly enhanced the impact of the meta-analyses. Furthermore, the inclusion of past behavior was important to evaluate the extent to which the theory explained unique variance in the behavior while accounting for behavioral stability.

The Present Study

The purpose of the present study is to illustrate the importance of conducting a simultaneous test of a stipulated pattern of effects when conducting meta-analyses of social cognitive theories applied to

health behavior. Specifically, we demonstrate our points by conducting a new analysis of Cooke et al.'s (2014) and McDermott et al.'s (2015) meta-analyses of the theory of planned behavior. These studies are selected as they are recent well-conducted syntheses of social cognitive theories applied the behaviors with important implications for health and the prevention of illness. Critically, though, neither study included a simultaneous omnibus test of the theory and are, therefore, appropriate candidate studies on which to illustrate the importance of such analyses to adequately test theory predictions. We aim to estimate a path analysis based on an augmented matrix of meta-analytically derived correlations to test the nomological validity of the theory in each behavioral domain. Specifically, we will conduct new meta-analytic syntheses of the studies identified in the original analyses to fill in the gaps in meta-analytically derived corrected correlation matrix necessary for the conduct of a path analysis. We will also include data on past behavior and its relations with the other theory variables so it could be included as a control variable in the path analytic models. The current analysis will make a number of important contributions to the literature. It will first extend Cooke et al.'s and McDermott et al.'s analyses by providing a simultaneous test of theory predictions based on the meta-analysis which was not possible from the zero-order effect sizes reported in their original analysis. It will identify the unique effects of variables in the model on the key outcomes variables, namely, intentions and behavior, and permit an evaluation as to whether the predictions in the model hold with the inclusion of the other theory variables and past behavior. It will also enable tests of the key mediation effects in the theory, specifically, whether intentions mediate the effects of attitudes, subjective norms, and perceived behavioral control on behavior. At a broader level, the analysis will illustrate how a reliance on zero-order correlations among constructs from a theory is insufficient as a means to test its nomological validity, and illustrate how simultaneous tests are the optimal means to test a model. The analysis will also illustrate that considerable information regarding the pattern of effects among constructs of a theory will remain undetected if meta-analysts do not apply path analysis to tests of the specified nomological network among the constructs.

In terms of specific hypotheses, we expect the pattern of effects stipulated by the theory of planned behavior to hold in the path analyses based on the augmented meta-analytic data sets from Cooke et al.'s and McDermott et al.'s meta-analyses. Two path models will be specified. In the first, attitudes, subjective norms, and perceived behavioral control are predicted to exert statistically significant effects on intentions, and intention is expected to have a significant effect on behavior. We will also specify a direct effect of perceived behavioral control on behavior, but this path is not considered fundamental to acceptance or rejection of the model as it is not a core hypothesis and reflects an effect conditional on behavior type (Ajzen, 1991; Hagger and Chatzisarantis, 2006). Further we hypothesize significant indirect effects of attitudes, subjective norms, and perceived behavioral control on behavior, mediated by intentions. The proposed model is illustrated in Figure 1a. In the second model, we predict that the inclusion of past behavior as a control variable predicting all constructs in the model will attenuate effect of theory constructs on intentions and behavior. The model augmented to include past behavior is illustrated in Figure 1b.

Method

We conducted a new analysis of Cooke et al.'s (2014) and McDermott et al.'s (2015) data using meta-analytic path analysis to provide a simultaneous test of theory of planned behavior hypotheses and extended the analysis to include past behavior. Cooke et al.'s analysis focused on 28 articles reporting 40 studies (total N = 12,056) on the theory of planned behavior with alcohol consumption, broadly defined, as the target behavior (e.g., drinking alcohol within governmental guidelines, quantity of drinks consumed, abstinence, and 'getting drunk') in non-dependent alcohol drinkers. Studies were international in origin, with the majority conducted in Europe (k = 29). Studies were from UK (k = 20), Norway (k = 4), USA (k = 4), Australia (k = 3), Canada (k = 3), Germany (k = 2), Estonia (k = 1), the Netherlands (k =1), South Korea (k =1), and Sweden (k = 1). All studies were correlational in nature with approximately half of the studies (k = 19, N = 3,119) reporting a prospective measure of alcohol consumption. McDermott et al.'s analysis identified 22 articles reporting 24 data sets (N = 6,417) on the

theory of planned behavior and its predecessor, the theory of reasoned action (Ajzen and Fishbein, 1980), applied to predict dietary patterns including healthy eating patterns (e.g., following a healthy diet, health eating) and restricted dietary patterns (e.g., eating a low-fat diet, watching your diet) as the target behavior in non-clinical, ostensibly healthy samples. Included studies were conducted in the UK (k = 8), USA (k = 5), Australia (k = 2), Canada (k = 1), the Netherlands (k = 1), Norway (k = 1), and Thailand (k = 1). Studies were correlational and all reported a prospective measure of behavior consistent with the authors' inclusion criterion. Full details of the search strategy, inclusion criteria, search results, and characteristics of included studies are provided in the supplemental materials of the original articles.

Our first step was to fill in gaps in the original studies' corrected meta-analytic matrices of correlations among study variables necessary for conducting the path analysis. Specifically, we derived intercorrelations among the antecedents of intentions (attitudes, subjective norms, and behavior) and added a row in the matrix for relations between past behavior and the other theory constructs. We did this by sourcing the original studies included in Cooke et al.'s and McDermott et al.'s analyses and replicating their procedures for extraction and coding of study data. In the samples of studies, the theory of planned behavior constructs were exclusively measured using standardized direct measures consistent with published guidelines (Ajzen, 2003; Fishbein and Ajzen, 2009). The homogeneity in measurement made the establishment of equivalence in constructs across studies relatively straightforward process as the items used in the measures had similar definition and content. Effect sizes (Pearson correlation coefficients; r) and associated sample sizes for relations among the theory constructs required to complete our data set were extracted from the zero-order intercorrelation matrices of the source studies. We aggregated effect sizes at the study level in cases where studies included multiple measures of the same dependent variable (e.g., total alcohol consumption, binge drinking) or theoretical construct (e.g., affective and instrumental attitudes, self-efficacy and perceived controllability), or measures of outcomes at multiple time points (Ajzen and Sheikh, 2013) consistent

with the original meta-analyses. Data from some studies (alcohol, $k = 2$; dietary, $k = 1$) were not included in the analysis because the correlations were not reported in the original studies.

A random-effects meta-analysis model was used to compute zero-order correlations corrected for sampling error (r_+) for the required effects averaged across the sample of studies using Comprehensive Meta-Analysis version 2.2 (Borenstein, 2011). We also conducted heterogeneity tests of effect sizes across studies: Cochran's (1952) *Q* statistic and the I^2 statistic (Higgins et al., 2003). Statistically significant *Q* values and I^2 values exceeding 25% were indicative of substantial heterogeneity in effects (Huedo-Medina et al., 2006). The matrices of corrected correlations were used as input for the hypothesized path-analytic models using the MPlus version 7.31 analysis package (Muthén and Muthén, 2012). Two models were tested for each behavior: a model testing the hypothesized pattern of effects among study constructs as stipulated by theory of planned behavior and a modified model that included past behavior as a predictor of all other constructs in the model. The models were estimated using a maximum likelihood estimation method with the harmonic mean average sample size as the input sample size (Viswesvaran and Ones, 1995). We used confidence intervals to test our hypothesis that including past behavior attenuated the effects of study constructs (attitudes, subjective norms, and perceived behavioral control) on intentions and the effect of intentions on behavior.

Results

Corrected correlations

Corrected meta-analytic correlations for the additional effect sizes computed in the current analysis to fill the gaps in Cooke et al.'s (2014) and McDermott et al.'s (2015) correlation matrices are presented in Table 1 along with confidence intervals and heterogeneity tests. The complete corrected correlation matrices used as input for the path analyses including data from the original studies are provided in Table 2. Raw data and analysis files are available on the Open Science Framework

(https://osf.io/f6h2t/). Results revealed that the additional effect sizes were all statistically significant and of sufficient size to be considered non-trivial. The only exception was the relation between perceived behavioral control and past behavior which exhibited confidence intervals that included the value of zero. Consistent with the results of the correlations identified by Cooke et al. and McDermott et al., the corrected correlations exhibited high levels of heterogeneity in all cases according to the I^2 statistic.

Meta-analytic path analyses

Standardized path coefficients and confidence intervals from the meta-analytic path analyses are presented in Table 3. The table also provides tests of difference in path coefficients for theory effects across the model testing the theory of planned behavior and the model testing the theory of planned behavior including past behavior.

Theory of planned behavior. For the models testing the theory of planned behavior excluding past behavior (Figure 1a), we found statistically significant direct effects of attitudes, subjective norms, and perceived behavioral control on intentions, and statistically significant direct effects of intention on behavior, for both alcohol and dietary behaviors, consistent with theory. However, the effect of perceived behavioral control was trivial ($\beta < .075$; Seaton et al., 2010) and the lower bound of the confidence interval approached zero. Perceived behavioral control was a statistically significant direct predictor of behavior for dietary behaviors but not alcohol behaviors[2]. We also found statistically significant indirect effects of attitudes, subjective norms, and perceived behavioral control on behavior mediated by intentions for both behaviors, as predicted. The only exception was the indirect effect of perceived behavioral control on intention for alcohol behaviors for which the lower bound of the confidence interval approached zero. Attitudes exhibited the strongest indirect effect on behavior, with

[2]The direct effect of perceived behavioral control on behavior has been identified as a conditional effect in the theory of planned behavior (Ajzen, 1991). Ajzen proposed that when perceived behavioral control approximated actual control, that is, served as a proxy measure of control, it should directly predict behavior, but otherwise its influence should be directed through intention. This effect should therefore be considered exploratory rather than confirmatory and its presence or absence should be exempted from decisions regarding the falsification of the theory.

an effect size that was significantly larger than those for subjective norms (alcohol behaviors, $t(36) = 9.18$, $p < .001$; dietary behaviors, $t(36) = 15.22$, $p < .001$) and perceived behavioral control (alcohol behaviors, $t(36) = 17.48$, $p < .001$; dietary behaviors, $t(35) = 8.31$, $p < .001$) for both behaviors. The models accounted for a substantial proportion of the variance in intentions (alcohol behaviors, 67.62%; dietary behaviors, 67.85%) and behavior (alcohol behaviors, 50.02%; dietary behaviors, 41.48%). Overall, results supported the proposed pattern of effects and nomological validity of the theory of planned behavior.

Theory of Planned Behavior including past behavior. The inclusion of past behavior in the test of the theory of planned behavior (Figure 1b) resulted in statistically significant reductions in the direct effects of attitude on intention and intention on behavior. The attenuation due to past behavior notwithstanding, these effects remained statistically significant. The direct effects of subjective norms and perceived behavioral control on intentions were also unchanged and remained statistically significant. The inclusion of past behavior also resulted in statistically significant reductions in the indirect effects of attitudes and subjective norms on behavior mediated by intention for both behaviors. Again, these effects remained statistically significant. The proportion of variance explained in intentions (alcohol behaviors, 75.30%; dietary behaviors, 71.27%) and behavior (alcohol behaviors, 67.96%; dietary behaviors, 75.99%) also increased with the inclusion of past behavior, reflecting the substantive direct effect of past behavior on future behavior.

Discussion

The purpose of the current research was to demonstrate the importance of conducting simultaneous tests of stipulated patterns of effects in meta-analyses of social cognitive theories applied to health behaviors. We demonstrated the importance of a simultaneous test by conducting a new analysis of two recent meta-analyses of the theory of planned behavior applied to two health behavioral contexts: alcohol (Cooke et al., 2014) and dietary behaviors (McDermott et al., 2015). Specifically, we conducted a path analysis specifying theory predictions using the meta-analytically derived correlations

from Cooke et al.'s and McDermott et al.'s original data augmented to include relations missing from the matrices of the original studies. Findings demonstrated that the proposed pattern of effects in the theory was supported in both behaviors, although the small, relatively trivial effect for perceived behavioral control on intentions ($\beta < .075$) in alcohol behaviors is a cause for concern for theory validity (c.f., Seaton et al., 2010). The inclusion of past behavior increased the variance explained in the key dependent variables, intentions and behavior, and also attenuated many of the effects in the theory, most prominently the intention-behavior relationship, consistent with previous findings (Hagger et al., 2002; McEachan et al., 2012). The finding that past behavior reduced the effects of intentions on behavior indicates that intentions are only mildly effective in accounting for stability and change in health behaviors, consistent with Sniehotta et al.'s (2014) contention that the theory of planned behavior is a static rather than dynamic theory. Further, the mediation of the effects of attitudes, subjective norms, and perceived behavioral control on behavior by intentions, key processes specified in the theory, were confirmed. The indirect effect of attitudes was the most pervasive while the effects for subjective norms and perceived behavioral control relatively modest for both behaviors.

The current analysis extends the findings of the original meta-analyses by providing a simultaneous test of theory hypotheses and, more broadly, demonstrates the importance of conducting such an analysis in order for it to be fit-for-purpose in evaluating the nomological validity of the theory. By conducting an omnibus test of theory hypotheses, we were able to ascertain the relative contributions of the study variables to the behavior, ascertain the direct and indirect effects of the study variables, and control for the effects of past behavior in the theory. The omission of this simultaneous test in the original analyses meant that important information on nomological validity, theory processes, and role of extraneous variables was missed in the original analyses, particularly the extent to which past behavior attenuated the proposed effects. Our analyses allow researchers to draw conclusions as to the nomological validity of the theory, testing key theory mechanisms through analysis of indirect effects, and evaluate the performance of the model when past behavior is included.

The current research has broader implications for the testing and evaluation of social cognitive theories applied to health behavior. Omission of a simultaneous theory tests precludes researchers from evaluating, on the basis of synthesized findings from multiple studies, whether the proposed pattern of effects in the theory is supported leading to its acceptance, or whether failure to support some or all of the effects leads to the conclusion that the theory should be rejected and provide guidance for future modification. Such tests directly address Ogden's (2003, 2015) contention that adequate tests are needed to make decisions on the validity of social cognitive theories in predicting health behavior. Consistent with calls for the clear specification of fundamental hypotheses of theories (Sniehotta et al., 2015) and the conduct of simultaneous tests of nomological validity (Hagger and Chatzisarantis, 2016), current findings provide further advocacy for subjecting meta-analytic syntheses of relations among theory constructs in health behavior to path analysis to provide fit-for-purpose validity tests. Finally, given the focus of meta-analysis on effect size and confidence intervals rather than statistical significance per se, path-analytic tests of theories based on meta-analytic correlations enable the researcher to test whether any of the proposed effects are trivial in size thereby invalidating the theory. Together, such omnibus tests provide researchers with a robust, a priori basis on which to falsify theories, that is to accept or reject their fundamental hypotheses and assumptions, consistent with the principles of nomological validity (Bagozzi, 1981; Cronbach and Meehl, 1955).

In conclusion, the application of path analytic procedures to meta-analysed relations among relations from constructs in social cognitive theories in health behavior provides researchers with a powerful means to accept or reject a theory, and assist them in subsequent modification efforts prior to further testing. Our current analyses aimed to illustrate how the adoption of such procedures provided important additional information on theory mechanisms through mediation analyses and on attenuation of proposed effects due to past behavior. We stress that our meta-analytic path analyses of previous data were intended to be illustrative rather than singling out particular analyses or theories, and we strongly advocate researchers apply these analyses in future meta-analytic tests of theories in the domain of

health behavior. Such an endeavour will assist in accelerating the advancement of an evidence base for theories in health behaviors and provide the basic research that could be used to develop effective behavioral intervention to promote health behavior.

Conflict of Interest Statement

Martin Hagger's contribution was supported by a Finnish Distinguished Professor Programme (FiDiPro) award from the Academy of Finland and Tekes, Finland. The Academy of Finland and Tekes had no role in the collection, analysis and interpretation of data, or the right to approve the finished manuscript prior to publication. Martin S. Hagger, Derwin K. C. Chan, Cleo Protogerou, and Nikos L. D. Chatzisarantis declare they have no conflict of interest.

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Table 1

Zero-Order Corrected Correlation Coefficients (r_+) and Heterogeneity Statistics among Theory of Planned Behavior Variables not Included in Cooke et al.'s (2014) and McDermott et al.'s (2015) Original Meta-Analyses

Construct	*N*	*k*	r_+	CI_{95}		*Q*	I^2
				LL	UL		
Cooke et al. (2015)							
Attitude-subjective norm	7641	33	.45	.37	.52	542.15***	94.10
Attitude-PBC	7641	33	.30	.18	.40	844.31***	96.21
Subjective norm-PBC	7641	33	.21	.11	.30	534.75***	94.02
Attitude-Behavior	4044	21	.41	.35	.46	92.11***	78.29
Subjective norm-Behavior	4044	21	.29	.22	.36	95.48***	79.05
Attitude-Past behavior	4738	22	.41	.33	.49	224.80***	90.66
Subjective norm-Past behavior	4738	22	.24	.16	.31	156.13***	86.55
PBC-Past behavior	4738	22	.09	-.09	.26	790.70***	97.34
Intention-Past behavior	4738	22	.51	.46	.56	110.51***	81.00
Behavior-Past behavior	3592	17	.60	.51	.68	225.72***	92.91
McDermott et al. (2015)							
Attitude-subjective norm	5064	18	.38	.30	.46	188.49***	90.98
Attitude-PBC	5020	17	.44	.37	.51	137.83***	88.39
Subjective norm-PBC	5020	17	.19	.10	.27	148.67***	89.24
Attitude-Behavior	3142	13	.35	.24	.45	130.79***	90.82
Subjective norm-Behavior	3142	13	.25	.16	.34	81.89***	85.35
Attitude-Past behavior	3013	8	.33	.20	.46	104.81***	93.32
Subjective norm-Past behavior	3013	8	.22	.10	.33	70.82***	90.12
PBC-Past behavior	3013	8	.28	.18	.38	51.93***	86.52
Intention-Past behavior	3013	8	.41	.18	.60	328.21***	97.87
Behavior-Past behavior	1296	4	.68	.58	.76	25.24***	88.11

Note. CI_{95} = 95% Confidence intervals; LL = Lower limit of CI_{95}; UL = Upper limit of CI_{95}; *Q* = Cochran's (1952); *Q* statistic; I^2 = ;Huedo-Medina et al.'s (2006) I^2 statistic; PBC = Perceived behavioral control

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 2
Zero-order Corrected Correlation Coefficients (r_+) among Theory of Planned Behavior Variables Included in Path Analytic Models

Construct	1	2	3	4	5	6
1. Attitude	–	.45	.30	.62	.41	.41
2. Subjective norm	.38	–	.21	.47	.29	.24
3. PBC	.44	.19	–	.23	.10	.09
4. Intention	.61	.35	.46	–	.54	.51
5. Behavior	.35	.25	.32	.47	–	.60
6. Past behavior	.33	.22	.28	.41	.68	–

Note. PBC = Perceived behavioral control; Correlations for alcohol behaviors printed above the principal diagonal and correlations for dietary behaviors printed below the principal diagonal.

Table 3

Standardized Path Coefficients for Direct and Indirect in Meta-Analytic Path Analyses of the Theory of Planned Behavior for Alcohol and Dieting Behaviors

Effect	Alcohol behaviors					Dieting behaviors				
	β	CI_{95}		Diff.		β	CI_{95}		Diff.	
		LL	UL	*t*	*p*		LL	UL	*t*	*p*
Direct effects										
Attitude→Intention	.51	.47	.54			.46	.43	.48		
	.39	.36	.42	6.39	<.001	.42	.39	.44	2.22	.033
SN→Intention	.24	.20	.27			.13	.11	.16		
	.22	.19	.24	0.92	.365	.11	.09	.14	1.11	.275
PBC→Intention	.03	.00	.06			.23	.21	.26		
	.04	.02	.07	0.50	.618	.20	.18	.22	1.84	.075
Past behavior→Intention	–	–	–			–	–	–		
	.30	.29	.32	–	–	.19	.17	.22	–	–
Intention→Behavior	.55	.51	.58			.41	.38	.44		
	.32	.29	.35	9.74	<.001	.20	.18	.23	10.54	<.001
PBC→Behavior	-.03	-.06	.01			.13	.10	.16		
	-.01	-.04	.02	0.85	.407	.07	.04	.09	3.01	.004
Past behavior→Behavior	–	–	–			–	–	–		
	.44	.41	.47	–	–	.58	.55	.60	–	–
Past behavior→Attitude	–	–	–			–	–	–		
	.41	.38	.44	–	–	.33	.30	.36	–	–
Past behavior→SN	–	–	–			–	–	–		
	.24	.20	.27	–	–	.22	.19	.25	–	–
Past behavior→PBC	–	–	–			–	–	–		
	.09	.05	.13	–	–	.28	.25	.31	–	–
Indirect effects										
Attitude→Intention→Behavior	.28	.25	.30			.19	.17	.20		
	.13	.11	.14	10.08	<.001	.08	.07	.10	10.16	<.001

SN→Intention→Behavior	.13	.11	.15			.05	.04	.06		
	.05	.07	.08	7.75	<.001	.02	.02	.03	5.26	<.001
PBC→Intention→Behavior	.02	.00	.03			.10	.08	.11		
	.01	.01	.02	1.24	.223	.03	.04	.05	2.48	.018
Correlations[a]										
Attitude↔SN	.45	.41	.49	–	–	.38	.35	.41	–	–
Attitude↔PBC	.30	.26	.34	–	–	.44	.41	.47	–	–
SN↔PBC	.21	.17	.25	–	–	.19	.16	.22	–	–

Note. Figures on upper line are for the model excluding past behavior and figures on the lower line are for the model including past behavior; β = Standardized path coefficient; CI_{95} = 95% confidence interval of coefficient; LL = Lower limit of CI_{95}; UL = Upper limited of CI_{95}; Diff. = *t*-test of difference in coefficients for the model testing the theory of planned behavior and the model testing the theory including past behavior with probability value; SN = Subjective norms; PBC = Perceived behavioral control; [a]For model excluding past behavior only.

Figure 1. Proposed models tested in meta-analytic path analysis of the theory of planned behavior for alcohol and dietary behaviors. The top model (a) represents the version of the model excluding control for past behavior while the bottom model (b) includes past behavior.