British Journal of Health Psychology (2013), 18, 2–17

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The predictive validity of implicit measures of self-determined motivation across health-related behaviours

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Objective. Research on health-related behaviour has typically adopted deliberative models of motivation and explicit measures. However, growing support for implicit processes in motivation and health-related behaviour has caused a shift towards developing models that incorporate implicit and explicit processes.

Methods. The current research advances this area by comparing the predictive validity of a newly developed implicit measure of motivation from self-determination theory (SDT) with explicit measures of motivation for 20 health-related behaviours, in a sample of undergraduate students ($N = 162$). A dual systems model was developed to test whether implicit motivation provided unique prediction of behaviour.

Results. Structural equation models for each behaviour indicated some support for the role of implicit measures; explicit measures and intention provided more consistent, significant prediction across most behaviours.

Conclusions. This study provides some support for dual systems models, and offers an important contribution to understanding why some behaviours may be better predicted by either implicit or explicit measures. Future implications for implicit processes and SDT are outlined.

Statement of contribution

What is already known on this subject? Previous research has highlighted the unique effects of implicit processes on goal-directed behaviour. Several studies have supported the role of implicit processes in motivation.

What does this study add? The current study adds to the previous literature by investigating the role of implicit processes and self-determination theory. Furthermore, the current study uses a relatively novel implicit measure across a wide range of behaviours. Finally, the current study incorporates a dual-systems model to provide a conceptual understanding of the findings.

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DOI:10.1111/j.2044-8287.2011.02063.x

Research into individuals' motivated behaviour has traditionally adopted deliberative models of motivation and explicit measures, often adopting prospective survey designs using self-report measures of motivation and associated social-cognitive constructs and linking them to behavioural engagement, resulting in a literature replete with explicit theories and models (Fishbein & Ajzen, 2009; Hagger & Chatzisarantis, 2009). However, the comparatively recent inception of implicit approaches has sought to extend knowledge of the processes that underpin behaviour (Dimmock & Banting, 2009). These approaches encompass both explicit and implicit processes in order to explain goal-oriented behaviour and are termed *dual-systems models* (Strack & Deutsch, 2004). In the last decade, research into self-determination theory (SDT) has also begun to incorporate implicit measures (e.g., Levesque & Brown, 2007). The aim of the present research was to extend this literature by testing the relative contribution of implicit and explicit measures of motivation to the prediction of behaviour using Strack and Deutsch's dual-systems model as a general framework. We used the go/no-go association task (GNAT; Nosek & Banaji, 2001) alongside explicit measures to assess individuals' implicit and explicit autonomous and controlled motives towards the enactment of 20 health-related behaviours over a 4-week period.

Self-determination theory

SDT is a theory of human motivation that has been applied extensively to numerous motivated behaviours (Deci & Ryan, 2008; Edmunds, Ntoumanis, & Duda, 2007). Central to the theory is the distinction between autonomous and controlled forms of motivation, which reflect the reasons why individuals engage in behaviour. When an individual's behaviour is self-determined, or *autonomous*, they are likely to pursue activities volitionally due to the inherent interest, enjoyment, or satisfaction derived from that activity, or because the activity helps them achieve outcomes that are salient to their true sense of self. These individuals feel a high level of experienced choice for engaging in the chosen behaviour, and experience no pressure or conflict when engaging in the activity. In contrast, individuals may engage in an activity in order to gain an externally referenced outcome, such as rewards or praise, or to avoid experiencing pressure and tension from contingencies perceived to be externally referenced; these individuals are said to be motivated by less autonomous, more *controlled* reasons. These individuals feel that they perform the activity out of a sense of obligation or control from external events, and feel pressured in what they are doing and that the activity is not consistent with their true sense of self. SDT classifies motivation into subtypes, which can be organized along a continuum, known as the *perceived locus of causality*[1] (PLOC; Ryan & Connell, 1989).

[1] *Intrinsic motivation lies at one extreme and is the prototypical form of autonomous motivation. Extrinsic motivation is divided into four subtypes, varying in their degree of self-determination or autonomy. External regulation, the most controlled form of the extrinsic motivation subtypes, lies at the pole opposite to intrinsic motivation. External regulation is the prototypical form of controlled motivation, reflecting behaviours performed for external reinforcements, such as gaining rewards or avoiding punishment. Introjected regulation lies adjacent to external regulation and is the motivation to pursue activities to avoid negative internal states, such as shame or guilt, or increase positive internal states, such as self-esteem. This form of motivation is viewed as controlled as reasons for behaving are perceived to be located outside the individual. Identified regulation is a form of extrinsic motivation that is more autonomous than introjected or external regulation, and refers to motivation to perform behaviour to obtain outcomes deemed personally important. Finally, integrated regulation is the most autonomous of the extrinsic motivation types, reflecting behaviours that have been fully incorporated into the repertoire of behaviours that satisfy an individual's sense of self, but the focus remains on the personally relevant outcomes of the behaviour.*

People may also vary in terms of generalized, dispositional motivational orientations, which can be either autonomous or controlled. Deci and Ryan (1985) identify individual differences in these relatively enduring motivation orientations. These orientations may also provide the basis for understanding the role of implicit constructs in research on autonomous motivation. Autonomously oriented individuals are likely to exhibit a quicker propensity for associating stimuli relating to autonomous forms of motivation (e.g., words related to autonomous motivation: 'value', 'enjoy') with personal attributes (e.g., words relating to the self: 'I', 'me'), than stimuli relating to controlled forms of motivation (e.g., words related to controlled motivation: 'should', 'forced'). As these underlying associations are outside of conscious awareness (Bargh & Ferguson, 2000), implicit measures are well suited to assess them.

For example, the effect of underlying motivational schema on performance was investigated in a study by Levesque & Pelletier (2003) who demonstrated that priming autonomous or controlled orientations led to outcomes similar to those who were dispositionally, or chronically, oriented towards these forms of motivation from SDT. This gives preliminary support for the theory that implicit motivational constructs provide unique prediction of behaviour. Furthermore, as priming affected implicit autonomous and controlled motivational orientations to give similar behavioural effects as individuals with chronic orientations, this may reflect the more dispositional, generalized nature of the implicit system. For this reason, the study of a variety of behaviours was deemed appropriate in the current research to assess whether implicit measures of motivation from SDT provided an account of autonomous and controlled motivation that generalized over different behaviours.

Combining SDT and implicit measures

Several articles have reported the role of implicit processes and the predictive validity of associated measures in the context of SDT (e.g., Banting, Dimmock, & Lay, 2009; Burton, Lydon, D'Alessandro, & Koestner, 2006; Levesque, & Brown, 2007; Levesque, Copeland, & Sutcliffe, 2008). For example, Burton *et al.* (2006) conducted research into the differential effects of two forms of autonomous motivation, intrinsic and identified, on students well-being and exam performance. Their research was particularly important due to their development of an implicit measure of autonomous motivation based on a lexical decision task. Participants' response latencies in classifying words related to intrinsic motivation, identified regulation, or neutral valence non-words were taken as a measure of their implicit autonomous motivation. Results supported the significant contribution of implicit autonomous motivation in the prediction of later exam performance. The implicit measure provided better prediction of final exam grades compared to explicit measures. Essentially, the faster the response times to intrinsic and identified words, indicating an implicit intrinsic motivation, the higher the final grade. This provides preliminary support for the predictive validity of implicit measures of autonomous motivation. However, there were notable limitations such as the adoption of a relatively rudimentary measure of implicit motivation compared to more widely used and developed implicit measures, such as the GNAT and implicit association test (IAT; Greenwald, McGhee, & Schwartz, 1998), and the need to study the relative contributions of implicit and explicit measures in the context of dual-systems paradigms that provide an explanatory system for incorporating both types of measure of motivation. It is reassuring that, even with these limitations, a significant effect of implicit motivation was shown.

Levesque and Brown (2007) extended research into the relationship between implicit measures and SDT by looking at a possible moderator (*mindfulness*) of implicit motivational self-concept. Mindfulness, or the degree to which a person has a dispositionally elevated level of attention and awareness, was hypothesized to moderate the effect of implicit motivation. In order to investigate the proposed relationships, Levesque and Brown developed an IAT (Greenwald *et al.*, 1998) to measure participants' implicit motivation along the dimension set out in PLOC continuum, which was reliable and valid. In a second study, the authors demonstrated that an implicit autonomous motivational orientation only provided significant prediction of day-to-day motivation for individuals with lower mindfulness. Furthermore, higher mindfulness resulted in higher levels of autonomously motivated behaviour, regardless of implicit orientation. Levesque and Brown's (2007) research provides further support for the role of implicit processes and measures in research into SDT. However, the IAT prevents separate indices of implicit autonomous motivation and implicit controlled motivation being measured. As the forms of motivation from SDT are not necessarily orthogonal and individuals may demonstrate either autonomous or controlled motivation at different occasions, the use of an implicit measure that allows separate measurement of autonomous and controlled motivation is preferable. Furthermore, the improved scoring algorithm, which is shown to reduce the effects of possible confounding variables (Cai, Sriram, Greenwald, & McFarland, 2004), was not used in their analyses.

The reflective-impulsive model

A model that draws these strands of research together is Strack and Deutsch's (2004) Reflective-Impulsive Model (RIM). The model encompasses the strengths of previous theories and models, such as Fazio and Towles-Schwen's (1999) Motivation and Opportunity as Determinants (MODE) model, to provide a more complete account. In the RIM, the reflective system elicits behaviour as a result of an explicit decision process based on consideration of knowledge, facts, and values; this process relies on higher-order, control resources. The impulsive system, as a result of reflective or perceptual input, activates schemata underpinned by associative networks and spreading activation (see Back, Schmulke, & Egloff, 2009). The RIM model provides a parsimonious account of both impulsive/implicit and reflective/explicit processes (Hofmann, Friese, & Strack, 2009). Another relevant benefit of this model is the incorporation of motivation orientations into the processes. Essentially, the impulsive system may be orientated towards approach or avoidance. Furthermore, compatibility between the dominant motivation orientation and environmental or reflective input facilitates processing. Conceptually, the RIM provided the basis for the model posited in current research (see Figure 1). In the model, implicit and explicit forms of motivation (such as the motivational orientations from SDT) are purported to lead to independent pathways to behaviour. However, the explicit system is also modelled to provide prediction of behaviour via intention. As intending is a key component of the reflective route, it is likely that measures of intention will provide some mediation of explicit measures of motivation (e.g., autonomous and controlled forms of motivation from SDT). This is unlikely to be the same for the impulsive system, which does not have intention as part of its route to behaviour. This distinction maps onto behaviours, such that those behaviours that are inherently planned (e.g., need scheduling) will be better predicted by measures tapping into the reflective system. In contrast, behaviours that are more spontaneous or automatic (e.g., 'spur-of-the-moment' decisions to do something) will be better predicted by measures tapping into the

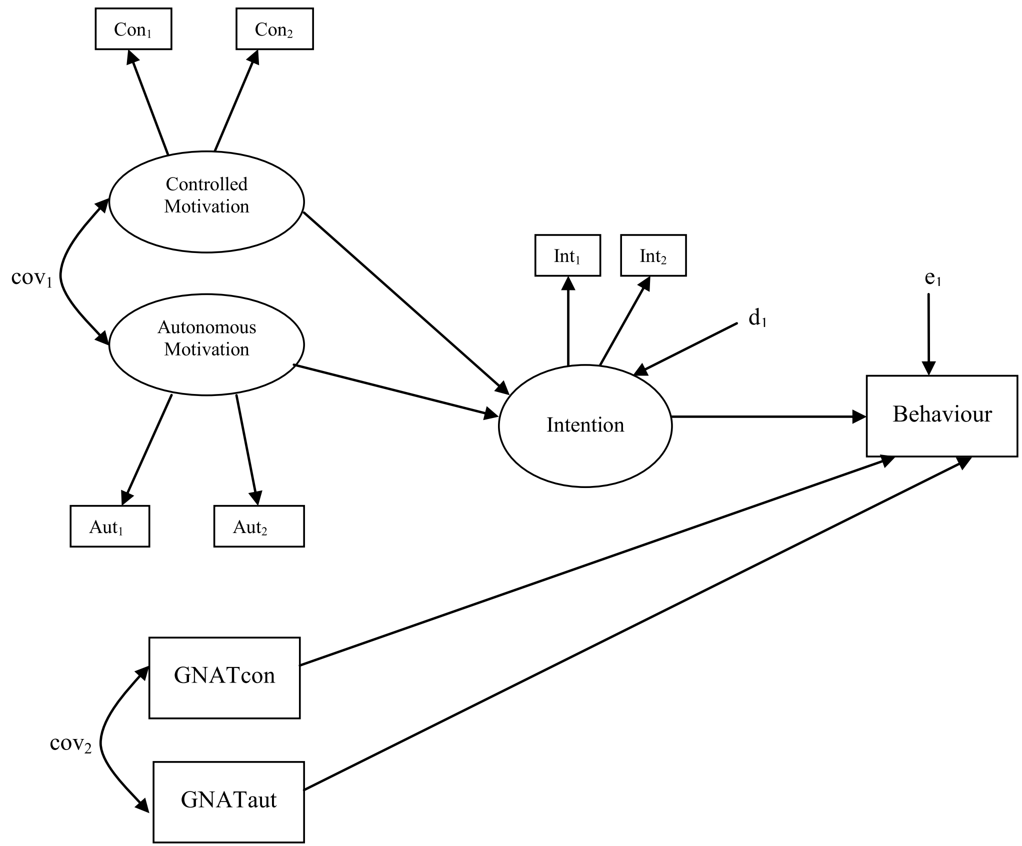

Figure 1. Hypothesized structural equation model for the predictive effects of implicit and explicit measures on behaviour. *Note*. Int, observed intention items indicating the latent intention measure; Con, explicit items indicating the latent controlled motivation measure; Aut, explicit items indicating the latent autonomous motivation measure; d, disturbance – represents error in prediction for a latent variable; e, error in prediction – represents error in prediction for an observed (non-latent) variable; cov, covariance – represents the covariance between the latent or observed variables; GNATaut, the autonomy GNAT measure; GNATcon, the controlled GNAT measure. GNAT measures were also calculated using the *D*-score.

impulsive system. In keeping with Strack and Deutsch's proposal, the current research will use the RIM as a framework to explain the relative effects of implicit and explicit forms of autonomous and controlled motivation by means of the impulsive and reflective systems, respectively.

The present study

The aim of the current research was to evaluate a dual systems model that examined the role of implicit processes, measured by the GNAT, and explicit measures of the forms of motivation from SDT in the prediction of behaviour in a number of health-related contexts. To begin, a model was developed (see Figure 1) consistent with existing models in the literature (Back et al., 2009). From this, a number of hypotheses were derived. On the lower far left of the model, the GNAT measures represent implicit autonomous and controlled forms of motivation. These measures were anticipated (H_1) to provide direct, independent prediction of behaviour. This was based primarily on previous research in which implicit measures have provided prediction separate from explicit measures (Czopp, Monteith, Zimmerman, & Lynam, 2004). Furthermore, dual systems models posit that in certain circumstances, and for certain behaviours, the impulsive system provides direct prediction (e.g., for behaviours that are more spontaneous, or when cognitive load is high). On the upper far left, the composite items of explicit autonomous and explicit controlled motivation are positioned. These measures were hypothesized (H_2) to predict intention, which will in turn act as a mediator (H_3) of the relationship between explicit measures and behaviour. These hypotheses were based on the RIM model, which posits intending as a final process in the reflective system. Furthermore, complementary theories such as the theory of planned behaviour (Chatzisarantis, Hagger, Smith, & Sage, 2006; Orbell & Hagger, 2006) also include intention as a mediator of the link between explicit future expectations regarding future behaviour and actual behaviour, while suggesting explicit measures do not provide a direct prediction of behaviour. Therefore, it was anticipated that explicit autonomous and controlled motives would not directly predict behaviour (H_4). Finally, the model presents intention as being the most proximal influence on behaviour. Therefore, intention was proposed (H_5) as a direct predictor of behaviour based on theories, such as the RIM and the theory of planned behaviour.

Method

Participants

Undergraduate students ($N = 162$; 101 female, 61 male, $M_{\text{age}} = 22.12$, range: 18–44 years) from the University of Nottingham, UK volunteered to participate in the current study. Twelve participants failed to complete the follow-up questionnaire due to absence or failure to contact, leaving 150 participants' data available for analysis. Students were contacted via e-mail with details of the study and the opportunity to participate. There was a $6 inconvenience allowance allocated for participation. The study protocol was approved by the School of Psychology Ethics Committee at the University.

Measures

Go/no-go association task

Two GNATs were used to gain separate implicit measurement of autonomous and controlled motivation. The GNAT is derived from the IAT and is based on the same underlying principles as other response-competition implicit tasks in that stronger associations will facilitate categorization performance. Participants were first presented with instructions concerning the task. In one part of the test, participants responded when words presented belonged to either label 'self' or 'intrinsic'[2] (or extrinsic, depending on which version they were completing), and in another part of the task, participants responded to the labels 'others' and 'intrinsic' (or extrinsic). Words representing autonomous forms of motivation (choice, free, spontaneous, willing, authentic) and controlled forms of motivation (pressured, restricted, forced, should, controlled) and words relating to 'Self' (I, me, my, mine, self) and 'Others' (others, they, them, their, theirs) were taken from research conducted by Levesque and Brown (2007), in which they were shown to offer a distinct representation of the two motivational orientations. Responses were made within a short response-time window (700 ms), which was within the range suggested by Nosek and Banaji (2001). A 250 ms inter-stimulus interval separated trials, during which participants received feedback regarding the previous trial: either a green star for correct, or a red 'X' for incorrect. The GNAT consisted of two main blocks, each split into 20 practice trials, followed by 80 test/critical trials. During the critical blocks, participants saw two labels; participants were instructed to press the space bar ('go' response) if the presented word stimuli matched either or the labels, or inhibit a response ('no-go') if not. Stimuli from the target, category, or distracter lists appeared randomly. Given the interest in target responses over distracter, there were twice as many target trials compared to distracter trials – to increase reliability, as only target trials were used for analyses. Results from both GNAT measures were calculated using the *D*-score (see Boldero, Rawlings, & Haslam, 2007; Teachman, 2006).

Perceived locus of causality[3]

Explicit autonomous and controlled motivation from SDT was measured through an adapted version of Ryan and Connell's (1989) PLOC scale during the first wave of data collection. Participants were given a common stem for each behaviour (e.g., 'I control calorie intake to control weight because . . . ' or 'I exercise regularly (three to four times a week) because . . . '). Participants were then asked a series of reasons, relating to the various forms of motivation from SDT (e.g., autonomous: 'I enjoy controlling my calorie intake to control weight'; controlled: 'I will feel guilty if I do not control my calorie intake to control my weight'). These were measured on a 4-point Likert-type scale ranging from *not true at all* (1) to *very true* (4).

The PLOC scales were then converted into weighted composite items representing separate autonomous and controlled indices (e.g., Guay, Mageau, & Vallerand, 2003; Hagger, Chatzisarantis, & Harris, 2006). Autonomous items were calculated as the sum of a randomly selected intrinsic motivation item weighted by a factor of two and a randomly selected identified regulation item. This was repeated for the remaining intrinsic and identified regulation items resulting in three items representing explicit autonomous motivation. Controlled items were calculated as the sum of a randomly selected extrinsic motivation item, weighted by a factor of two, and a randomly selected introjected

[2] *It was however made clear to participants exactly what was meant by the terms 'intrinsic' and 'extrinsic' and this was used to represent the autonomous-controlled distinction for participants because it was more intuitive means of representing the distinction between the two broad terms of motivation from the theory.*

[3] *The full questionnaire including all explicit measures is available on request from the first author.*

regulation item. This was repeated for the remaining extrinsic motivation and introjected regulation items to produce three items representing explicit autonomous motivation.

Intention

Intention to participate in behaviours was measured from responses to two items (e.g., 'I intend to use stairs instead of a lift or escalator in the next 4 weeks' and 'I plan to wash my hands after going to the toilet in the next 4 weeks'). Responses were given on 7-point Likert-type scales from *unlikely* (1), to *very likely* (7). Scores were then used as latent variables for each of the behaviours.

Follow-up

After 4 weeks, participants self-reported their performance for each of the 20 behaviours (e.g., 'In the past 4 weeks, how often have you eaten at least 5 portions of fruit and vegetables?') using 7-point Likert-type scales from *never* (1) to *almost every day* (7). The criterion and concurrent validity of this measure has been verified against objective measures (Hagger *et al.*, 2006).

Procedure

All participants were tested in isolation in a sound-proofed experimental cubicle. After sufficient information was given, and informed consent gained, they were asked to follow study instructions presented on a 14″ CRT computer screen. Participants completed GNATs administered using E-Prime software after completing 20 standard practice trials. The GNAT stage of the study lasted approximately 5 min. Order of GNAT completion was counterbalanced. After completion of the implicit measures, participants were asked to complete the explicit measures which typically lasted 20 min. Trials were fully counterbalanced so that half the participants conducted either implicit measure first, while the other half conducted the explicit measures first. There was no significant difference in scores between those who completed either GNAT first. Contact details were taken to expedite the collection of follow-up data 4 weeks later. Participants were contacted via e-mail or telephone, depending on personal preference, so they could provide their self-reported participation in the 20 target behaviours. After completion of the follow-up measure, a full debrief of the study was offered and any further questions answered to the satisfaction of all participants.

Data analyses

Data were analysed using structural equation modelling (SEM), using the EQS program (Version 6.1; Bentler, 2004), using a robust maximum likelihood method (Satorra & Bentler, 1988) based on the variance/covariance matrices of each dataset. The proposed model was estimated separately for each of the 20 behaviours. The models were non-standard SEM models that included both latent and non-latent variables (Bentler, 1989). Items for the autonomous and controlled explicit forms of motivation indicated latent variables and, as is convention in SEM analyses, one factor loading was fixed at unity to define the factor scale. The GNAT measures of autonomous and controlled motivation were included in the model as observed predictor variables. The latent and observed exogenous predictor variables were allowed to co-vary. Goodness-of-fit of the estimated models was assessed through multiple criteria: the comparative fit index (CFI), the non-normed fit index (NNFI), and the root mean square error of approximation (RMSEA). These fit indices were used because they display restricted random variation under model misspecification and a small sample size (Fan, Thompson, & Wang, 1999). Values approaching .95 for the CFI and NNFI, and 0.5 for the RMSEA are indicative of an adequate fit between model and covariance matrix (Hu & Bentler, 1999). A bootstrap resampling analysis was also conducted for each model to further check that models were not adversely affected by artifacts such as sample size and non-normality, and ensure model robustness. In these analyses, datasets for each behaviour were taken as the 'population', and samples were drawn randomly from this. The bootstrap procedure was replicated 999 times for each behaviour.

Results

No data were removed due to failing to meet improved scoring algorithm criteria (see Greenwald, Nosek, & Banaji, 2003). Overall, the fit statistics of the models across all behaviours met the multiple criteria for adequately fitting models (median SB-χ^2 = 21.58, median $p > .05$; median CFI = .99; median NNFI = .97; median RMSEA = .06).

Structural equation models

Figure 1 presents the general structural model for each of the behaviours and coefficients for behaviours are presented in Table 1.[4] Results indicated that implicit measures of autonomous and controlled motivation typically exhibited non-significant effects on behaviour (overall median beta for all behaviours $\text{GNAT}_{\text{intrinsic}} = .04$; $\text{GNAT}_{\text{extrinsic}} = -.03$). However, the implicit measure of autonomous motivation significantly predicted tooth brushing ($\beta = -.21$, $p < .05$) and posture ($\beta = .15$, $p < .05$) behaviours. The implicit measure of controlled motivation significantly predicted alcohol consumption ($\beta = -.20, p < .01$),[5] and reduction in caffeine consumption ($\beta = -.15, p < .05$). These effects of implicit measures were direct and independent of intentions. However, as few behaviours were significantly predicted by implicit measures, this provided limited support for the hypothesis (H_1). The effect of explicit measures of autonomy on intention was significant for 15 behaviours (median $\beta = .62$), while controlled indices provided significant prediction for 10 behaviours (median $\beta = .31$), demonstrating a pervasive effect for the explicitly measured forms of motivation on intentions to perform the behaviour in future, providing substantive support for this hypothesis (H_2) for the majority of the behaviours. Intention mediated the path from explicit measures of autonomous motivation to behaviour for five behaviours (median $\beta = .15$), and nine behaviours for the controlled path (median $\beta = .19$), so the hypothesis (H_3) was partially supported. Contrary to our hypothesis (H_4), the explicit controlled motivation measure significantly and directly predicted four behaviours (median $\beta = -.22$), and the explicit

[4] *Correlation matrices between all factors for all behaviours are omitted in the interests of conserving space. They are available from the first author on request.*

[5] *The direction (positive or negative) of the beta depends on the valence of the behavioural measure and the psychological measure. In this example, motivation to drink within limits should be negatively related to alcohol consumption, whereas if the motivational measure referred to motivation to drink ad libidum then it should have been positively correlated.*

Table 1. Standardized coefficients of the paths between implicit and explicit measures and behavioural outcome

Behaviour	Int →Beh	Cont →Beh	Auto →Beh	GNATaut →Beh	GNATcon →Beh	Cont →Int	Auto →Int	GNATaut →Int	GNATcon →Int	Cont →Int →Beh	Auto →Int →Beh	GNATaut → Int →Beh	GNATcon → Int →Beh	R^2_{INT}	R^2_{BEH}
Calories	.404**	.150	.227**	.026	-.054	.476**	.362**	.056	.117*	.193**	.146**	.023	.047	.542	.464
LowFat	.627**	.143	−.090	−.023	.036	.232	.505**	.024	.013	.145	.317**	.015	.008	.474	.430
Belt	.538**	−.178	.036	.126	−.087	.451**	.022	−.041	−.004	.242**	.012	−.022	−.002	.218	.251
Sleep	.036	−.254*	.169	.065	−.118	.145	.541**	.025	−.027	.005	.020	.001	−.001	.377	.069
Alcohol	.013	.161	.084	.037	−.202**	.040	.656**	−.132*	.021	.001	.008	−.002	.000	.481	.104
Condoms	.277**	.062	−.319**	−.019	.024	.522**	.131	.030	.047	.145	.036	.008	.013	.363	.109
HandsFood	.381**	−.014	.312**	.065	−.083	.368**	.330**	−.071	.199**	.140**	.126**	−.027	.076*	.404	.353
Walk	.254*	.054	.229	.019	−.022	.191*	.559**	−.002	.003	.048	.142*	−.001	.001	.392	.202
Teeth	.280*	−.181*	.039	−.211*	−.039	.006	.303**	−.117	.062	.002	.085*	−.033	.017	.096	.149
JunkFood	−.094	−.049	−.390**	.052	−.008	.263**	.514**	.083	.102	−.025	−.048	−.008	−.010	.435	.221
Caffeine	−.142	.384**	−.609**	−.063	−.146*	.042	.768**	−.027	−.008	−.006	−.109	.004	.001	.640	.284
Stairs	.167	.005	.202	.047	−.025	.173*	.623**	−.130*	−.019	.029	.104	−.022	−.003	.461	.113
HandsToilet	.732**	−.145	.079	.033	−.076	.363**	.184	−.032	.124	.266*	.135	−.024	.091	.221	.496
Supplement	.699**	.126	−.056	.043	.065	.053	.839**	.033	.059	.037	.586**	.023	.042	.764	.551
Exercise	.517**	.045	.015	.027	−.024	.185**	.764**	.110*	.025	.096*	.395**	.057	.013	.709	.305
Planwork	.304**	−.102	.055	.030	−.070	.084	.454**	−.048	−.023	.025	.138**	−.015	−.007	.244	.108
Posture	.411**	−.321**	.208	.154*	−.102	.262**	.618**	−.117*	−.045	.108	.254	−.048	−.018	.634	.244
SodiumSalt	−.014	.121	−.533**	.061	.032	−.001	.812**	.049	.074	.000	−.011	−.001	−.001	.658	.226
Fibre	−.106	.070	.440*	.037	.057	.019	.812**	−.014	.065	−.002	−.086	.001	−.007	.675	.158
FruitVeg	.393*	−.095	.271	.095	.071	−.032	.840**	−.061	−.032	−.013	.330**	−.024	−.012	.679	.367

Note. Int, behavioural intention; Cont, controlled measure (explicit); Auto, autonomous measure (explicit); GNATaut, autonomous GNAT; GNATcon, controlled GNAT; Calories, reducing calorie intake; Low fat, eaten low-fat foods; Belt, wearing a seatbelt; Sleep, good night's sleep; Alcohol, drinking within daily limits; Condoms, using a condom; HandsFood, wash hands before preparing food; Walk, walking to take time-out or relax; Teeth, cleaning teeth; JunkFood, avoided junk food; Caffeine, reducing caffeine/legal stimulant intake; Stairs, take stairs instead of lift/elevator; HandsToilet, wash hands after toilet; Supplement, using supplement to maintain healthy diet; Exercise, exercised regularly; PlanWork, plan work to avoid stress; Posture, sat with correct posture; SodiumSalt, avoid foods high in sodium/salt; Fibre, eaten sufficient dietary fibre; FruitVeg, eaten at least five portions; $^{*}p < .05$; $^{**}p < .01$.

Table 2. Goodness-of-fit statistics for structural equation models of implicit and explicit predictors for behaviours

	Goodness-of-fit statistics				Bootstrap statistics CFI			
Behaviour	SB-χ^2	CFI	NNFI	RMSEA	*M*	CI_{95}(LB)	CI_{95}(UB)	Skewness
Control calories to control weight gain	21.50	.990	.975	.054	.97	.94	.99	−.67
Eat low-fat foods	36.27**	.965	.916	.980	.94	.91	.97	−.41
Wear a seat belt in a taxi or car	15.47	.998	.995	.014	.94	.85	.100	−1.13
Get a good night's sleep	16.87	.991	.979	.029	.93	.85	.99	−1.26
Drink within alcohol limits	22.26	.986	.967	.057	.96	.92	.99	−.72
Wear condoms	9.93	1.000	1.00	.000	.98	.95	1.00	−1.97
Wash hands before handling food	11.87	1.000	1.017	.000	.97	.94	1.00	−.85
Go for walks to relax or unwind	22.66	.976	.942	.059	.93	.88	.98	−.56
Brushed your teeth	13.54	1.000	1.00	.000	.95	.87	1.00	−.99
Avoided eating junk food	19.99	.989	.973	.047	.96	.92	.99	−.51
Reduced consumption of caffeine	14.66	1.000	1.00	.000	.97	.94	1.00	−1.18
Walked stairs instead of using lift or elevator	34.26**	.956	.894	.093	.93	.87	.97	−.73
Washed hands after using toilet	22.33	.969	.926	.057	.92	.86	.97	−6.44
Taken supplements to maintain healthy diet	25.15*	.989	.974	.067	.97	.95	.99	−.70
Exercised regularly (three to four times per week)	42.56*	.953	.888	.111	.94	.90	.97	−.54
Planned work in advance	21.66	.983	.959	.055	.95	.90	.99	−.65
Sat with the correct posture	16.35	.997	.993	.025	.97	.93	.99	−.59
Avoid foods high in sodium or salt	14.87	.1000	.100	.000	.98	.95	1.00	−.64
Eaten sufficient foods dietary fibre	36.58**	.950	.880	.098	.92	.87	.96	−.54
Eaten five portions of fruit or vegetables per day	33.10**	.967	.921	.090	.94	.91	.98	−.21**

Note. Model degrees of freedom = 15; CFI, comparative fit index; NNFI, non-normed fit index; RMSEA, root-mean squared error of approximation; $^*p < .05$; $^{**}p < .01$.

measure of autonomous motivation significantly predicted six behaviours (median $\beta = -.32$). Finally, as hypothesized (H_5), intention significantly predicted 13 behaviours (median $\beta = .40$). Intention therefore predicted the majority of the behaviours.

Bootstrap procedure

The average CFI with 95% confidence intervals (CI_{95}) and skewness statistics for the bootstrapped models for each behaviour are given in Table 2. The 999 bootstrapped replications resulted in a successful fit of the specified model for all behaviours. The average CFI exceeded the cut-off criterion for analysis. In addition, the upper-bound CI_{95} for the CFI reached unity (median = .91), and the lower bound was above the minimum acceptable criterion of .90 (median = .99) for all behaviours. Furthermore, the distribution of the CFI was significantly and negatively skewed for the majority of behaviours (median = $-.69$), except fruit and vegetable consumption ($p < .05$). This is desirable in bootstrap analysis as it indicates a large number of well-fitting models in replicated samples. Overall, the bootstrap procedure provided support for the robustness of the hypothesized model.

Discussion

The aim of the current research was to assess the suitability of a dual systems model (see Strack & Deutsch, 2004) as a framework for investigating the effects of implicit and explicit measures of autonomous and controlled motivation on behaviour. Measures of implicit autonomous and controlled motivation were developed based on the GNAT. A series of hypotheses based on the premises of a dual systems model were proposed and systematically tested in a prospective study of 20 health-related behaviours.

Our first hypothesis (H_1) proposed that implicit measures of motivation would provide a unique, independent prediction of behaviour. Overall, there was limited support for the direct effect of implicit measures of motivation on behaviour across the 20 behaviours. There was the significant, independent effect of implicit autonomous motivation for the tooth brushing and posture behaviours, and for implicit controlled motivation in the alcohol consumption and caffeine reduction. To some extent, this outcome reflects the mixed findings in the research on implicit influences on behavioural engagement (see Levesque et al., 2008 for review). Therefore, the impulsive route in the proposed dual systems model was only supported in a small subset of behaviours in the current research. This likely reflects the type of motivational process typically involved in the enaction of the behaviours. Behaviours that require less planning, or are more spontaneously or automatically performed were better predicted by the implicit measures of motivation.

Further hypotheses related to the predictive role of explicit measures of motivation from SDT and intention on each of the behaviours. Dual systems models (Strack & Deutsch, 2004) and previous research (Ajzen, 1991, 2002; Hagger et al., 2006) suggested that explicit measures should predict intention (H_2); this was the case for over half of the behaviours for autonomous motivation, and for half of the behaviours for controlled motivation. Furthermore, support was found for the hypothesis that intention would mediate the explicit measures of autonomous motivation to behaviour link for over half of the behaviours (H_3). Overall, this gives some support for the proposed dual systems framework, a key premise of which is that both impulsive and reflective systems should each provide unique contribution to the prediction of behaviour, but the reflective system is mediated by variables that represent deliberation and planning such as intention. However, contrary to our hypothesis (H_4), explicit measures did provide direct prediction of several behaviours. A possible explanation for this was outlined by Hagger et al. (2006). Essentially, it is possible that the direct relations between motivational orientations and behaviour are not adequately captured by measures of behavioural intention, or may indeed reflect more spontaneous, less-conscious influences of motives on performances.

Generally, the prediction of behaviour by implicit measures of motivation suggests that initiation of behaviour is influenced by non-conscious processes. These processes are likely to have been reinforced through previous experiences and outcomes (Strack & Deutsch, 2004). In the current study, our GNAT measures provided generalized implicit measures of individuals' autonomous and controlled motivation orientation. Therefore, the negatively valenced prediction of alcohol consumption by our implicit measure of controlled motivation likely means that a tendency to be controlled by external factors will lead to less alcohol consumption. This is probably because people who have a predominant controlled-oriented motivational orientation are most likely to have had alcohol abstinence externally reinforced in previous situations. Similarly, a positive prediction of posture by implicit measures of autonomous motivational orientation indicates a tendency to attain a correct sitting posture through previous autonomous experiences which emphasize the personally referenced value attached to the outcome of sitting in the correct position (e.g., maintaining good health, minimizing pain). Essentially, an autonomously oriented individual may have incorporated correct posture into their repertoire of personally endorsed behaviours. For example, toothbrushing is habitual and performed without planning or conscious deliberation, and is therefore more likely to be predicted by implicit measures of motivation from SDT. Predictions by explicit measures likely reflect behaviours that are performed as a result of deliberative decision-making processes to behave in a particular way. For example, prediction of reducing caffeine intake by the explicit measure of controlled motivation indicates a tendency to reduce the intake of caffeine as a result of conscious, deliberative factors that are externally endorsed. Washing hands before handling food may be explained in terms of explicitly measured forms of autonomous motivation as individuals are likely to have reflected on the benefits of hand hygiene and the associated personally valued outcomes of the behaviour. The role of intention as a mediator between the explicit measures of motivation and behaviour is indicative of behaviours for which planning serves an important function in the performance of the behaviour (e.g., exercising, taking a walk to provide a break from work).[6]

There are several possible explanations for why implicit measures of motivation from SDT did not provide predictions for more behaviours. First, the use of a self-reported means to measure behaviour may have introduced systematic bias towards prediction by explicit measures. By their very nature, self-report measures are likely to assess more reflective processes, which may correspond closely with explicit measures of motivation and lead to a greater propensity for those measures to account for variance in the behaviours. Second, related to this, it is possible that many of the behaviours were those that required a great deal of deliberation and reflection. For instance, ‘planning work’ requires an obvious reflective process, and ‘exercising’ also requires considerable planning such as getting the relevant kit together, packing a bag, and making time in one’s schedule. It may be the case that implicit processes exert greater influence for certain types of behaviour. For instance, behaviours that require more spontaneous decision making, such as having a further drink at the pub when offered, rather than minimizing alcohol intake, or being tempted by a tasty-looking food (e.g., chocolate), instead of eating fruit and vegetables. To this extent, health interventions could focus on different systems depending on the type of behaviour that interventionists are targeting for change. For example, targeting behaviours that are more spontaneously enacted, and providing strategies to overcome the sudden urge or desire to enact them, may increase the efficacy of intervention strategies. The current research, therefore, also highlights the

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[6] *Brushing your teeth is a routine that is carried out on a regular basis, with comparatively less forethought or planning than other behaviours such as stair climbing. To this extent, toothbrushing should fall into the domain of the impulsive system, given its automaticity. In contrast, climbing stairs may depend on a number of reflective processes. For instance, if someone is actively trying to increase light exercise in the day, is rushed to get somewhere, or simply has an ache in their leg making them reconsider whether climbing stairs is possible, these contingencies may require more cognitive involvement in the decision-making process and making it a more reflective process.*

importance of assessing on the type of behaviour being focused on in the intervention. Furthermore, the GNAT may measure more global constructs of motivation orientation, rather than behaviour-specific. Compared to the measures such as the PLOC (Ryan & Connell, 1989), which was a direct measure of participants' motivation and made explicit reference to each behaviour, the implicit measures likely represent dispositional motives operating at a global level of generality. As a result, the effects of such measures on specific behaviours are likely to be comparatively weak relative to the specific, explicit measures.[7]

Though the current study was the relatively small sample size; however, bootstrap statistics should help with this issue. Future research could incorporate related behaviours into the structural model to provide prediction of the outcome variable.[8] A further limitation of the current study is that the GNAT measure of motivational orientations developed for this study may not fully or adequately capture the implicit motives from SDT. Although the GNAT was developed and analysed according to previous research and adopted recommended algorithms, results cannot unequivocally support the predictive validity of this measure without further corroborating evidence. It should be noted, the literature has been impeded by a lack of consistency in the types of measurement instruments to tap implicit processes. This appears to be the case for studies using implicit processes in SDT. For example, the measure used by Burton et al. (2006) adopted a lexical decision task, which is structurally different to the GNAT, while Levesque & Brown (2007) used an IAT which did not permit the distinction between autonomous and controlled forms of implicit motivation separately; rather, the two constructs were conceptualized as a bipolar continuum. Therefore, although this research may tap the same construct, the inconsistencies in the measures and their inherent drawbacks mean that it is difficult to draw definitive comparisons across the literature as to the effects of implicit motivational constructs on behaviour. The current research is therefore important in being the first to incorporate separate measures of implicit autonomous and controlled forms of motivation; however, more research is needed to provide further corroboration. A further possibility for future research may be to measure the effect of priming autonomous motivation and controlled motivation and examining the effects on implicit measures. As priming activates implicitly held knowledge structures and schema, it should, in theory, affect the perceptions measured by implicit measures. This would provide possible further validation of the implicit measure, as the measure should be affected in the same direction as the prime.

Conclusion

In conclusion, the current study provided some limited support for the use of implicit measures of forms of motivation from SDT and the adoption of a dual-process model of behaviour with respect to these forms of motivation on health behaviours. Though present data demonstrate that behavioural prediction is far more effective through explicit measures of motivational constructs from SDT, there were some behaviours

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[7] *In relation to the present research, effects of the GCOS were also tested and found to be relatively weak alongside the implicit and explicit measures. Though a behaviour-specific implicit measure may yield different or larger effects, the implicit motivation variable, measured here as a generalized construct, still has a pervasive effect on some of the behaviours.*

[8] *We thank an anonymous reviewer for this idea.*

in which implicitly measured forms of motivation affected behaviour. The bias towards intentional, planned behaviours in the present study means that abandoning implicit measures on the basis of current data is premature. Future research should take this into account when investigating implicit measures of motivation and behaviour. While theories of goal-oriented behaviour have traditionally adopted an explicit approach, the current research follows a growing trend in the literature demonstrating the existence and importance of implicit processes underlying behaviour. To this extent, further research into comparison of competing implicit measures of motivation is necessary, as well as other implicit paradigms, such as priming.

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