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The Motivational Thought Frequency scales for increased physical activity and reduced high-energy snacking

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Abstract

Objectives: The Motivational Thought Frequency (MTF) Scale has previously demonstrated a coherent 4-factor internal structure (*Intensity, Incentives Imagery, Self-efficacy Imagery, Availability*) in control of alcohol and effective self-management of diabetes. The current research tested the factorial structure and concurrent associations of versions of the MTF for increasing physical activity (*MTF-PA*) and reducing high-energy snacks (*MTF-S*).

Design: Study 1 examined the internal structure of the MTF-PA and its concurrent relationship with retrospective reports of vigorous physical activity. Study 2 attempted to replicate these results, also testing the internal structure of the MTF-S and examining whether higher MTF-S scores were found in participants scoring more highly on a screening test for eating disorder.

Methods: In Study 1, 626 participants completed the MTF-PA online and reported minutes of activity in the previous week. In Study 2, 313 participants undertook an online survey that also included the MTF-S and the Eating Attitudes Test (EAT-26).

Results: The studies replicated acceptable fit for the 4-factor structure on the MTF-PA and MTF-S. Significant associations of the MTF-PA with recent vigorous activity and of the MTF-S with EAT-26 scores were seen, although associations were stronger in Study 1.

Conclusions: Strong preliminary support for both the MTF-PA and MTF-S was obtained, although more data on their predictive validity is needed. Associations of the MTF-S with potential eating disorder illustrate that high scores may not always be beneficial to health maintenance.

Data availability

Data and analysis scripts for studies in this paper can be accessed at [github.com/jon-may/MTF-](https://github.com/jon-may/MTF-PA)

[PA](https://github.com/jon-may/MTF-PA)

Acknowledgements

Funding for participant payments was provided by the relevant university schools. A National Health and Medical Research Council of Australia Career Development Fellowship is held by Jason Connor (1031909).

Conflicts of Interest

No potential conflicts of interest.

Development of the Motivational Thought Frequency and State Motivation Scales for Physical
Activity

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Introduction

Low levels of activity and diets high in sugars and fat contribute to overweight and obesity, which in turn are common risk factors for prevention of non-communicable diseases (World Health Organization, 2014). Motivations comprise an important potential modifiable target for these risks.

Motivations can be seen as desires to reach a goal state—cognitive-affective events that are conscious, although their determinants are sometimes outside awareness (Kavanagh, Andrade & May, 2005). In recent years, much of the research on predictions of health maintenance behaviours from motivations has examined concepts from self-determination theory (Deci & Ryan, 1985, 2000; e.g. Ng et al., 2012; Teixeira et al., 2012) or from the theory of planned behaviour (Ajzen, 1991; Courneya & McAuley, 1995). The former focuses on the source of motivation (the extent it is autonomous or intrinsic); the latter on key contributors to motivation (attitudes, perceived norms, perceived behavioural control) rather than on the degree of motivation that may result. While there is substantial evidence attesting to the importance of these factors for functional behaviour change (Hackman & Knowlden, 2014; Ng et al., 2012; Sanaeinasab et al., 2019), there may also be a need to consider the extent that the resultant motivation is affectively intense and frequently in attention. We argue that this end state constitutes a plausible driver of maintained health maintenance behaviours in the natural environment.

While highly valued life goals often appear stable over time, our proximal motivation levels to achieve them can fluctuate significantly (Minami, Yeh, Bold, Chapman, & McCarthy, 2014; Morgenstern, Kuerbis, Houser, Muench, Shao, & Treloar, 2016). For example, we may be highly committed to getting fit or improve our diet, but not be focused on that motivation because of

other valued goals that are inconsistent with it (e.g. to rest or have a cream cake), or that simply take attentional priority, such as a problem at work (Hagger, Koch, Chatzisarantis, & Orbell, 2017; Kavanagh, Andrade, & May, 2005). To the extent such variability occurs, it creates challenges for assessment. Reports of averaged or typical experiences are notoriously prone to error (Sallis & Saelens, 2000; Tversky & Kahnemann, 1974), unless they are relatively stable over time. Repeated assessments of state motivation provide a more precise measurement, but soon become burdensome for the respondent. A more practical solution may involve retrospective reports that target the frequency of motivational cognitions. Such measures would avoid error associated with averaging, and minimise recall biases if focused on recent experiences (Kavanagh et al., 2013).

A new measure of motivation could also take account of recent empirical advices in understanding the nature of motivational cognitions that have greatest impact. Converging evidence shows that intense desires for goals typically involve vivid, multisensory imagery (May, Kavanagh, & Andrade, 2015)—an observation that is highly consistent with research showing that mental imagery is tightly related to affect through its simulation of actual experience (Holmes & Mathews, 2005). Imagery already has a long tradition of research and application in predicting and enhancing performance in physical activity, sports and exercise (Chan & Cameron, 2012; Hall & Rodgers, 1989; Hausenblas, Hall, Rodgers, & Munroe, 1999). Research has often focused on optimising physical movements, but the ability of imagery to strengthen motivation for practice and effort is also recognised (Cumming & Williams, 2012).

Assessment of motivational imagery may be optimised by reference to the Elaborated Intrusion theory of desire (Kavanagh et al., 2005). This theory unpacks determinants of motivational imagery, and highlight ways it can be enhanced or weakened. Motivational images are typically triggered automatically by associated thoughts, sensations or contexts. If they

capture ongoing attention and are elaborated in working memory (Baddeley & Andrade, 2000), they become more vivid and stronger in affective intensity. These central propositions have been strongly supported in a substantial body of subsequent research (May et al., 2015). Elaborated Intrusion theory suggests three foci for assessment of motivational cognitions: their affective intensity, the frequency or vividness of related imagery, and their availability or intrusiveness (i.e. the extent they are automatically triggered and capture attention).

The Alcohol Craving Questionnaire (ACQ; Kavanagh et al., 2013) and its generalization, the Craving Experience Questionnaire (CEQ; May et al., 2014), address these foci in relation to appetitive desires. Those measures were then adapted to assess functional motivation to control alcohol consumption in Robinson, Kavanagh, Connor, May and Andrade (2016) and self-manage diabetes in Parham et al (2016). Intensity items were rephrased to focus on a behavioural goal rather than an appetitive target. Imagery items assessed its content focus (imagery about incentives, successes or strategies) rather than listing senses that were involved. Items on intrusive thoughts about an appetitive target were substituted by ones on the availability of cognitions about functional desires.

The Motivational Thought Frequency (MTF) scales for alcohol and self-care in diabetes resulted from this research. While Robinson et al. (2016) initially found a similar three-factor structure to the ACQ and CEQ, Parham et al. (2016) found that a four-factor structure provided better fit, with imagery items splitting into imagery about incentives and self-efficacy (Bandura, 1986). The superiority of that four-factor model on the MTF for alcohol control was confirmed in a reanalysis of the data from Robinson et al. (2016) by Kavanagh, Robinson, Connolly, Connor, Andrade & May (2018).

In this paper, we apply the MTF to measurement of motivation for an increase in physical activity and reduction in high-energy snacking. Both studies examined whether the internal structure of the MTF for physical activity (MTF-PA) was represented by four factors, as observed for alcohol control (Kavanagh et al. (2018) and diabetes management (Parham et al., 2016), and tested whether participants who were already engaging in physical activity to a greater extent had higher MTF-PA scores. In order to minimise floor effects, both studies used participants who were contemplating an increase in their physical activity, or were already attempting to do so. Study 1 was conducted in the UK and Australia, allowing a test of the stability of the internal structure between two Western nations.

Study 1

Material and Methods

Participants

Participants were adult respondents to an online survey on physical activity, offered by Queensland University of Technology (QUT) in Brisbane, Australia, and The University of Plymouth, UK. As stated above, eligible participants reported that they were trying to increase activity levels or considering doing so. Respondents were students or staff at the universities who responded to group emails and internal website postings, or were recruited via Facebook.

****Tables 1 and 2 near here****

Measures

The MTF-PA items (Table 2) were identical to Parham et al. (2016) and Robinson et al. (2016): Only the introduction to the items was changed. The MTF-PA asked respondents about the frequency over the previous week of motivational cognitions about becoming more physically active. Ratings were made from 0 (Never) to 10 (Constantly). To preserve interval scaling, the integers 1-9 were not described. A State Motivation scale with similar items was also administered, but results are not reported in this paper.

Current physical activity was assessed using questions from the Active Australia Survey (Australian Institute of Health and Welfare, 2011), which derived the number of occasions of vigorous physical activity in the previous week, and total minutes of that activity. The survey defines vigorous physical activity as activity “which made you breathe harder or puff and pant (e.g. jogging, cycling, aerobics, competitive tennis)”. Self-reported activity on the AAS has moderate associations with pedometer readings, even in older adults (Heesch, Hill, Van Uffelen, & Brown, 2011). Its questions are similar to those in the International Physical Activity Questionnaire, which has established reliability in research across 12 countries (Craig et al., 2003). Test-retest agreements for the past week (taken a day apart) are comparable for vigorous activity across these instruments, although results on moderate activity are less stable on the Active Australia Survey (Brown, Trost, Bauman, Mummery, & Owen, 2004). Accordingly, the current research only used its questions on vigorous activity.

Procedure

Approvals were obtained from the human ethics committees of each university. Recruitment emails or websites included a link to the survey. After providing informed online

consent, participants confirmed eligibility and completed the measures online. At the end of the survey, first-year psychology students were given study credit, and other participants were given the option of providing their email address and entering a draw to win a gift voucher (offering two AUD150 vouchers or one of UKP30, depending on location).

Analyses

For the confirmatory factor analyses, we used lavaan (Roseel, 2012) and semTools packages (Pornprasertmanit et al., 2016) within R 3.4.2 (R Core Team, 2017). To adjust for multivariate non-normality and potential kurtosis and allow for missing data, robust maximum likelihood (MLR) and Yuan-Bentler χ^2 adjustment were employed. Better fit was primarily indexed by reductions in the Bayesian Information Criterion, adjusted for sample size (BIC): for comparison, Akaike's Information Criterion (AIC) is also reported. Additional indices involved χ^2 , and robust estimates of Bentler's Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Standardised Root Mean Square (SRMR) and Root Mean Square Error of Approximation (RMSEA). Good fit was defined by CFI and TLI > .95, SRMR < .08 and RMSEA < .06 (Hu & Bentler, 1999), with acceptable fit involving approach to these levels. We noted that specific cut-off values for model fit have been the subject of recent criticism (e.g. Grieff & Heene, 2017), and that RMSEA is prone to variable results (Chen, Curren, Bollen, Kirby, & Paxton, 2008). We therefore placed less emphasis on RMSEA than on other criteria, and focused on the relative fit of plausible models.

Initially, a single-factor model was compared with ones relating to the hypothesised factor structure. We then compared a 3-factor model that had Intensity, Availability and a single Imagery scale, with the previously observed 4-factor one that separated imagery about self-efficacy and incentives into separate subscales. We examined modification indices to see whether additional

benefit could be derived by correlating error terms within subscales (in recognition of their covariation with other items in the subscale). This serial process stopped when acceptable model fit was obtained and no modification index was ≥ 30 . Since we saw the subscales as sitting within an overarching structure of motivational cognition frequency, factors were allowed to correlate with each other.

We undertook an analysis to check whether data from the UK and Australian samples provided similar models, using the R package `semTools` `measEq.syntax` function to build models (Jorgensen et al., 2019), examining metric, scalar strict and mean invariance, and utilising Sartorra-Bentler Chi-Square and change in CFI. In no CFA analyses did we adjust for other measured covariates, in the interests of power. We computed internal consistencies of MTF subscales as hierarchical ω_2 with 95% confidence intervals using the percentile bootstrap method of the `ci.reliability` function in the R package `MBESS` 4.60 (Kelly, 2007; 2017).

The required minimum sample size for a confirmatory factor analysis is related both to power, and to the number of factors, items per factor, factor loadings, degree of missing data and bias in parameter estimates. While data were available on the factors, items and factor loadings when the MTF was used in other problem domains, the degree of missing data and parameter biases in the current study could not be estimated a priori. Published Monte Carlo simulations suggest that, with power of .80 for all parameter estimates of interest, moderately high loadings, up to 10% missing data, 2-5 factors and 3-4 items per factor, a minimum of around 400 participants may be needed (Wolf, Harrington, Clark, & Miller, 2013). In this study, we attempted to obtain at least 50% more than that number, to address uncertainties and maximise replicability.

Results

Sample characteristics

A total of 674 people began the survey, and 626 of these (93%) provided data for the MTF-PA: 533 from Australia and 93 (15%) from the UK. Participants who did not complete the MTF were older ($M = 35.5$, $SD = 13.7$ vs. 29.7 , $SD = 11.5$, $F(1,671) = 11.28$, $p = .001$), and more highly educated ($\chi^2(4) = 12.64$, $p = 0.013$; e.g. 42% had postgraduate qualifications, compared with 20% of completers). The UK appeared to have a greater proportion of noncompleters (11% vs. 6% Australian), but that difference was not statistically significant ($\chi^2(1) = 3.49$, $p = .062$). No other differences between completers and noncompleters were observed.

Demographic data across participants completing the MTF-PA are in Table 1. Mean total durations of vigorous activity in the previous week were well above those in the 2011-12 Australian Health Survey (21), which were 41 minutes for women (Standard Error, $SE = 5.1$) and 74 for men ($SE = 4.5$). Australian respondents had more minutes of vigorous activity in the previous week than UK participants ($M = 114$ [$SD = 141$] vs. 68 [91], $F(1,600) = 9.11$, $p = .003$). More Australian participants were undergraduates (35% vs. 12%), and fewer had completed a degree (43% vs 60%; $\chi^2(2) = 19.50$, $p < .001$). Consistent with this result, Australian participants were younger on average ($M = 28.2$ [$SD = 10.9$], vs. 38.2 [10.9]; $F(1,623) = 66.13$, $p < .001$), and fewer were married or cohabiting (30% vs. 53%; $\chi^2(1) = 17.61$, $p < .001$).

****Table 3 near here****

Confirmatory Factor Analyses

The 4-factor model for MTF (Intensity, Availability and the two conceptually distinct types of Imagery—Self-efficacy Imagery, Incentives Imagery) provided acceptable fit on all indices except Robust RMSEA, and was superior to a single- or 3-factor model (Table 3).

Further improvement resulted from allowing errors of three pairs of similar items to correlate within factors, and Robust RMSEA was then acceptable. Two of those item pairs (Items 7/8, 12/13) were the same as for management of diabetes (Parham et al., 2016), but this study added a correlation of Items 1/3. None of the item pairs were the same as in alcohol control (Items 4/6, 9/10; Kavanagh et al., 2018). Accordingly, the model without these intercorrelations is preferred. A check for invariance of the models between UK and Australia confirmed invariance of factor loadings ($\Delta\chi^2(9) = 14.21, p = .115; \Delta CFI = -.001$), but did find differences in intercepts ($\Delta\chi^2(9) = 21.06, p = .012; \Delta CFI = -.002$).

****Table 4 near here****

Characteristics of the resultant subscales

Mean scores and reliabilities for the subscales and scale totals are displayed in Table 4. No participants had a total absence of imagery on both the Incentives Imagery and Self-Efficacy Imagery subscales. We computed Internal consistencies of MTF subscales as hierarchical ω_2 with 95% confidence intervals using the percentile bootstrap method of the ci.reliability function in the R package MBESS 4.60 (Kelly, 2007; 2017). All reliabilities were very good at 0.83 or above. Subscale scores were highly intercorrelated (.68-.83; Median $r = .71$), with the highest correlations

between imagery subscales. Correlations of MTF Intensity with the Imagery subscales (Self-Efficacy Imagery: $r = .73$; Incentives Imagery: $r = .71$) were also noteworthy.

Associations with vigorous physical activity

Both number of occasions and total time on vigorous activity over the previous week had substantial skew (for both: 2.34, SE = 0.10) and kurtosis (12.58, SE = .20; 8.20, SE = .20 respectively), so we used a median split (at 2 times and 60 mins) for tests of associations with MTF-PA scores. Occasions of vigorous activity were strongly associated with all MTF subscales (by Pillai's Trace, $F(4, 619) = 16.45, p < .001, \eta^2 = .096$; for individual subscales, $\eta^2 = .051-.092$), as was the total time on vigorous activity ($F(4, 619) = 13.97, p < .001, \eta^2 = .083$; for individual subscales, $\eta^2 = .051-.083$).

Study 2

Study 2 aimed to test whether the factorial structure for the MTF in Study 1 could be replicated in an independent sample and in a version measuring motivation to reduce high-energy snacks (the MTF-S). It also attempted to replicate the results of Study 1 on relationships of the MTF-PA with physical activity, and examined whether scores on the MTF-S were significantly higher in a sub-sample that screened positive for the presence of an eating disorder.

Material and Methods

Except as detailed below, the methodology of Study 2 was the same as Study 1. Participants were adult respondents to a second online survey hosted by QUT in Australia, which was conducted a year after Study 1. Recruitment strategies were augmented by advertising on a research participant recruitment website (www.findparticipants.com) and snowballing.

Participants who were not in a first year Psychology subject pool could enter a draw to win an iPad Mini™.

Both the MTF-PA and an MTF focused on the reduction of sweet snacks (MTF-S) were administered. Items of the MTF-PA and MTF-S were identical: the only difference between the scales was the initial instruction (“thinking about becoming more physically active/cutting down on sweet snacks between meals”; Table 2).

The survey also included the Eating Attitudes Test (EAT-26; Garner, Olmsted, Bohr, & Garfinkel, 1982), to assess whether MTF-S scores changed in participants whose EAT-26 scores suggested the presence of an eating disorder. The EAT-26 has strong psychometric support as a screening test for eating disorders (Garner, Olmsted, Bohr, & Garfinkel, 1982; Koslowsky et al., 1992). Its first 26 items (1-25 rated 0, Never/Rarely/Sometimes; 1, Often; 2, Usually; 3, Always, Item 26 reverse scored) address self-reported dieting, bulimia and food preoccupation, self-control of eating and perceived pressure from others to lose weight. Scores potentially range from 0-78, with ≥ 20 indicating possible disorder. Five further items focus on self-reported frequency (scored 0, Never; 1 if > frequency) of eating binges, strategies used to control weight or shape (vomiting; use of laxatives, diet pills or diuretics; exercise for more than 60 mins a day), and whether they had lost 20 pounds or more in the previous 6 months (0, No; 1, Yes). Presence of any of these behaviours provides an additional indicator of possible disorder. Participants who had concerns about their eating were encouraged to consult their doctor.

Results

Participants

There were 313 respondents, 311 of whom completed the MTF scales. Participants were similar to Study 1. Thirty-four (11%) scored above the screening cutoff for an eating disorder on the EAT-26.

Confirmatory Factor Analyses and Internal Consistencies

The 4-factor models for both the MTF-PA and MTF-S were superior to the 3-factor model (Table 3). All indices met criteria for good fit except for Robust RMSEA. On the MTF-PA, allowing intercorrelation of the same pairs of within-factor error terms as Study 1 gave minimal further improvement, but some improved fit for the MTF-S was seen when the first two Intensity items were allowed to intercorrelate.

Internal consistencies of the MTF-PA and MTF-S subscales were high and comparable with Study 1, apart from the MTF-S Intensity subscale, which was moderate (Table 4). Only two participants (0.6%) had a total absence of imagery on both the Incentives Imagery and Self-Efficacy Imagery subscales of the MTF-PA. Notably, both had very low motivation across the total scale ($M = 0.4, 1.4$). High correlations between MTF subscales were again obtained (MTF-PA: $r = .73-.81$; Median = .77; MTF-S: $r = .81-.87$; Median = .84). Scores for the MTF-PA were all significantly higher than for the MTF-S ($p < .001$; $\eta^2 = .173-.270$; e.g. Full Scale: $F(1, 311) = 89.21, p < .001$; $\eta^2 = .223$).

****Table 5 near here****

Associations of the MTF-S with the EAT-26

All MTF-S subscales were significantly related to the EAT-26 Total score (Table 5), accounting for 4-7% of the variance. Because of substantial positive skew being present on the EAT-26 behavioural items (Table 5), associations with the MTF-S examined whether participants reported the behaviour on any occasion. However, this procedure still resulted in small numbers reporting the behaviour in some cases. All subscales were also associated with exercising more than an hour a day to control weight ($\eta^2 = .014-.031$) and with the use of laxatives, diet pills or diuretics to control weight or shape ($\eta^2 = .018-.033$). Only Availability was significantly related to bingeing ($\eta^2 = .018$; Others: $\eta^2 = .008-.009$), and no scales were related to vomiting to control weight or shape ($\eta^2 = .003-.004$) or loss of ≥ 20 lbs in the previous 6 months ($\eta^2 = .001-.004$).

Associations of the MTF-PA with physical activity

As in Study 1, occasions and time on vigorous activity over the previous week had substantial skew (2.56, SE = 0.14; 3.70, SE = 0.14 respectively) and kurtosis (11.62, SE = .28; 21.28, SE = .28 respectively), and the same median split was applied (2 times; 60 mins). For the MTF-PA, Pillais' Trace was significant for both the number of occasions ($F(4, 308) = 4.80, p = .001, \eta^2 = .059$) and time spent ($F(4, 308) = 6.04, p < .001, \eta^2 = .073$). However in contrast to Study 1, only the Self-efficacy Imagery (Occasions: $F(1, 311) = 8.07, p = .005, \eta^2 = .025$; Time: $F(1, 311) = 7.39, p = .007, \eta^2 = .023$) and Availability subscales significantly contributed to the effects (Occasions: $F(1, 311) = 7.64, p = .006, \eta^2 = .024$; other subscales $\eta^2 = .002, .006$; Time: $F(1, 311) = 11.85, p = .001, \eta^2 = .037$; other subscales $\eta^2 = .002, .007$).

Administration of the EAT-26 also included an item on physical exercise to lose weight. Because the item was highly skewed (1.224, SE = .138), we examined associations with exercising

for at least an hour a day \geq 2-3 times a month to lose weight. Participants showing this level ($n = 85/310$) had higher MTF-PA scores ($F(4, 307) = 3.44, p = .009, \eta^2 = .043$), with all subscales except Intensity significantly contributing to the effect ($\eta^2 = .007$; remainder .018-.034).

General Discussion

Discussion

Both studies confirmed that the MTF-PA had the same four-factor structure to studies on its application to alcohol control (Kavanagh et al., 2018) and diabetes management (Parham et al., 2016), with imagery for incentives and self-efficacy forming distinct factors. MTF-PA intercepts differed between the UK and Australian sites, presumably because of differences in demographic characteristics and activity levels between the samples. However, the factor loadings remained stable, giving support for our expectation of model stability. Study 2 generalised the results to reduction of high-energy snacks (the MTF-S), albeit with slightly lower indices and only moderate reliability for the Intensity subscale. Consistent with the sample comprising participants who were at least considering increasing physical activity (without mention of any dietary goal), scores on the MTF-PA were higher than on the MTF-S.

The fact that subscales within the MTF were correlated was highly consistent with Elaborated Intrusion Theory (Kavanagh et al., 2005). In particular, the close positive associations between the Intensity and Imagery factors of each scale highlighted the importance of imagery for the strength functional desires. This finding was also consistent with previous research on the relationship between imagery and the strength of desires for appetitive targets (May et al., 2015), supporting our contention that functional and dysfunctional desires are underpinned by similar cognitive processes. Since some people report an absence of any imagery (Bainbridge, Pounder,

Eardley, & Baker, 2019; Keogh & Pearson, 2018), we were interested in the proportions of participants in the two studies who reported a zero frequency of imagery about increasing physical activity, despite considering or being involved in increasing it. Even though those people may not have had aphantasia, we were gratified to see that no participants in Study 1 reported an absence of imagery, and the two who did in Study 2 also reported very low motivation. This observation gave confidence that our results were not affected by the presence of 'pure' aphantasia, although a lack of measurement of imagery ability meant that some participants may not have experienced vivid imagery.

In both studies, there were significant associations between MTF scores and more concurrent physical activity, although in Study 2, only Self-Efficacy Imagery and Availability significantly contributed to the effect. Similar results were found for frequent exercise to lose weight, except that Incentives Imagery then also gave a significant contribution. Perhaps when habits of physical activity are established, self-efficacy and availability become the most important aspects for maintenance, although it is not clear why such an effect would not also have occurred in Study 1. Interpretation of these results is inhibited by the cross-sectional nature of the study and by a lack of distinction between participants who were considering increasing their physical activity, rather than already doing so.

The current study also found that participants screening positive for an eating disorder on the EAT-26 had higher MTF-S scores, although the proportion of explained variance was relatively small, indicating that other factors such as conditioning were also involved. Participants who had used laxatives or exercise to lose weight also had higher MTF-S scores, although bingeing was only significantly associated with Availability. No relationship was seen for vomiting to control weight or shape or substantial recent weight loss, although those behaviours were rare and were likely to

be multiply determined. The observed associations between the MTF-S and EAT-26 highlight that, while frequent thoughts about a goal such as reducing high-sugar snacks can be highly functional, it may become dysfunctional in some contexts.

In sum, the current studies replicated the four-factor models obtained on the MTF for alcohol control (Kavanagh et al., 2018) and diabetes management (Parham et al., 2016). They also showed that the structure is preserved across UK and Australian samples, with some differences in intercepts between samples. Together, they provide substantial support for the internal structure remaining similar across different behavioural goals and sample characteristics. This stable internal structure across functional goals, including ones that involve increasing or limiting behaviour, is reminiscent of the stability of internal structure that was observed for the CEQ when assessing differing appetitive desires (May et al., 2014), and is consistent with predictions of Elaborated Intrusion theory of desire (Kavanagh et al., 2005).

Work on the measures' predictive utility and the meaning of scores is at a much earlier stage. While these studies provided evidence of concurrent associations with physical activity and eating disorder, there is a need to examine the extent that the MTF-PA or MTF-S offer a unique contribution to the prospective prediction of functional behaviours beyond predictions from past behavioural achievements (cf. Hagger, Chan, Protogerou, & Chatzisarantis, 2016; Kavanagh, Sitharthan, & Sayer, 1996). Research on the relative predictive power of the MTF in comparison with existing measures of motivation, such as ones derived from the Theory of Planned Behaviour (TPB; e.g. Giucciari & Jackson, 2015) or Self-Determination Theory (Deci & Ryan, 1985) is also required. This research could examine whether the maintained frequency of motivational cognitions form a mediational pathway between the concepts in those theories and intentions, effort and persistence in a functional behaviour. For example, it could examine whether the

superiority of autonomous motives in supporting functional behaviour change is through the intensity and maintained frequency of the motivational cognitions they trigger. Research is also needed on whether the MTF is sensitive to change from a motivational intervention and whether it identifies mechanisms of change.

The current studies provide supportive evidence for the MTF on several currently accepted validity criteria (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014; Goodwin, 2002; Messick, 1995). Items were developed by consensus between the authors on their representativeness of the focal construct, which is articulated in an empirically supported theory. The focus on frequency is consistent with a key characteristic of affectively laden cognitions, and the rating scales only label extremes, preserving interval scaling. The identified concurrent associations offer preliminary information on concurrent predictive validity.

Limitations of the current studies include an over-representation of university students or staff (although Studies 1 and 2 also had community members), and of more highly educated and more active members, relative to the general population. The use of some snowballing in Study 2 may also have resulted in correlated responses between some participants who were friends or family members. In addition, there were insufficient males in Study 1 or 2 to assess invariance of model fit across genders. It is also possible that untested covariates and common method variance may have contributed to for some results, including associations between the MTF and concurrent behaviours. The current results require replication in studies that address these issues.

Conclusion

The MTF has strong and consistent psychometric characteristics and application across different behavioural foci, including the frequency of motivational cognitions for physical exercise (MTF-PA) and high-energy food control (MTF-S). Future research should consider the predictive utility and potential of these instruments for the assessment of the mechanisms underpinning functional goal achievements.

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Table 1. Characteristics of participants in Studies 1 and 2.

		Study 1	Study 2
	N		(N = 311) ¹
Female (N, %)	626	475 (76%)	243 (78%)
Age—M (SD) in Study 1; Median range in Study 2	625	29.7 (11.5)	18-24
Currently partnered (N, %)	626	401 (64%)	161 (52%)
Completed university studies (N, %)	626	285 (46%)	122 (39%)
Previously attempted to increase physical activity	624	562 (90%)	
Last attempt (Median weeks ago)	562	35	...
Duration (Median weeks)	562	10	...
Currently considering an increase physical activity			...
Duration of contemplation (Median weeks)	624	10	...
Duration of current attempt (Median weeks)	624	4	...
Previous week			
Occasions vigorous activity—M (SD)	602	2.5 (2.6)	2.5 (2.9)
Total duration of vigorous activity (mins, M (SD))			
Women	141	91.7 (105.2) ²	114.4 (147.0) ^{1,2}
Men	453	119.0 (124.0) ²	160.2 (186.4) ^{1,2}
EAT-26 total score (M, SD)	...	...	8.7 (9.7)
Score ≥ 20 (N, %)	...	...	36 (12%)

1. Except for duration of vigorous activity (n = 304; 238 females, 66 males).

2. Omits outliers > 3SD above the mean.

Table 2. The Motivational Thought Frequency Scale for Increased Physical Activity (MTF-PA) or Reduced Snacking (MTF-S)

Items¹

Thinking about [becoming more physically active/cutting down on sweet snacks between meals], please select a number on each row to answer these questions.

Over the last week, how often did you...

1. ...feel you wanted to do it?
2. ...feel you needed to do it?
3. ...have a strong urge to do it?
4. ...imagine how good it would be to do it?
5. ...imagine how much better you'd feel if you did it?
6. ...imagine how much worse you'd feel if you didn't do it?
7. ...imagine yourself doing it?
8. ...imagine how you would do it?
9. ...imagine succeeding at it?
10. ...picture times you did something like this in the past?

Over the last week, how often...

11. ...did thoughts about it come to mind?
12. ...did other things remind you about it?
13. ...did thoughts about it grab your attention?

1. Items 1-3 form the Intensity subscale; 4-6 Incentives Imagery; 7-10 Self-Efficacy Imagery, and 11-13 Availability. Each item is rated on an 11-point scale from 0 (Never), to 10 (Constantly). Only the extremes are labelled, to preserve interval scaling. Mean scores are used for each subscale, to retain scaling from 0-10. Where a full scale score is used, it takes a mean across all items.

Table 3. Confirmatory Factor Analyses on the Motivational Thought Frequency scales for Physical Activity (MTF-PA) and Snacking (MTF-S)

Motivational Thought Frequency Scale	Yuan-Bentler χ^2	df	Robust CFI	Robust TLI	Robust AIC	BIC ¹	Robust SRMR	Robust RMSEA	90%CI
Study 1 (N=626)									
Increased Physical Activity (MTF-PA)									
3 factors ²	372	62	.932	.914	30407	30460	.044	.113	.102-.124
4 factors ³	296	59	.948	.932	30287	30344	.048	.101	.090-.113
4 factors, correlating errors for Items 7/8, 1/3, 12/13 ⁴	224	56	.965	.951	30167	30227	.035	.086	.074-.098
Study 2 (N = 311)									
Increased Physical Activity (MTF-PA)									
3 factors ²	149	62	.958	.948	15733	15757	.035	.082	.066-.100
4 factors ³	128	59	.968	.957	15704	15730	.035	.075	.057-.092
4 factors, correlating errors for Items 7/8, 1/3, 12/13 ⁴	118	56	.971	.960	15694	15721	.032	.072	.054-.091
Reduced snacking (MTF-S)									
3 factors ²	203	62	.945	.931	15502	15525	.053	.104	.089-.121
4 factors ³	186	59	.952	.936	15480	15503	.054	.101	.085-.117
4 factors, correlating errors for Items 1/2 ⁴	109	58	.981	.974	15371	15396	.027	.064	.045-.082

1. Sample size adjusted.
2. The 3-factor model comprised Intensity, Imagery and Availability.
3. The 4-factor model comprised Intensity, Incentives Imagery, Self-Efficacy Imagery and Availability.
4. Correlations of errors were only undertaken for items within a subscale. They were done in successive steps, using the largest within-factor index at that step, until none exceeded 30. At the final step, no modification index of an item with another factor was ≥ 30 .

Table 4. Normative data and reliability for the MTF-PA and MTF-S

MTF scale/subscale	Study 1 (n = 626) ¹					Study 2 (n = 311) ¹				
	ω_2 [95CI]	M	(SD)	20%ile	80%ile	ω_2 [95CI]	M	(SD)	20%ile	80%ile
Physical Activity (MTF-PA)										
Intensity	.83 [.80, .86]	6.8	(1.9)	5.3	8.3	.83 [.79, .87]	7.7	(2.0)	6.3	9.3
Incentives Imagery	.85 [.82, .87]	6.9	(2.2)	5.1	9.0	.82 [.78, .86]	7.5	(2.3)	5.8	9.3
Self-Efficacy Imagery	.85 [.82, .87]	6.5	(2.1)	4.8	8.3	.88 [.84, .90]	7.2	(2.1)	5.5	9.0
Availability	.94 [.92, .95]	6.5	(2.1)	4.8	8.3	.89 [.86, .92]	7.4	(2.1)	5.8	9.3
Full scale	.95 [.93, .95]	6.2	(1.7)	4.8	7.6	.95 [.94, .96]	7.4	(2.0)	5.8	9.0
Reduced snacking (MTF-S)										
Intensity		...	...	...	...	.68 [.60, .74]	6.6	(2.5)	4.7	9.0
Incentives Imagery		...	...	...	...	.90 [.87, .92]	6.4	(2.9)	4.0	9.0
Self-Efficacy Imagery		...	...	...	...	.92 [.90, .93]	5.8	(2.5)	3.3	8.0
Availability		...	...	...	...	.93 [.92, .95]	6.2	(2.7)	3.7	8.3
Full scale		...	...	...	...	.96 [.95, .96]	6.2	(2.5)	4.4	8.3

1. Means of average item scores (potential range = 0-10).

Table 5. Relationships between the MTF-S and EAT-26

	EAT-26 Total			Self-reported behaviours on EAT-26 (Yes/No) ¹													
	<i>R</i>	<i>p</i>		Binges where felt may not be able to stop (44/310 yes) ²			Vomited to control weight or shape (10/311 yes) ³			Used laxatives, diet pills or diuretics to control weight or shape (16/311 yes) ⁴			Exercised > 60 mins/day to control weight (85/310 yes) ⁵			Lost ≥ 20lbs in past 6 months (22/309 yes) ⁶	
			<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2
			(4, 305) ⁷			(4, 306) ⁷			(4, 306) ⁷			(4, 305) ⁷			(4, 304) ⁷		
Multivariate ⁷	.28	< .001	1.52	.195	.020	0.33	.857	.004	2.69	.032	.034	3.20	.013	.040	0.47	.759	.006
MTF-S Subscales	<i>r</i>	<i>p</i>	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2	<i>F</i>	<i>p</i>	η^2
			(1, 308)			(1, 309)			(1, 309)			(1, 308)			(1, 307)		
Intensity	.20	< .001	2.35	.126	.008	1.26	.263	.004	5.64	.018	.018	4.32	.039	.014	0.86	.353	.003
Incentives Imagery	.24	< .001	2.66	.104	.009	1.07	.302	.003	7.96	.005	.025	9.24	.003	.029	0.40	.529	.001
Self-Efficacy Imagery	.22	< .001	2.89	.090	.009	0.98	.322	.003	10.44	.001	.033	9.63	.002	.030	0.41	.525	.001
Availability	.27	< .001	5.59	.019	.018	1.12	.290	.004	7.87	.005	.025	9.87	.002	.031	1.23	.268	.004
Full scale	.25	< .001	3.76	.054	.012	1.24	.266	.004	9.18	.003	.029	9.37	.002	.030	0.74	.390	.002

1. A binary cutoff of never vs. any frequency was used, because of substantial positive skew.
2. Skew = 1.94, SE = 0.14.
3. Skew = 5.63, SE = 0.14.
4. Skew = 4.12, SE = 0.14.
5. Skew = 1.22, SE = 0.14.
6. Skew = 4.73, SE = 0.14.

⁷ The multiple regression, uses *R*; Multivariate *F* uses Pillai's Trace