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Back to the drawing board? A review of applications of the transtheoretical model to substance use

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Abstract

The transtheoretical model (TTM) is still enormously popular with practitioners, clinicians and many researchers in the addictions field. However, in a recent years a number of commentators have criticized aspects of the model and the research based on it. This paper extends a recent critique of the TTM as applied to smoking cessation to include applications of the model to cessation or reduction of alcohol or drug use. The first section discusses measures of the central construct of stages of change and notes a number of serious problems. Staging algorithms are based on arbitrary time periods and some are logically flawed. In the case of multi-dimensional questionnaires (the URICA, the SOCRATES and the RCQ), the pattern of correlations among the subscales shows that they are not measuring discrete stages of change. The one study to date that has compared the two different methods found low concordance, which is probably due to incompatible stage definitions. In the second section of the paper, the evidence base for the TTM is reviewed. The review is organized by the four research designs that have been used to test predictions from stage models: cross-sectional comparisons of people in different stages; examination of stage sequences; longitudinal prediction of stage transitions; and experimental studies of matched and mismatched interventions. It concludes that current evidence for the model as applied to substance use is meagre and inconsistent. Researchers are urged to develop better stage models.

Introduction

At the time of writing, the transtheoretical model (TTM; Prochaska & DiClemente, 1986, 1992; Prochaska, DiClemente & Norcross, 1992; Prochaska & Velicer, 1997) is still enormously popular with practitioners, clinicians and many researchers in the addictions field. However, in recent years a number of commentators have questioned whether the model provides a valid description and explanation of the process of change and have criticised aspects of the model and the research based on it (Davidson, 1992, 1998; Sutton, 1996; Bandura, 1998). A recent book chapter examined critically the evidence for the TTM as applied to smoking cessation (Sutton, 2000b). This paper extends this critique to include applications of the model to cessation or reduction of alcohol or drug use.

Several important differences between these two bodies of research should be mentioned at the outset. First, there have been many more studies applying the TTM to smoking cessation

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than to alcohol and drug use. Secondly, more powerful research designs have been used in the smoking studies, including multi-wave longitudinal studies and experimental studies of matched and mismatched interventions. Nevertheless, the vast majority of studies, whether on smoking or alcohol and drug use, have used cross-sectional designs. Thirdly, studies on smoking have generally used staging algorithms to measure stages of change whereas most studies of alcohol and drug use have used multidimensional questionnaires. Finally, Orford (1992) has suggested that the TTM, and decision-making models in general, may simply be less applicable to alcohol and drug use than to smoking.

The transtheoretical model

Although it is frequently referred to simply as the stages of change model, the TTM incorporates 15 different theoretical constructs. In addition to the central construct of stages of change, the model includes the 10 processes of change, the perceived pros and cons of changing, and self-efficacy and temptation. The TTM was an attempt to integrate these different constructs into a single comprehensive framework—hence the name transtheoretical.

Since it was first introduced, the TTM has been modified several times. The version of the model used most widely in recent years specifies five stages: precontemplation, contemplation, preparation, action and maintenance. Prochaska *et al.* (1992) represented the stages of change as a spiral. People start at the bottom of the spiral, in precontemplation. They then move through the stages in order (contemplation, preparation, action, maintenance) but will typically relapse back into an earlier stage. They may cycle and recycle through the stages several times before reaching the top of the spiral and achieving successful long-term behaviour change.

Measuring stages of change

Two main methods have been used to measure stages of change: staging algorithms and multidimensional questionnaires.

Staging algorithms

With few exceptions (e.g. Biener & Abrams, 1991), studies applying the TTM to smoking cessation have employed staging algorithms. Using a small number of questionnaire items, each participant is allocated to one of the stages; no individual can be in more than one stage at a given time point.

The algorithms used by Prochaska, DiClemente and colleagues to classify smokers suffer from a number of serious problems (Farkas *et al.*, 1996; Etter & Perneger, 1999; Sutton, 2000b). For example, in an algorithm introduced by DiClemente *et al.* (1991), and used since in a large number of studies, the stages are defined in such a way that smokers trying to quit for the first time cannot pass through the preparation stage and some smokers cannot move directly to the next stage in the sequence.

Staging algorithms have been used in several studies of drug use. Table 1 shows the stage definitions used in the studies by Belding and colleagues (Belding *et al.*, 1995, 1996, 1997). Unlike the DiClemente *et al.* (1991) algorithm, this scheme is logical and consistent but it illustrates a problem shared by most staging algorithms based on the TTM: the time periods are arbitrary. Using different time periods would lead to a different allocation of subjects to stages and a different stage distribution. The use of arbitrary time periods casts doubt on the assumption that the stages as measured by staging algorithms are qualitatively distinct, that is, that they are true stages rather than pseudostages (Sutton, 1996, 2000b; Bandura, 1998). For instance, precontemplation, contemplation and preparation may behave as if they were arbitrary segments of an underlying continuum that could be labelled "planned time to action". Similarly, action and maintenance, which are distinguished purely and arbitrarily by whether or not the duration of abstinence exceeds 6 months, may behave like pseudostages. The importance of the distinction between true stages and pseudostages cannot be overstated. If the stages, or subsets of them, behave like pseudostages, there is no reason to expect different factors to influence different stage transitions and hence no basis for matching interventions to stage.

Most studies that have investigated alcohol and drug use from the standpoint of the TTM have used multi-dimensional questionnaires to measure stage of change. In this approach, each stage is measured by a set of questionnaire items,

Table 1. *Stage definitions used by Belding and colleagues (1995, 1996, 1997)*

Precontemplation	Used unauthorized drugs in last 30 days. Do not plan to quit using in next 6 months
Contemplation	Used unauthorized drugs in last 30 days. Plan to quit in next 6 months, but not in next 30 days
Preparation	Used unauthorized drugs in last 30 days. Plan to quit in next 30 days
Action	No use of unauthorized drugs in last 30 days, but have used in last 6 months
Maintenance	No use of unauthorized drugs in last 6 months

Table 2. *Example items from the University of Rhode Island Change Assessment (URICA)*

Precontemplation
"As far as I'm concerned, I don't have any problems that need changing"
"All this talk about psychology is boring. Why can't people just forget about their problems?"
Contemplation
"I have a problem and I really think I should work on it"
"I'm hoping this place will help me to better understand myself"
Action
"I am doing something about the problems that had been bothering me"
"Anyone can talk about change: I'm actually doing something about it"
Maintenance
"It worries me that I might slip back on a problem I have already changed, so I am here to seek help"
"I'm here to prevent myself from having a relapse of my problem"

and scores are derived for each individual representing their position on each dimension. Three such multi-dimensional questionnaires have been used in studies of alcohol and drug use: the University of Rhode Island Change Assessment (URICA; McConnaughy, Prochaska & Velicer, 1983), the Stages of Change Readiness and Treatment Eagerness Scale (SOCRATES; Miller & Tonigan, 1996) and the Readiness to Change Questionnaire (RCQ; Rollnick *et al.*, 1992). These will be discussed in turn.

The University of Rhode Island Change Assessment (URICA)

The URICA was the first multi-dimensional questionnaire designed to measure stages of change. It consists of 32 items, eight for each of four stages (precontemplation, contemplation, action, maintenance; Table 2). The items refer generically to the subject's "problem" but do not specify a particular problem behaviour. The URICA is intended for use in clinical contexts.

Factor analysis of data from two samples of psychotherapy patients yielded a similar four-factor solution (McConnaughy *et al.*, 1983; McConnaughy *et al.*, 1989). In applications to alcohol and drug use, the four-factor structure has been confirmed in some studies (DiClemente & Hughes, 1990; Carney & Kivlahan, 1995) but not in others (Belding *et al.*, 1996; El-Bassel *et al.*, 1998). Table 3 shows the intercorrelations among the URICA subscales in six studies. There is a fairly consistent pattern of relatively large correlations among subscales representing adjacent stages (the correlations in the diagonal of each of the matrices shown in Table 3). McConnaughy and colleagues argue that this simplex pattern supports the transtheoretical model. Note, however, that the correlations between contemplation and maintenance (non-adjacent stages) are also relatively large.

However, finding positive correlations (or large negative correlations) between adjacent or non-adjacent subscales is actually evidence against the idea that the stages as measured by the URICA are discrete and qualitatively distinct. The items designed to measure a particular stage should tap unique features of that stage rather than those that are common to more than one stage. (Of course, even with discrete stages, there will be some characteristics that carry over from one stage to the next, but an instrument designed to identify which stage a person is in should attempt to capture the unique features of each stage.) In fact, the ideal pattern would be

Table 3. *Correlations among the URICA subscales in six studies*

Study	Sample			Correlation matrix C	A	M
McConnaughy *et al.* (1983)†	155 psychotherapy patients		PC	−0.45	−0.16	0.05
			C		0.53	0.27
			A			0.38
McConnaughy *et al.* (1989)†	323 psychotherapy patients		PC	−0.52	−0.23	−0.22
			C		0.50	0.45
			A			0.48
Abellanas & McLellan (1993)	41 male methadone maintenance patients	Cigarettes:	PC	−0.04	0.09	−0.01
			C		0.51	0.72
			A			0.51
		Cocaine:	PC	−0.47	−0.33	−0.18
			C		0.92***	0.69**
			A			0.62**
		Heroin:	PC	−0.28	0.07	−0.13
			C		0.29	0.54
			A			−0.11
Belding *et al.* (1996)†	275 methadone maintenance patients		PC	−0.28	−0.17	−0.21
			C		0.52	0.65
			A			0.44
Greenstein *et al.* (1999)†‡	89 adolescents admitted to hospital psychiatric unit		PC	−0.57	−0.45	−0.41
			C		0.70	0.72
			A			0.48
Velasquez *et al.* (1999)	132 dually diagnosed patients		PC	−0.38**	−0.34**	−0.30**
			C		0.74**	0.67**
			A			0.56**

URICA subscales: PC = precontemplation; C = contemplation; A = action; M = maintenance. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ (as reported in original paper); † significance of correlations not reported in original paper; ‡ used a modified version of the URICA.

one in which each participant obtained relatively high scores on one of the stage dimensions, but relatively low scores on the other stage dimensions. To take an extreme case, if each participant scored 40 (the maximum) on one stage dimension and 8 (the minimum) on the other three stage dimensions (and assuming that there were equal numbers of participants having maximum scores on each of the four dimensions), the correlation between any two URICA subscales would be −0.33. Thus, the ideal result would be a pattern of moderate negative correlations between the URICA subscales—very different from the patterns shown in Table 3. (Note that a high negative correlation between two subscales is as undesirable as a positive correlation.)

Several studies have performed cluster analysis on the URICA subscale scores to derive distinct cluster profiles (McConnaughy *et al.*, 1983, 1989; DiClemente & Hughes, 1990; Carney & Kilvahan, 1995; Willoughby & Edens, 1996; Edens & Willoughby, 1999; El-Bassel *et al.*, 1998). These analyses have yielded different numbers of clusters that do not map on to the original stages. For example, in a study of patients entering outpatient alcoholism treatment, DiClemente & Hughes (1990) identified five distinct clusters which they labelled Precontemplation, Ambivalent, Participation, Uninvolved or Discouraged, and Contemplation. Several of the cluster profiles were characterized by above average scores on more than one stage dimension. For example, the 51 subjects in the Participation cluster were well below average on the precontemplation subscale and above average on the contemplation, action, and maintenance subscales. These subjects can be thought of as being in more than one stage at the same time, which

is inconsistent with the idea of distinct stages. More generally, the logic of this approach is not clear. If profiles derived from cluster analysis of subscale scores from a questionnaire designed to measure four stages do not map on to these stages, should the model be revised accordingly (i.e. should the original stages be replaced by the "new" stages) and, if so, what temporal ordering should be imposed on the new stages?

The Stages Of Change Readiness and Treatment Eagerness Scale (SOCRATES)

Miller & Tonigan (1996) described the development of the SOCRATES, a 20-item scale designed to measure stages of change for problem drinking. There are four items for each of five stages of change: precontemplation, contemplation, determination, action and maintenance. The questionnaire was included in the pretreatment assessment battery for Project MATCH, a multi-site clinical trial comparing three treatments for alcohol problems among patients in outpatient and aftercare settings (Project MATCH Research Group, 1993). Miller & Tonigan do not report the full correlation matrix, but they note that the precontemplation and determination subscales were negatively correlated (-0.70 in the outpatient sample and -0.62 in the aftercare sample), that the action and maintenance subscales were positively correlated (0.69 and 0.56, respectively), and that other correlations were modest. These findings show a lack of a clear distinction between precontemplation and determination and between action and maintenance.

Exploratory factor analysis revealed three orthogonal factors: Taking steps (which included all the action and maintenance items); Recognition (which included the precontemplation and determination items); and Ambivalence (which included all four contemplation items). Miller and Tonigan (1996, p. 84) conclude that "… this instrument does not appear to measure the stage constructs as conceived by Prochaska and DiClemente … Rather the scales of SOCRATES seem better understood as continuously distributed motivational processes that may underlie stages of change".

A modified version of the SOCRATES was used by Isenhart (1994) in an inpatient sample of substance abusers. The items were adapted so that they were applicable to both alcohol and non-alcohol drug users. Correlations between the scale scores were not reported. Although the selection of items did not correspond exactly to that used by Miller & Tonigan (1996), a broadly similar factor structure emerged. Unlike Miller & Tonigan, who explicitly eschewed the use of cluster analysis, Isenhart used this method to derive three "motivational subtypes" which he labelled Ambivalent, Uninvolved and Active. As in the studies using the URICA, the derived profiles did not correspond to the hypothesized stages and they showed high scores on more than one stage dimension. It is interesting to note that Isenhart (1997) later changed his view about the value of using cluster analysis to identify motivational subtypes.

The Readiness to Change Questionnaire (RCQ)

The RCQ is a 12-item scale designed to measure stage of change (precontemplation, contemplation and action) with respect to reducing alcohol consumption among excessive drinkers who are not seeking help for an alcohol problem (Rollnick *et al.*, 1992; Heather, Rollnick & Bell, 1993). In an exploratory factor analysis three factors emerged corresponding to each of these stage dimensions (Rollnick *et al.*, 1992). Precontemplation correlated negatively with contemplation (-0.53) and action (-0.36), but contemplation and action were positively correlated (0.57), suggesting that the questionnaire is not capturing unique features of these stages.

Wells-Parker *et al.* (1998) found a similar pattern of correlations in a sample of drink-driving offenders: -0.55 for precontemplation and contemplation; -0.36 for precontemplation and action; and 0.44 for contemplation and action.

Using the same dataset as Heather *et al.* (1993), Budd & Rollnick (1996) reported the results of confirmatory factor analyses which showed that the original measurement model (in which each item is assumed to measure only one of the three stage dimensions) did not provide a good fit to the data, but that a hierarchical factor model which included a second-order factor (termed "readiness to change") and three first-order factors (precontemplation, contemplation, action) fitted the data well.

The findings from studies using the URICA, the SOCRATES and the RCQ show that, whatever it is that these multi-dimensional questionnaires are measuring, they are clearly not

measuring discrete stages of change. Indeed, even with further development and refinement, it is doubtful whether such questionnaires are likely to prove a useful way of measuring stage of change. It can be argued that any method that measures an individual's position on a number of continuous dimensions, where each dimension is supposed to correspond to a different stage, is conceptually inconsistent with the notion of discrete stages. Of course, this is not to say that such instruments may not prove useful for other purposes. For instance, stage allocations and readiness to change scores based on the RCQ have been shown to predict reductions in alcohol consumption and time to first drink (Heather *et al.*, 1993; Budd & Rollnick, 1996; McMahon & Jones, 1996). However, as noted in a later section of this paper, the most appropriate criteria for assessing the predictive validity of stage measures are stage transitions.

Comparisons of stage measures

Few studies have compared different methods of measuring stages of change. Farkas *et al.* (1996) tabulated some of the different definitions used in the studies of smoking by Prochaska and colleagues between 1983 and 1991. They note that the different classifications have never been compared empirically. This lack of standardization makes it difficult to compare results from different studies and to accumulate the research findings into a coherent body of knowledge. Using data from a large sample of smokers from the California Tobacco Survey, Farkas and colleagues (1996) compared the DiClemente *et al.* (1991) algorithm which classifies smokers into precontemplation, contemplation and preparation stages with an earlier algorithm that allocates smokers to precontemplation, contemplation and relapse stages. The two algorithms produced markedly different stage distributions. For example, the earlier algorithm classified almost half the sample in the most advanced stage (relapse) whereas the revised scheme placed only 16% in the most advanced stage (preparation). The two algorithms would lead to very different conclusions concerning the proportion of smokers for whom action-orientated programmes are appropriate. Farkas and colleagues also showed that the earlier stage measure provided better prediction of cessation and quit attempts assessed at 1–2-year follow-up than the revised algorithm and that both schemes allocated smokers with very different probabilities of quitting to the same stage (see also Pierce *et al.*, 1996).

In a sample of methadone maintenance patients, Belding *et al.* (1996) compared their staging algorithm (see Table 1) with the URICA. There were no significant differences between algorithm stages on either the precontemplation or the maintenance subscales. For example, those classified in the precontemplation stage by the algorithm did not have significantly higher URICA precontemplation scores than those classified in other algorithm stages. On the other hand, participants allocated by the algorithm to the preparation stage scored significantly higher on the URICA contemplation scale than participants in the precontemplation stage. Also, participants in the preparation, action and maintenance stages scored significantly higher on the URICA action scale than those in the precontemplation stage. Finally, participants in the maintenance stage scored significantly higher on the action scale than those in the contemplation stage. No other differences were significant. Cohen's kappa was only 0.14. The authors concluded that the two measures may assess different aspects of readiness to change.

This demonstration of low concordance between different stage measures is not unexpected; it probably stems from incompatible stage definitions. This is a fundamental problem that needs to be solved if any progress is to be made in research using the TTM.

Review of the evidence base for the TTM

In the remainder of this paper, the evidence base for the TTM is briefly reviewed. The review is organized by the four research designs that have been used to test predictions from stage models (Weinstein, Rothman & Sutton, 1998a). These are: cross-sectional studies comparing people in different stages, examination of stage sequences, longitudinal prediction of stage transitions and experimental studies of matched and mismatched interventions. The review is brief for two reasons. First, the smoking studies have been reviewed in detail elsewhere (Sutton, 2000b), so they are summarized only briefly here. Secondly, no published studies on alcohol or drug use could be found that used any of the last three types of research design. Thus, the

main value of this section may lie in drawing the attention of investigators to the kinds of studies that could be done to test predictions from the TTM and other stage models. The findings summarized below have to be interpreted cautiously in light of the measurement problems detailed in the preceding section.

Cross-sectional comparisons of people in different stages

In many TTM studies, participants are classified into stages and compared on theoretically relevant variables (i.e. processes of change, pros and cons, self-efficacy and temptation). This approach has been used in numerous applications of the model to smoking cessation (e.g. DiClemente *et al.*, 1991) and several applications of the model to alcohol and drug use (e.g. DiClemente & Hughes, 1990; Prochaska *et al.*, 1994; Belding *et al.*, 1995). For instance, Belding *et al.* (1995) found differences in reported use of processes of change by methadone maintenance patients in different algorithm stages.

However, although finding significant differences between people in different stages is usually taken as supporting the TTM, patterns of differences require very careful interpretation (Weinstein, Rothman *et al.*, 1998a; Kraft, Sutton & Reynolds, 1999; Sutton, 2000a). Consider a model with three stages: I, II and III. Suppose that, in a cross-sectional study, a given theoretically relevant variable (self-efficacy, say) shows an approximately linear increase across the three stages. How should this be interpreted? One possible interpretation is that self-efficacy influences the transition from stage I to stage II and the transition from stage II to stage III and is about equally important in both transitions. However, a key assumption of stage models is that different factors are important at different stages; in other words, that the set of factors that influence the transition from stage I to stage II is different from the set of factors that influence the transition from stage II to stage III. These sets may overlap: there may indeed be some variables that are important at every stage (and these are the ones that we would expect to show an approximately linear increase or decrease across stages). However, if the stage assumption is correct, there must be theoretically relevant variables that do not show a consistent linear increase or decrease across stages. More specifically, we would expect some variables to show discontinuity patterns. For example, a given variable may show a significant increase between stage I and stage II but no difference between stages II and III (a pattern that would be consistent with the hypothesis that this variable influences the first transition but not the second). Researchers who attempt to test the TTM or other stage models in cross-sectional studies should derive hypotheses concerning the pattern of means to be expected for each theoretically relevant variable. This in turn requires a clear specification of the variables that influence each stage transition; in other words, we need a causal model for each stage transition.

Causal inferences drawn from cross-sectional data have to be regarded as weak and conditional on a number of assumptions. For instance, in the example given above, we assumed one-way causation (self-efficacy influences stage transition but not vice versa). In principle, longitudinal and experimental designs should enable stronger inferences to be drawn. Note, however, that when using these designs to investigate the TTM, it has to be assumed that the measurement schedule provides a complete picture of the stage transitions that occur. If the measurement interval is too long or people move rapidly through stages, transitions will be missed (Weinstein *et al.*, 1998a). It may be possible to "fill in the gaps" by careful retrospective questioning at each follow-up, but no study to date has used this approach.

Examination of stage sequences

If it is assumed that no stage transitions are missed, longitudinal data can be used to examine sequences of transitions through the stages. No studies on alcohol or drug use have measured stage membership on more than two occasions. However, several studies of smoking have tracked stage transitions in smokers and ex-smokers. For example, Prochaska *et al.* (1991) reported data on 544 participants who provided information about stage of change every 6 months over a 2-year period (i.e. a total of five waves of measurement). Using a staging algorithm, respondents were classified on each occasion as being in the precontemplation (PC), contemplation (C), action (A) or maintenance (M) stages. Sixteen per cent of participants

showed a stable progression over the 2 years from one stage to the next in the sequence (e.g. precontemplation to contemplation) without suffering any reverses (e.g. PC-PC-PC-C-C). Twelve per cent of participants moved backwards one or two stages (e.g. C-C-C-PC-PC). Thirty-six per cent of participants showed a flat profile; that is, they stayed in the same stage across the five waves of measurement (e.g. PC-PC-PC-PC-PC). The findings indicate that forward progressive movement through the stages is not the modal pattern of change among volunteer self-changers.

Findings such as these are not necessarily inconsistent with stage model predictions. Stage models can vary in terms of the sequences and transitions they allow (Sutton, 1997). At one extreme, a stage model may postulate an invariant and irreversible sequence: everyone moves through the same sequence and only forward transitions to the next stage are allowed. Bandura (1998) has criticized the TTM for violating these assumptions. However, while invariance and irreversibility may be appropriate for developmental stages, it seems unrealistic to insist on such strict assumptions for stages of change of addictive behaviours.

A somewhat more realistic model would allow not only forward movement to the next stage but also backward movement to the immediately preceding stage. As in Bandura's ideal stage model, this model assumes that the probability of moving directly from one stage to a non-adjacent stage is zero. A number of less restrictive stage models could be specified.

Although it may be considered desirable to demonstrate that a stage measure has predictive validity, for example in predicting time in treatment or treatment outcome at 12 months, stage models imply that the key criteria to be used in assessing predictive validity are stage transitions. Put simply, knowing a person's current stage should enable one to predict which stage he/she is likely to move to next. Researchers who use the TTM and other stage models should specify and test predictions about the pattern of stage transition probabilities (Sutton, 2000b). Note that such predictions can also be derived from pseudostage models but in this case we would not expect the transition probabilities to show discontinuities; rather, the probabilities should decline gradually with increasing distance between (pseudo)stages. If longitudinal data on stage membership are available on two (or more) occasions separated by an appropriate time interval, models for the transition probabilities can be estimated using latent transition analysis [1] (Collins & Wugalter, 1992; Martin, Velicer & Fava, 1996; Velicer, Martin & Collins, 1996).

Longitudinal prediction of stage transitions

As well as examining stage sequences, longitudinal data can be used to test whether different theoretically relevant variables predict stage transitions among people in different baseline stages. The assumption is that such predictors represent causal factors that influence stage movement. Stage models such as the TTM should specify, or hypothesize, the factors that influence transitions between each pair of adjacent stages. Analyses of longitudinal data on predictors of stage transitions should be stratified by initial stage and should compare people who move to the next stage in the sequence with those who remain in a given stage with respect to their baseline characteristics. Prediction of movement to the preceding stage may also be of interest.

To date, no studies of this kind have been published on alcohol and drug use and only five studies on smoking could be identified (DiClemente, Prochaska & Gibertini, 1985; Prochaska *et al.*, 1985; De Vries & Mudde, 1998; Velicer *et al.*, 1999a; Herzog *et al.*, 1999). The first four of these studies were reviewed in detail by Sutton (2000b) who concluded that

> It is remarkable that so few prospective analyses of stage transitions have been reported in almost 20 years of research on the TTM. The four studies ... used different measures (e.g. three different staging algorithms were used) and no consistent findings emerged. Given the relatively long follow-up periods used in these studies, it is highly likely that stage transitions were missed. Future studies should use more frequent measurement of stage of change.

The fifth study, by Velicer and colleagues (1999a), also used a long follow-up period (12 months). Perhaps for this reason, none of the reported analyses directly compared smokers who stayed in a given stage with those who moved to the next stage. Measurement problems make some of the findings difficult to interpret. For example, two analyses compared smokers

who stayed in the preparation stage with preparers who moved to other stages. However, because of the way that preparation is defined by the DiClemente *et al.* (1991) algorithm (plan to quit in the next 30 days and have made at least one quit attempt lasting 24 hours or more in the last 12 months), those who "stayed" in the preparation stage over a 12-month period must have visited the action stage, even if only briefly, at least once during that time. Similarly, those who moved from precontemplation or contemplation at baseline to preparation at follow-up must have passed through the action stage in the intervening period.

Experimental studies

Stronger evidence that behaviour change follows a stage process would be to demonstrate consistently in experimental studies that stage-matched interventions are more effective than stage-mismatched interventions in moving people to the next stage in the sequence (Weinstein *et al.*, 1998b; Weinstein, Rothman & Sutton, 1998a). For example, people in the precontemplation stage should do better (in terms of the proportion who move to the next stage in the sequence) if they receive an intervention designed for precontemplators than if they receive an intervention designed for contemplators. No studies on alcohol or drug use have employed this approach. Only two studies of matched and mismatched interventions for smokers could be located (Dijkstra *et al.*, 1998; Quinlan & McCaul, 1999). Neither found clear support for the stage model predictions.

Project MATCH is sometimes regarded as providing a test of the TTM. However, this is not the case (Sutton, 1999). Although Project MATCH was not based directly on the TTM, it did include as matching variables two measures of readiness to change derived from the URICA and the SOCRATES. As described in an earlier section, these are both multi-dimensional instruments, but in the analysis of the MATCH data a single score was derived for each individual from each of the two questionnaires. Use of a single score implies a readiness to change continuum rather than discrete stages. The URICA score was treated as a primary a priori matching variable. It was predicted that clients with relatively low readiness to change scores would do better if they received motivational enhancement therapy than if they received cognitive–behavioural coping skills therapy. A similar prediction was made for the SOCRATES score, which was treated as a secondary a priori matching variable. In the event, neither hypothesis received consistent support, although both scores were predictive of drinking outcomes.

Prochaska and colleagues have developed stage-matched smoking cessation interventions based on self-help manuals and individually tailored computer-generated feedback reports (which they refer to as an "expert system") and have tested these in several large randomised trials (Prochaska *et al.*, 1993; Velicer *et al.*, 1999b). These are impressive studies, but the analyses reported to date provide no direct evidence on the validity of the TTM. If it could be shown that the intervention effects were mediated by relevant theoretical variables (pros and cons of quitting, self-efficacy and temptation and the processes of change), this would provide support for the TTM, but no such process analysis has been reported to date.

Conclusion

The notion that behaviour change involves movement through a sequence of discrete stages is an important idea that deserves further consideration. Unfortunately, the TTM is a poor implementation of this idea. There are serious problems with the existing methods used to measure the central construct of stages of change. Staging algorithms are based on arbitrary time periods and some are logically flawed. In the case of multidimensional questionnaires (the URICA, the SOCRATES and the RCQ), the pattern of correlations among the subscales shows that they are not measuring discrete stages of change. The low concordance between the different methods probably stems from incompatible stage definitions. Even leaving aside these measurement problems, current evidence for the TTM as applied to substance use is meagre and inconsistent.

Researchers are urged to develop new stage models in which the stages can be regarded as qualitatively distinct. Such models should clearly define the stages and specify the factors that influence each stage transition. Considerable attention should be paid to developing sound

measures of the stages of change and the other model constructs. Wherever possible, predictions from such models should be tested using strong research designs.

Note

[1] LTA extends previous approaches to analysing discrete latent variables (latent class theory and Markov techniques) to models that include both static and dynamic latent variables such as stage membership. In the simplest case where there is only a single indicator of stage membership, no latent class (discrete grouping variable such as experimental versus control condition), and only two time points, LTA provides estimates of two types of parameters: the proportion of the population in each stage at each occasion of measurement; and the probabilities of being in each of the stages at Time 2 conditional on stage membership at Time 1 (i.e. the transition probabilities). LTA can be used to ascertain how well a particular theoretical model fits the data. Goodness-of-fit statistics can be used to compare competing models. LTA requires specialist software; a Windows version of the programme can be downloaded from http://methcenter.psu.edu.

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