Nutrition Research Reviews (1999), **12**, 281–317

Applying the transtheoretical model to eating behaviour change: challenges and opportunities

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Abstract

This review provides a rigorous investigation of the question of whether the transtheoretical model (TTM) (or stages of change model) is applicable to eating behaviour change. The TTM is currently the most popular of a number of stage theories being used to examine health behaviour change. Stage theories specify an ordered set of 'stages of readiness to change' into which people can be classified and identify the factors that can facilitate movement from one stage to the next. If eating behaviour change follows a stage process, then nutritionists could identify the predominant stage or stages in a population and focus resources on those issues most likely to move people to the next stage (e.g. from no intention of changing, to thinking about changing). In addressing this question, the review draws on the defining characteristics of stage theories as clarified by Weinstein *et al*. (1998), provides an in-depth coverage of methodological considerations, and a detailed summary table of dietary studies applying the TTM. Specific recommendations are made for improving the accuracy of dietary stage classifications. Among the key conclusions are: (1) dietary studies using the TTM have been hampered by a focus on nutritional outcomes such as dietary fat reduction, rather than clearly understood food behaviours (e.g. five servings of fruit and vegetables per day); (2) accurate stage classification systems are possible for food-based goals, but major misclassification problems occur with nutrient-based goals; (3) observation of an association between stage and dietary intake is not sufficient to demonstrate the validity of the model for dietary behaviour; (4) there is a need for valid questionnaires to measure all aspects of the TTM, and more research on the whole model, particularly the 'processes of change', rather than on single constructs such as 'stage'; (5) cross-sectional studies generally support the predicted patterns of between-stage differences in decisional balance, self-efficacy, and processes of change; (6) studies which test the key hypothesis that different factors are important in distinguishing different stages are rare, as are prospective studies and stage-matched interventions. Only such studies can conclusively determine whether the TTM is applicable to eating behaviour. Since the ultimate test of the TTM will be the effectiveness of stage-matched dietary interventions, the review ends by exploring the requirements for such studies.

Transtheoretical model: Stage theories: Behaviour change: Food choice

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Abbreviation: TTM, transtheoretical model.

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Introduction

Efforts to prevent disease and to promote healthy eating habits are most likely to succeed if based on an understanding of factors influencing food choice and an appreciation of established theory and research on changing health behaviour (Glanz & Rimer, 1997). Social and clinical psychology provide several theories which can facilitate our understanding of psychosocial determinants of dietary behaviour (Glanz & Eriksen, 1993). Amongst the most familiar theories and models applied by health behaviour researchers are: social learning theory or social cognitive theory (Bandura, 1986), the theory of planned behaviour (Ajzen & Madden, 1986), the health belief model (Janz & Becker, 1984), consumer information processing theory (Bettman, 1979) and the stages of change (or transtheoretical) model (Prochaska *et al*. 1992*a*). All but the last of these models can be seen as continuum theories, in which variables influencing behaviour are combined in a prediction equation indicating, along a continuum, the probability that an individual will perform the behaviour (Weinstein *et al*. 1998). The manner in which the predictor variables combine to influence behaviour is assumed to be the same for everyone. Stage theories, on the other hand, assume that predictor variables will influence different people in different ways.

Stage theories are increasingly being used to examine health behaviour change. The transtheoretical model (TTM), although currently the most popular stage model in health psychology, is by no means the only stage model. Other stage theories include: the precaution adoption process model (Weinstein & Sandman, 1992), the health action process approach (Schwarzer, 1992), and models focusing on delay in seeking medical care (Safer *et al*. 1979).

Stage theories specify an ordered set of categories into which people can be classified, and identify the factors that can induce transitions from one category to the next (Weinstein *et al*. 1998). On the basis of a stage theory, the predominant stage or stages in a population can be identified, and resources targeted towards those issues most likely to move people to the next stage. Thus treatments may be matched to individuals because people in different stages have different needs.

Weinstein *et al*. (1998) have recently clarified the defining characteristics of stage theories. A stage theory requires: (1) an accurate classification system for assigning each individual to only one stage; (2) a specified sequence of stages followed by a majority of people (although other paths to action are possible and people do not need to spend a fixed or minimum length of time in any stage); (3) that people at the same stage face similar issues, and thus can be influenced by similar interventions; and, most importantly, (4) that different factors are important in producing transitions at different stages, or in other words, that people at different stages face different barriers to change. Although the precaution adoption process model and TTM differ in the number of stages specified (seven and five respectively), both distinguish people who have not yet decided to change their behaviour, those who have decided to change, and those already performing the new behaviour.

If eating behaviour change can indeed be described by a stage theory, we need not only to be able to classify people into different stages of readiness to alter their dietary habits, but also to demonstrate that different barriers are more important, and different interventions more effective, at the different stages. Demonstration of the usefulness of the TTM for promoting dietary change requires that its predictions are carefully tested for specific eating behaviours. This review explores the evidence currently available to support use of this model for dietary change. It goes beyond previous reviews of dietary applications of the model (Sigman-Grant, 1996; Ni Mhurchu *et al*. 1997) by providing an in-depth and comprehensive coverage of methodological issues and intervention considerations and as such will be of value to both TTM

Table 1. Dietary applications of the transtheoretical model

Study	Goal behaviour (i.e. action criteria)	Aspects of TTM studied	Sampling frame and response rate	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Testing TTM constructs or constructs from other models and theories	Validation	Results and comments
Group 1: Simple cross-sectional studies									
Auld *et al.* (1998), USA	Low-fat diet, high-fibre diet	Stage	Mail survey randomly sent to 7110 adults in eleven states and District of Columbia. Response rate 52%	*n* 3198 total, *n* 2004 and 2066 staged for fat and fibre	O (Kristal, 1990, rapid assessment questionnaire) plus attitudes/beliefs PC 8% fat, 7% fibre C 13% fat, 10% fibre Prep 35%, fat 44% fibre A or M 45% fat, 38% fibre				Only 64–66% of participants could be staged Only those with fat score predictive of fat intake $\leq$30% energy were classified in A or M
Curry *et al.* (1992), USA	Limit fat intake	Stage	Random sample of enrollees in a large HMO Response rate 62% plus participants in a RDD survey. Response rate 57%	*n* 1083 (2nd larger survey) 44 years, 57% F 91% $\geq$ HS	S, telephone PC 17% F, 29% Ma C 6% F, 7% Ma Prep 11% F, 7% Ma A 8% F, 6% Ma M 59% F, 50% Ma	Kristal *et al.* (1990) rapid assessment questionnaire (% energy from fat correlates with two 4-d diet records, *r* 0·54)		Fat intake significantly lower in A or M than in earlier stages; however, many in A or M not eating a low-fat diet	
de Graaf *et al.* (1997)	Healthy eating (as defined by individuals in various European countries)	Stage	1000 interviews by market research organizations to get nationally representative samples from each of fifteen European countries. No response rate stated	*n* 14 331, stage could be assessed for 88% (*n* 12 541)	S PC 46% F, 59% Ma C 2% Prep 1% A 7% M 36% F, 26% Ma R 7% F, 6% Ma	None			Most defined 'healthy eating' as eating less fat, more vegetables or a balanced/varied diet Influences on food choice: those in PC found taste more important, those in M found health more important
Greene *et al.* (1994), USA	Avoid or limit high-fat foods	Stage	Random sample of non-smoking adults. Response rate 32%	*n* 614 45 years 53% F mean education 15 years	S PC 18% C 14% Prep 8% A 17% M 48%	Forty-six item Kristal *et al.* (1990) food frequency questionnaire		Fat intake decreased across the stages, from 39% energy in PC to 32% in M Subjective staging algorithm: 75% in A or M had fat intakes > 30% energy	Algorithm with behavioural component was not sensitive; most subjects with low fat intakes were not classified in A or M

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Table 1. *Continued*

Study	Goal behaviour (i.e. action criteria)	Aspects of TTM studied	Sampling frame and response rate	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Testing TTM constructs or constructs from other models and theories	Validation	Results and comments
Laforge *et al.* (1994), USA	Eat five or more servings of fruit and vegetables per day	Stage	RDD survey of adults Response rate 84 %	*n* 405 > 18 years, 63 % F	One global question on servings of fruit and vegetables per day PC 38 % C 29 % Prep 19 % A 2 % M 13 %	Checklist of whether or not four fruit and vegetable items were eaten yesterday (score range 0–4)		Checklist score increased across stages	Dietary assessment not much more detailed than global question in staging algorithm PC more likely to be male, less educated
Group 2A: Cross-sectional tests of TTM predictions; comprehensive tests: stage, processes, decisional balance and self-efficacy									
Horwath & Gulliver (1998), New Zealand	Dietary guideline for milk-product consumption (≥ two servings/d)	Stage Processes Self-efficacy Decisional balance	Two random samples of women aged 25–70 years from electoral rolls, first survey *n* 500 (instrument development), second survey *n* 1200 (validation sample) 80 % response rate	*n* 352 and *n* 872 44 years, 100 % F Contacted by phone to assess stage: *n* 261 and *n* 704	O, short dietary interview on usual milk-product intake as integral part of algorithm PC 27 % C 4 % Prep 4 % A 4 % M 61 %	Validated Ca FFQ	Exploratory and confirmatory factor analysis of multi-item questionnaires to assess process use, self-efficacy and decisional balance	Identified eight processes (SL and SR combined; no RM identified) and two higher order factors (experiential and behavioural) Single self-efficacy scale, with higher self-efficacy in A, M Pros and cons identified, showing predicted pattern of change across the stages	For each process, use was significantly different across stages Experiential process use peaked in Prep, behavioural process use peaked in A, M CC, SC, ER, SL peak in M
Ounpuu (1997) Ounpuu *et al.* (1999*a*,*b*), Canada	Consistently avoid eating high-fat foods	Stage Decisional balance Self-efficacy Processes	Random telephone recruitment of women aged 25–70 years Questionnaire and 3-d-diet record booklet mailed to subjects 57 % response rate	*n* 491 44 years, 100 % F 68 % ≥ HS	S: from Greene *et al.* (1994) PC 19 % C 11 % Prep 10 % A 12 % M 47 %	3-d diet records posted at same time as questionnaire and staging algorithm	Tested Rossi *et al.* (1994 *a*,*b*,*c*) questionnaires in different population: exploratory and confirmatory principal components analysis	Energy from fat highest in PC (38 %) but > 40 % in A, M have > 30 % Decisional balance: two factor correlated solution proved the best model fit Self-efficacy: three factor structure; PC, C, Prep < A, M	27 % of sample are pseudomaintainers

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Table 1. *Continued*

Rossi *et al.* (1994*c*), USA	Dietary fat reduction	Stage Decisional balance	Random sample of non-smokers Response rate not reported	*n* 412 42 years, 51% F 50% ≥HS	S PC 20% C 16% Prep 8% A 21% M 35%	Kristal *et al.* (1990) rapid assessment questionnaire	Confirmatory factor analysis of decisional balance scale	With movement across the stages, a shift occurred in which the pros became more salient than the cons	Correlated two factor model provided best fit for data and both pros and cons increased in C
Rossi *et al.* (1994*a*), USA	Dietary fat reduction	Stage Self-efficacy	Random sample of non-smokers Response rate not reported	*n* 333 46 years, 50% F 42% ≥HS	S PC 32% C 28% Prep 18% A 4% M 17%		Structural modelling techniques	Three self-efficacy factors; positive/social, negative/affective, difficult situations	Self-efficacy highest in A, M
Rossi (1993), USA	Reduction of dietary fat and of five high-fat food categories	Stages	Random sample of non-smokers	*n* 200 55% F	O PC 15% C 5% Prep 4% A 10% M 67%	Kristal *et al.* (1990) FFQ		Dietary fat decreased across the stages, but about 40% in M had >30% energy from fat Pseudo-maintainers had fat intake between those in Prep and A	Increasing engagement in more fat reduction behaviours across most high-fat food sources from PC to M
Rossi *et al.* (1994*b*), USA	Dietary fat reduction	Stage Processes	Random sample of 450 non-smokers Response rate not specified	*n* 270 46 years 50% F 42% > HS	S PC 31% C 27% Prep 21% A 4% M 17%		Confirmatory factor analysis of eleven factor processes questionnaire	Correlated eleven factor model provided the best fit (i.e. eleven processes found: ten from Table 2 + interpersonal systems control)	Process use increased across stages Hierarchical two factor structure of experiential and behavioural processes replicated

(*Table continues*)

Table 1. *Continued*

Study	Goal behaviour (i.e. action criteria)	Aspects of TTM studied	Sampling frame and response rate	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Testing TTM constructs or constructs from other models and theories	Validation	Results and comments
Rossi & Rossi (1993), USA	Dietary fat reduction	Processes	RDD survey of 750 non-smokers 27 % response rate	*n* 201 44 years, 55 % F 48 % > HS		Rapid assessment questionnaire Kristal (1990)	Confirmatory factor analysis of thirty-one item processes questionnaire	Structural modelling analysis revealed eleven processes (ten from Table 2 + interpersonal systems control) HR, RM higher in C; DR higher in A; CC, SC higher in M	Process use increased across the stages (PC least, M most) CC and SC had lowest α Hierarchical two factor structure of experiential and behavioural processes replicated
Prochaska *et al.* (1992*b*), USA	Weight control	Stage Processes Self-efficacy	Hospital staff enrolled in a weight control programme; ≥ 10 % overweight	*n* 30 completed assessments at weeks 1, 5, 10 40 years, 91 % F mean 15 years education	Thirty-two item scale: a weight-control version of a scale validated to assess stages of change in psychotherapy		Previously validated scales: processes, forty-eight items; self-efficacy, forty items	Self-efficacy increased significantly across the stages	Processes and stages were the best predictors of treatment attendance and weight loss
Rossi *et al.* (1994*d*), USA	Weight control	Processes	Participants in three community weight loss programmes. 71 % response rate	*n* 285 48 years, 85 % F mean 12 years education	S: most in A since sample drawn from intervention programmes		Previously validated thirty-two item process questionnaire	Structural modelling analysis	Eight factor model (i.e. eight processes identified); two higher order factors (i.e. experiential and behavioural processes)
O'Connell & Velicer (1988), USA	Weight loss	Stage Decisional balance	University students enrolled in psychology	*n* 264 but 123 staged 18–27 years 70 % F	S PC 15 % C 53 % A 18 % M 15 %		Principal components analysis	Pros (α 0·91) and cons (α 0·84) scales identified	Action group showed greatest imbalance of pros over cons
Rossi *et al.* (1991*a*,*b*), USA	Weight control	Stage Processes	Volunteers in study of smokers and ex-smokers	*n* 650 39 years, 63 % F 75 % > HS			Principal components analysis of sixty item questionnaire	Ten factor solution (SL and SR merged; also included 'substance use' process)	Significant differences found in nine of ten process scales across the stages

(*Table continues*)

Table 1. *Continued*

Group 2B: other cross-sectional studies testing some TTM predictions									
Bowen *et al.* (1994), USA	Limit fat intake	Stage Processes	Volunteers from an outdoor music festival audience	*n* 720 35 years, 62 % F 84 % > HS	S: same as Curry *et al.* (1992) PC 22 % C 13 % Prep 5 % A 19 % M 41 %		Exploratory factor analysis	Eight processes identified: SC and CC combined to form 'behavioural and nutritional strategies'. Self liberation did not appear	All eight processes used more by those in later stages; however, no statistical tests reported of process use by stage
Brug *et al.* (1996), Netherlands	Reduce fat intake	Stage Self-efficacy	Random sample of 689 employees of a research unit in an oil company 74 % response rate	*n* 507 39 years 17 % F	S; similar to Curry *et al.* (1992) PC 14 % C 8 % Prep 26 % A 12 % M 40 %	Twenty-five-item validated Fat scores determined by FFQ	Attitudes: eight items Social support: three items Self-efficacy: two items	Attitudes and social support most positive in Prep and A Self-efficacy lowest in C and Prep	Most subjects in M had high fat scores and so need more valid dietary staging algorithms Only significant difference in fat consumption was a higher intake in PC (A, M same as C, Prep!)
Brug *et al.* (1997), Netherlands	Increase fruit and vegetable intake	Stage	Volunteers responding to advertisements	*n* 739 44 years 81 % F 90 % ≥ HS	S PC vegetables 6 %, fruit 9 % C vegetables 8 %, fruit 8 % Prep vegetables 33 %, fruit 36 % A vegetables 5 %, fruit 5 % M vegetables 48 %, fruit 40 %	Validated eight-item FFQ (servings of fruit and vegetables correlate with comprehensive food survey *r* 0·58)	Attitudes: one item Self-efficacy: one item	Intake and self-efficacy most positive in A, M Attitudes most positive in Prep and A	Large numbers of those in A, M had intakes below recommended levels
Domel *et al.* (1996), USA	Eating more fruit and vegetables	Stage Self-efficacy	Fourth and fifth grade students in three schools Response rates 73–93 %	*n* 134 (pilot test) *n* 252 (application) 50 % girls	Thirty-two item questionnaire (eight items per stage for PC, C, A, M)	7-d food records	Preferences Outcome expectation	Principal components analysis of multi-item stage questionnaire showed two factors: PC and beyond PC. No difference by stage in fruit and vegetable consumption	25 % of students could not provide responses consistent with theory Does TTM apply to children?

(*Table continues*)

Table 1. *Continued*

Study	Goal behaviour (i.e. action criteria)	Aspects of TTM studied	Sampling frame and response rate	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Testing TTM constructs or constructs from other models and theories	Validation	Results and comments
Campbell *et al.* (1998), USA	Eat more fruit and vegetables	Stage Self-efficacy Benefits and barriers	5596 members of African-American churches in ten rural counties 79% response rate	*n* 3557 51 years 70% F 66% ≥ HS	One global question on servings of fruit and vegetables per day PC 25% C 3% Prep 65% A 1% M 7%	Seven-item FFQ	Self-efficacy, benefits: one item each Barriers: six items Social support: five items	Those in A, M ate more fruit and vegetables, had higher self-efficacy and social support Barriers were most prevalent in PC Perceived benefit high across all stages	Knowledge of recommendations increased across stage Interventions should focus on barriers, self-efficacy, social support, knowledge of recommendations
Campbell *et al.* (1999), USA	Eat more fruit and vegetables	Stage Self-efficacy	Eight community intervention project sites involving adults or young adults	Vary according to site	One global question on servings of fruit and vegetables per day, other questions as for smoking Most sites: Prep 50% PC 20%, C < 5% A < 4%	Seven-item FFQ	Autonomy for food choice Self-efficacy: one item	Those in A, M ate more fruit and vegetables, were more aware of five-a-day programme, had higher self-efficacy Percentage with high autonomy increased across stages	Fewer women in PC; more highly educated likely to be in A or M Dietary assessment instrument very brief Multi-item self-efficacy scale may be more useful
Glanz *et al.* (1998*a*), USA	Low-fat, high-fibre diet	Stage	5043 employees from twenty-eight worksites (a group at increased risk of colorectal cancer) were sent a mail questionnaire 57% response rate	*n* 2764 57 years 0% F 58% > HS	S: Glanz *et al.* (1994) Distribution only shown by predisposing and enabling factors	Semi-quantitiative FFQ (Kristal *et al.* 1994)	Predisposing and enabling factors (α 0·5 and 0·55)	Fat, fibre and fruit and vegetable intake differed significantly across the stages in the predicted manner. However, those in M had 32% energy from fat, and those in A and M only ate 3–4 servings of fruit and vegetables per day	For fat and fibre: higher predisposing and enabling scores strongly and significantly linked with higher proportion in M and very low proportions in PC Poor agreement between stages for fat and fibre Stage explains the most variance in dietary intake

(*Table continues*)

Table 1. *Continued*

Glanz *et al.* (1994), USA	Low-fat and high-fibre diet	Stages	Employees of ninety-three geographically diverse worksites Mean response rate 78 %	*n* 17 121 40 years 32 % F 59 % > HS	S: PC 14 % fat, 12 % fibre C 19 %, fat, 28 % fibre Prep 4 %, fat, 9 % fibre A 46 % fat, 33 % fibre M 17 % fat, 18 % fibre	Eighty-eight-item FFQ	Self-efficacy (one item per goal) Motivation for change	Fat intake differed significantly: earlier stages < A < M; fibre increased across stages Those with higher self-efficacy more likely to be in A, M	Larger proportion reported trying to decrease fat than increase fibre
Lamb & Joshi (1996), England	Avoiding fat in the diet	Stage four processes: CR, SR, SL, HR	Convenience sample of university students; 40 % of those seated in buffet area agreed to participate	*n* 133 18–25 years 55 % F	S: does not use Prochaska *et al.*'s (1997) intentional criteria and time frames PC 21 % C 32 % Prep 23 % A 14 % M 11 %	Frequency of use of fourteen fat sources Score computed for % energy from fat (validity unknown)	Process items reflect attitudes or beliefs about fat reduction and nutrition knowledge, not the actual degree of use of various strategies	Fat scores differed significantly: PC, C < Prep < A, M (43 % energy in PC, C to 17 % in M) Four processes assumed, no factor analysis A discriminant function using CR, SL and SR distinguished the stages	Only CR was significantly different at the predicted transition (i.e. PC to C) SR and HR not significantly different between any stages CR: PC < C < Prep < A, M SL: PC, C, Prep, A < M Major impact of SL was later than that of CR
Ling & Horwath (1999*a*,*b*), Singapore	Singapore guidelines: ≥ 4 fruit and vegetable servings per day, 5–6 (F) or 6–7 (Ma) grain servings per day	Stage Self-efficacy Decisional balance	1200 Chinese households randomly selected from Singapore residential telephone listings 71 % response to mail survey	*n* 796 (mail), *n* 716 (phone, survey – stage) 39 years 51 % F	O: Sixteen-item validated FFQ as integral part of staging algorithm PC 29 % fruit and vegetables, 43 % grains C 33 % fruit and vegetables, 7 % grains Prep 29 % fruit and vegetables, 8 % grains A, M 9 % fruit and vegetables, 42 % grains	Separate validation study of staging algorithm using three 24 h recalls	Exploratory and confirmatory factor analysis of multi-item scales to assess decisional balance and self-efficacy	For both food-based goals: internally consistent pros and cons scales, showing predicted crossover across the stages Multi-dimensional self-efficacy scales, showing predicted increase across the stages	Poor agreement between stages for fruit and vegetables and grains Decisional balance more important in distinguishing early stages and self-efficacy later stages

(*Table continues*)

Table 1. *Continued*

Study	Goal behaviour (i.e. action criteria)	Aspects of TTM studied	Sampling frame and response rate	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Testing TTM constructs or constructs from other models and theories	Validation	Results and comments
Sorenson *et al.* (1998), USA	Increase fruit and vegetable consumption	Stage	Twenty worksites; 1588 employees Mean response rate 87 %	*n* 1359 84 % F 81 % > HS	O: Seven-item fruit and vegetable screener is integral part of algorithm PC, C 30 % Prep 58 % A, M 12 %		Social support (six items)		Co-worker support significantly associated with Prep *v.* PC or C Stage not linked to household support
Sporny & Contento (1995), USA	Reduce amount of fat and fatty foods eaten	Stage Self-efficacy Outcome expectancies (similar to pros and cons)	Convenience sample of mainly upper middle class, government employees from a single town Response rate not reported	*n* 615 43 years 66 % F 14 years education	S PC 8 % C 9 % A 38 % M 45 % 2 years used to distinguish A and M	Rapid assessment questionnaire (Kristal *et al.* 1990)	Perceived threat Perceived benefits and barriers Social influence	Fat decreased significantly: PC, C < A < M. However those in A had 34 % energy from fat Self-efficacy: PC, C, Prep < A < M	A and M associated with reduced barriers (especially taste, difficulty in performing behaviours) and increased health concern, social modelling and self-efficacy
Steptoe *et al.* (1996), England	Eat a low-fat diet, reduce fat intake	Stage Decisional balance	Mail survey of 800 households (randomly selected from electoral register) in two areas of South London (one affluent, one less wealthy) 46 % response rate	*n* 366 52 years 57 % F Mean age on leaving school was 16·6 years	S (same as Curry *et al.* 1992) PC 29 % F, 43 % Ma C 13 % F, 13 % Ma Prep 3 % F, 6 % Ma A 6 % F, 5 % Ma M 50 % F, 33 % Ma	DINE instrument to assess fat and fibre scores (correlates *r* 0·51 and 0·46 with 4-d diet records)	Decisional balance items referred to 'eating healthy food' rather than dietary fat reduction	Fat scores decreased significantly across stages; however, many in A, M not eating a low-fat diet Pros and cons factors identified (benefits and costs: α 0·77 and 0·64)	PC, cons higher A, M, pros higher Crossover between Prep and A Low response rate so results not representative of general population
Jeffery *et al.* (1998), USA	Dieting	Stage	Women volunteers 20–45 years in good health, BMI > 21	*n* 719 (baseline) *n* 645 (year 3) 38 years, 100 % F 86 % > HS	S PC 39 % C 4 % Prep 24 % A 33 %	None reported		Stage classification for 'dieting' did not predict success in future weight control	Goal behaviour (dieting) complex and non-specific Outcome monitored (weight change) is a physiological outcome – not a behaviour Not surprising that this is not related to stage classification

(*Table continues*)

Table 1. *Continued*

Study	Goal behaviour (i.e. action criteria)	Study design and response rate	Intervention and control groups	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Outcome	Effect of stage	Other comments
Group 3: Longitudinal studies									
Beresford *et al.* (1997), USA	Lower fat intake and raise fibre intake	Randomized controlled trial of twenty-eight physician practices; 3 and 12 month follow up Response rate 51 % intervention group, 53 % control group	I: self-help booklet with physician endorsement and reminder letter from physician Ct: usual care (no intervention)	I: *n* 859 (12 months) Ct: *n* 959 75 % < 75 years 68 % F 74 % > HS	S As in Curry *et al.* (1992)	FFQ (modified Block *et al.* 1986) and food habit questions related to fat and fibre (Kristal *et al.* 1990)	I: significantly greater reduction in fat and increase in fibre score. (Increase in fibre in g/4200 J not significantly different between I and C groups)	Those in A or M at baseline showed greater reduction in % energy as fat than those in earlier stages Increase in fibre in g/4200 J varied little by stage; however, fibre score increased more in A or M group	Presented only baseline data on stage. Did not examine effect of intervention on stage Did not examine whether stage movement was associated with dietary change
Glanz *et al.* (1998*a*), USA	Lower fat intake and raise fibre intake	Randomized matched-pair design with worksite as unit of randomization Employees at 111 work sites employing more than 28 000 Mean response: baseline, 69 %; followup 71 % (3 years)	I: building awareness, skills training, relapse prevention via a range of activities and environmental change Ct: no intervention at control work sites	I: *n* 5068 (fat) Ct: *n* 5317 I: *n* 5042 (fibre) Ct: *n* 5292 43 years 28 % F 58 % > HS	S As in Glanz *et al.* (1994) A or M (fat) 62 % A or M (fibre) 50 %	FFQ (eighty-eight items)	Movement from pre-action stages at baseline to a later stage was significantly more likely at intervention sites	Baseline stage predicts participation in intervention activities (lowest in PC) Movements to later stages were associated with decreases in fat intake and increases in fibre intake	Did not have separate staging algorithms for fibre and fruit and vegetable intake
Green & Rossi (1998)	≤ 30 % energy as fat	Randomized trial of subjects recruited by mail from random sample of non-smoking adults 32 % response rate	I: one dietary feedback report and brief educational materials at baseline Ct: nothing at baseline I + Ct: identical dietary feedback at 12 months	Subjects from Greene *et al.* (1994) who had > 30 % energy as fat at baseline *n* 296 provided data at all time points 46 years 48 % F 15 years education	Baseline: all those who perceived they were avoiding fat but had ≥ 30 % energy as fat were labelled 'unclassified' (54 %) 12 and 18 months: as in Greene *et al.* (1994)	Forty-six-item Kristal *et al.* (1990) food habit questionnaire	Feedback accelerated rate of fat reduction at 6 months, but not at 12 or 18 months Over 18 months precontemplators decreased their % energy as fat less than other subjects	Those in Prep (*n* 21) or unclassified (*n* 150) at baseline were more likely to move forward or backward than those in PC or C at baseline By 12–18 months, those progressing at least one stage reduced their fat intake more than those who did not progress	Single, individualized dietary feedback had no long-term effect

(*Table continues*)

Table 1. *Continued*

Study	Goal behaviour (i.e. action criteria)	Study design and response rate	Intervention and control groups	Sample (*n*, mean age, % women)	Stage distribution (%)*	Dietary assessment	Outcome	Effect of stage	Other comments
Group 4: Stage-matched intervention studies									
Campbell *et al.* (1994), USA	Decreased fat and increased fruit and vegetable intake	Randomized patients attending family practice clinics 82% response rate 4 month follow up	I: One tailored mailed nutrition message matched to stage, behaviour and psychosocial information OR: standardized nutrition message Ct: no messages	*n* 558 (baseline) 41 years, 75% F 14 years education	S PC fat 25%, fruit and vegetables 28% C and Prep fat 45%, fruit and vegetables 39% A and M fat 29%, fruit and vegetables 33%	FFQ (twenty-eight items including eighteen for fat) Fat (g) decreased across stages; fruit and vegetable servings were highest in A and M (3·9 servings per day)	Fat and saturated fat (g) decreased significantly more in tailored group *v.* control group. Standardized group did not differ significantly from control group	Did not examine effect of intervention on stage transitions	Those sent tailored messages were more than twice as likely as those sent nontailored messages to remember receiving the information Fruit and vegetable intake did not significantly increase in any study group

*Unless otherwise stated, stage classification includes an assessment of behaviour, either subjective (S) or objective (O), and intention.
TTM, transtheoretical model; S, subjective; O, objective; PC, precontemplation; C, contemplation; Prep, preparation; A, action; M, maintenance; R, relapse; HMO, health maintenance organization; RDD, random digit dial; F, female; HS, high school level; FFQ, food frequency questionnaire; I, intervention; Ct, control; HR, helping relationships; RM, reinforcement management; DR, dramatic relief; CC, counter-conditioning; SC, stimulus control; ER, environmental re-evaluation; SL, self liberation; SR, self re-evaluation; Ma, male.

researchers and practitioners. The two previous reviews have focused largely on stage classification, and included tables summarizing six to seven dietary studies. In this present review, Table 1 summarizes thirty-four dietary studies, grouped according to the broad approach taken to test the validity of the model for dietary change. Many of the studies providing the most comprehensive tests of TTM predictions (Table 1: group 2A and group 3) have been reported since the other reviews were published.

Outline of the transtheoretical model

Although originally developed by Prochaska and DiClemente around 1980 to examine smoking cessation (Prochaska, 1979; DiClemente & Prochaska, 1982), the TTM has since been applied to a wide range of health behaviours from sunscreen and condom use, to exercise adoption, mammography screening and quitting cocaine (Prochaska *et al*. 1994). Applications include cessation and acquisition behaviours, as well as addictive and non-addictive behaviours.

Classification system

People are assigned to one of five stages on the basis of their behaviour and current intentions for future action (Prochaska *et al*. 1997). Using the example of smoking cessation, a precontemplator is a smoker who has no intention of quitting in the foreseeable future (operationalized as the next 6 months). At this stage, people tend to avoid thinking, talking or reading about the problem behaviour, and in fact, see more benefits than disadvantages to continuing to behave in the same way. Other theories have characterized such people as resistant or unmotivated, or as not ready for health promotion programmes. Traditional health promotion programmes have not been designed to match the needs of precontemplators, or to speak in a language that is relevant to them.

A contemplator is a smoker who is thinking about quitting sometime in the next 6 months, but is not planning to quit in the next month. Contemplators tend to be acutely aware of arguments both for and against changing, and the profound ambivalence which can result may keep people stuck at this stage for long periods (Rossi *et al*. 1995*b*). These people are also not ready for traditional action-oriented programmes. Preparation indicates that the person intends to take action within the next month and has made some movement towards action (at least one unsuccessful 24 h quit attempt in the past year). These individuals have a plan of action, and perceive the benefits of changing as outweighing the costs. Those in preparation are the ones for whom action-oriented programmes are most appropriate.

Action involves successfully altering overt behaviour (i.e. quitting smoking) for anywhere between 1 d and 6 months. This model makes an important distinction between 'action', which is observable, or overt behaviour change, and other modifications of behaviour. Prochaska *et al*. (1997) specify that in order to be classified in action, people must attain the criterion that scientists agree is sufficient to reduce disease risk (e.g. total smoking abstinence, consuming less than 30 % energy as fat). Action is the least stable stage and tends to have the highest risk for relapse. After 6 months a person is said to have reached maintenance, the stage in which people work to prevent relapse. Those in maintenance are less tempted to relapse and increasingly confident that they can continue their changes. For smoking and other addictive behaviours, a stage may eventually be reached where there is no temptation to relapse in any situation ('termination'), and it is as though the problem behaviour never existed. For smoking, this typically takes approximately 5 years.

It is important to note that the time frames used to distinguish the stages are somewhat arbitrary. Relapse curves and use of change strategies (Prochaska & DiClemente, 1983) provide support for the action and maintenance time frames for smoking cessation and other addictive behaviours. However, these same time frames have generally been assumed, in the absence of supporting evidence, to be relevant to all health behaviours. It may well be easier to identify the time elapsed since a major event such as quitting smoking, than to estimate the number of months for which multiple changes to eating behaviour have been followed (Greene & Rossi, 1998). Furthermore, for behaviours undertaken infrequently (such as mammography screening), different time frames are more appropriate.

Progression through the stages is primarily forward and sequential; however, it is neither inevitable or irreversible. Some people endlessly think about changing, without ever acting ('chronic contemplators'). Relapse to earlier stages can occur, so that repeated change attempts and relapses can produce a spiral-like progression through the stages (Prochaska *et al*. 1992*a*). Longitudinal studies have shown that behaviour change is not a linear movement through the stages, but instead can be either progressive, regressive, spiralling or static (Prochaska *et al*. 1992*a*). Research on smokers indicates that, on average, self-changers make three to four quit attempts before successful cessation is achieved (Prochaska, 1991).

Stage distributions for random samples of smokers are typically: 40 % precontemplation, 40 % contemplation and 20 % preparation (Velicer *et al*. 1995) and there are some data to support similar distributions for people performing other high-risk behaviours (Rossi, 1992*a*).

Other constructs of the model

Despite the great popularity of this model over several years, many studies applying it to behaviours other than smoking have been restricted to examination of the stage classification scheme. The creation of stages and examination of stage characteristics, however, is insufficient to test the validity of a stage model. Stage is just one variable in the TTM. The model also specifies many factors which produce transitions between the stages (processes of change), as well as outcome measures that can be used to monitor success at different stages (self-efficacy (DiClemente, 1981) and decisional balance (Velicer *et al*. 1985)). Here the model integrates key constructs from different theoretical models. The change that occurs at different stages is qualitatively different, requiring different cognitive, emotional and behavioural activities. Thus different outcome variables can be used to monitor success at the different stages.

Outcome measures. Self-efficacy (confidence to perform the new behaviour) and decisional balance (relative importance of the perceived pros and cons of adopting the new behaviour) constructs are shared by a number of continuum theories (e.g. social learning theory, theory of planned behaviour, health belief model). The pros and cons of change are the individual's perceptions of the actual consequences of changing high-risk behaviours. In the TTM, self-efficacy is conceptualized not only as confidence in ability to change the risk behaviour, but also as temptation to continue the risk behaviour.

Smoking cessation research shows that self-efficacy improves and temptation declines with progression across the stages (DiClemente *et al*. 1985) and there is a shift from cons being perceived as being more important than pros in precontemplation, to pros being perceived as

Table 2. The processes of change

Process	Definition and intervention strategies
Experiential:	
Consciousness raising (CR)	Increasing understanding and awareness of self and problem behaviour (observations, bibliotherapy)
Dramatic relief (DR)	Experiencing and expressing strong emotional reaction to events occurring in the environment; involves catharsis (psychodrama, role-playing)
Self re-evaluation (SR)	Appraising the pros and cons associated with changing the problem behaviour (clarify values, imagery, imagine how overcoming problem will feel)
Environmental re-evaluation (ER)	Appraising how one's problem behaviour affects other people or the environment in general (empathy training)
Social liberation (SL)	Is concerned with changes in the environment that provide the individual with alternatives (policy intervention)
Behavioural:	
Self-liberation (SL)	Choosing and committing to act, believing in ability to change (decision-making therapy)
Counter-conditioning (CC)	Substituting alternatives for problem behaviour (relaxation, desensitization, assertion)
Stimulus control (SC)	Removal of cues or avoidance of situations which trigger the behaviour, restructuring one's environment to add stimuli for alternative behaviours
Helping relationships (HR)	Trusting others, and accepting and utilizing their support to change (social support, self-help groups)
Reinforcement management (RM)	Rewarding oneself or being rewarded by others for making changes (contracts, overt and covert reinforcements)

more important than cons in the later stages. The latter observation has been replicated across many behaviours (Prochaska *et al*. 1994).

Change strategies. The ten processes of change form the basis for intervention (Table 2). They are the common strategies or techniques, emerging from a comparative analysis of various psychotherapeutic approaches (Prochaska, 1979) that can be used to change behaviour. For example, 'consciousness raising', from the Freudian tradition, involves gaining an awareness or understanding of the problem, and 'reinforcement management', from the Skinnerian tradition, involves increasing the rewards for the healthy behaviour, and reducing the rewards for the unhealthy behaviour. Other processes involve self-reappraisal, supportive relationships, and commitment. Research across a number of behaviours (including smoking, weight control, psychological distress, exercise, alcohol abuse) demonstrates that precontemplators infrequently use all processes, that use of those processes which involve gaining insight and understanding (experiential processes, or emotional or cognitive strategies) increases in contemplation and peaks in the preparation stage, while those in action and maintenance are more likely to use behavioural processes (Prochaska & DiClemente, 1985; Prochaska *et al*. 1988; Rossi *et al*. 1991*b*; Rossi, 1992*b*). Successful change appears to depend on doing the right things (processes) at the right times (stages). Although the oldest part of the model, the processes of change are the least studied aspect outside the smoking cessation research.

How do we test whether the transtheoretical model is valid for dietary change?

Before reviewing the available data on applications of the model to eating behaviour change, let us examine the types of data required to test the hypothesis that dietary change follows a stage

https://doi.org/10.1079/095442299108728965 Published online by Cambridge University Press

process. Weinstein *et al*. (1998) provide a more detailed account of suitable research designs for testing stage theories generally.

Cross-sectional studies

Initial steps taken to study the TTM as applied to eating behaviour involve comparison of people classified in different stages in terms of variables presumed to differ across the stages. At the simplest level are comparisons of eating behaviour and demographic characteristics. Comparisons of differences in process use, self-efficacy and decisional balance across the stages provide tests of model predictions. While smooth, linear changes across stages are consistent with the stages representing an underlying continuum, changes across stages which show different patterns for different variables and are of different magnitudes, suggest (but do not provide conclusive support for) a stage model (Weinstein *et al*. 1998).

Perhaps the strongest cross-sectional test of the model is whether different variables are important in predicting membership of specific stages relative to other stages. In other words, are different variables important in discriminating precontemplators from those in later stages, than are important in discriminating those in preparation from those in action or maintenance?

Longitudinal studies

Longitudinal studies can provide a variety of more powerful tests of the model, examples being: testing the hypothesized sequence of stages, whether stage classification predicts future behaviour, and whether different factors predict different stage transitions.

Such tests using longitudinal data have rarely been undertaken for eating behaviour change. Thus it is useful to outline briefly the types of longitudinal data supporting the contention that smoking cessation follows a stage process, since these provide some ideas of the kinds of analysis which might usefully be applied in studies of eating behaviour change.

Prochaska *et al*. (1991) demonstrated using 6-monthly stage classifications over a 2-year period that, although 36 % of smokers and ex-smokers stayed in the same stage for all of the five examination points, 16 % progressed from one stage to the next in the specified sequence without any regression. Stage classification for smoking cessation also predicts future behaviour: smokers in the preparation stage are three times as likely to quit smoking over 18 months as those in the precontemplation stage (Prochaska *et al*. 1992*a*). Prochaska *et al*. (1985) also observed that self-efficacy contributed strongly both to the transition from contemplation to action and from action to maintenance, but that decisional balance predicted change for those in the precontemplation and contemplation stages. Intuitively, it makes sense that for those in the early stages not yet committed to the idea of change, the most important predictor of progression to later stages is the relative importance of the pros and cons of changing, but that confidence in ability to perform the new behaviour is the more important factor later on once a decision or commitment to change has already been made. Another longitudinal analysis (Prochaska *et al*. 1992*a*) has shown that people who remain at the same stage for prolonged periods show little change in the use of processes, while those progressing from one stage to the next demonstrate a gradual increase in the overall process use. The utility of self-efficacy has also been shown in a longitudinal study of volunteers trying to quit smoking. Lower self-efficacy scores were predictive of subjects who remained in the same stage or relapsed (DiClemente *et al*. 1985).

The ultimate test: stage-matched interventions

The ultimate test of the model is whether stage-matched dietary interventions outperform standardized approaches. According to the model, if different factors influence transitions at different stages, then individuals should respond better to interventions tailored to match their stage of change.

For smoking, individualized self-help materials matched to stage and other TTM variables more than doubled the rate of cessation compared with traditional, action-oriented self-help manuals (Prochaska *et al*. 1993).

Weinstein *et al*. (1998) have gone a step further in noting that only stage models predict that the sequence of interventions is important in determining intervention efficacy. Stage-appropriate interventions sequenced to follow the sequence of hypothesized stages should be most effective; however no one has yet investigated the effects of using different sequences of treatments.

An overview of findings from the reviewed literature in Table 1

Table 1 summarizes studies which have applied the TTM to eating behaviours, dividing them into broad categories according to the approach used to test the model. All studies identified since 1988 covering all age groups are included in the table. Over one-third were published in 1998 or will appear in 1999, and a number of unpublished manuscripts from Prochaska's group are included. About two-thirds of studies were concerned with the goal of lowering dietary fat intakes. Studies have been undertaken among predominantly Caucasian populations, with only one specifically exploring model constructs in African-Americans (Campbell *et al*. 1998) and one in Chinese-Singaporeans (Ling & Horwath, 1999*a,b*; A Ling and CC Horwath, unpublished results).

Studies in group 1 (Table 1) involve cross-sectional comparisons mainly of eating behaviour and demographic characteristics across the stages of change. Group 2 studies test model-predictions using cross-sectional data by examining changes across the stages, and are further divided into two categories: 2(A) includes comprehensive tests of all aspects of the model, while 2(B) examines only selected constructs from the TTM or other theories and models. Group 3 includes longitudinal studies which provide the opportunity to examine whether stage classification is related to the probability of successful behaviour change in the future. Group 4 studies provide the ultimate test of the model by examining the effectiveness of stage-matched interventions relative to standardized approaches.

The 'dietary assessment' column (Table 1) indicates the reference method chosen to evaluate whether those classified in different stages differed in their eating habits in the predicted manner. This is the common approach taken to 'validating' the stage classification system. The 'stage distribution' column shows the sample distributions by stage (reported in some studies separately by sex or different dietary goals) and also indicates whether any brief objective measure of intake was included as an integral part of assessing stage (discussed in detail later, pp. 299–302). In assessing stage, 'subjective' measures of eating behaviour are considered to be those based on subjects' self-perceptions of, for example, whether they are eating a low-fat diet or limiting fat intake (e.g. Curry *et al*. 1992). In contrast, 'objective' measures of eating behaviour are considered to be those undertaken by the researchers, usually using a short questionnaire or interview (e.g. Sorenson *et al*. 1998; Ling & Horwath, 1999*b*).

As Table 1 clearly shows, most dietary applications of the model involve cross-sectional studies, and many examine only the stage construct. A number of these simply compare dietary

intake at different stages, while others examine whether those classified in different stages differ in socio-demographic characteristics or various attitudes or beliefs (de Graaf *et al*. 1997). However, it cannot be emphasized strongly enough that mere demonstration of dietary intake or socio-demographic differences across the stages does not demonstrate, as has often been assumed, that eating behaviour change follows a stage process.

About one-third of studies examined to some degree the associations between other aspects of the TTM and the stage variable (e.g. Bowen *et al*. 1994; Lamb & Joshi, 1996; Steptoe *et al*. 1996; Ling & Horwath, 1999*a*; A Ling and CC Horwath, unpublished results), and only three groups of investigators included measurement of all the TTM constructs (Prochaska *et al*. 1992*a*; Rossi *et al*. 1994*c*,*d*; Ounpuu, 1997, 1999*b*; Gulliver, 1998; Horwath & Gulliver, 1998). These latter studies are capable of providing the most comprehensive test of model predictions. Other investigators have compared people at different stages using variables derived from other behavioural theories (Sporny & Contento, 1995; Glanz *et al*. 1998*a*). Only five studies reported predictions of stage membership (Sporny & Contento, 1995; Ling, 1999) or whether stage predicts future behaviour (Beresford *et al*. 1997; Glanz *et al*. 1998*b*; Jeffery *et al*. 1999) and only one tested the effectiveness of a stage-matched intervention (Campbell *et al*. 1994).

While there is much convincing evidence from studies at all levels that smoking cessation follows a stage process, as will be discussed later (pp. 304–308), the validity of the TTM and effectiveness of stage-matched interventions have been less thoroughly tested for eating behaviour change.

Since Table 1 provides considerable detail on study design, sample characteristics, methods and key findings, the following discussion will highlight important issues arising in applications to eating behaviour change, summarize the main conclusions that can be drawn from the reviewed literature, as well as raise unanswered questions. Direct study comparisons are made difficult by substantial differences in study populations, methods used to assess stage, and dietary methodology. Although included in Table 1, weight-control applications will be discussed separately in a later section (pp. 308–309), since this goal includes a complex set of behaviours (eating habits, exercise, use of medications or other substances to control weight).

Methodological challenges in applying the model to eating behaviour change

The immediate dilemma which faces anyone attempting to apply the model to eating behaviour is a realization of the numerous ways in which dietary change differs from smoking cessation (Table 3). Dietary guidelines involve themes of balance and moderation, with goal behaviours (or action criteria) being gradations of intake, often achieved as a result of multiple changes to

Table 3. Differences between eating behaviour change and smoking cessation

Characteristic	Smoking	Eating behaviour
Addictive behaviour	Yes	No
Goal of behaviour change	Cessation	A level of intake, not 'all or none'
Understanding of goal behaviour by lay public	Clear	Very poor (especially for 'nutrient' goals)
Reporting of behaviour	Relatively simple	Extremely difficult (especially for 'nutrient' goals)
Behaviour change required to achieve desired goal	A single behaviour	Multiple changes, more complex
Difficulty of behaviour change	Very difficult at first but gradually easier over time	Easy to initiate, but constant vigilance may be required
Immediately discernible physiological changes	Yes	No

food selection patterns, preparation methods or serving sizes consumed. Nutritionists obviously do not wish anyone to cease eating, or even to cease eating a particular food group or nutrient such as fat! Dietary behaviours are usually complex behaviours which are difficult to report, since most people lack the knowledge to rate their own diets in terms of say, fat or fibre (Greene *et al*. 1993). Essentially, the problem is that for dietary goals, people do not know where they are at in relationship to the action criterion, or what changes they would need to make in order to reach the criterion. While smoking cessation becomes easier with time, it may be that with eating behaviour change, constant vigilance is required to make many healthy choices over unhealthy options over an extended period of time (Jeffery *et al*. 1999). Perhaps for eating behaviour change, the risk of relapse remains high since people are constantly confronted with social situations in which a range of less healthy choices are available and modelled by others. Some evidence suggests social situations to be a far more common reason given for relapse by those attempting eating behaviour change than by those quitting smoking (Marlatt, 1982). Furthermore, there is a multitude of different eating styles and individual food preferences that could be compatible with the ultimate goal of eating, for example, a low-fat diet. It can also be questioned whether the factors responsible for transitions between adjacent stages are the same for changing eating behaviour as for smoking cessation.

Stage classification for readiness to change eating behaviour

A staging algorithm, or series of mutually exclusive branching questions, is the most common method for assigning stage classifications (e.g. Prochaska *et al*. 1992; Sorenson *et al*. 1998). The alternative continuous-scales approach (in which there is a series of statements designed to capture the essence of each stage) assigns each individual a score on each stage (Prochaska *et al*. 1992*a*,*b*). The latter approach is not intended to be used to assign individuals to discrete stages of change. Rather, the continuous method can indicate stage profiles for individual subjects and identify those with variations or complex combinations of stage-specific attitudes and behaviours (McConnaughy, 1989), or subtypes of individuals within a stage (Rossi *et al*. 1995*b*).

Several issues must be addressed regarding stage classification approaches for dietary behaviour changes. These are vital for effective use of the model not only by TTM researchers, but also practitioners. Currently there is no clear consensus on stage definitions for eating behaviours.

Obviously stage distributions are strongly influenced by the classification system. If dietary behaviour goals (or action criteria) are poorly understood, errors occur not only in the assignment of stage, but with all TTM constructs, since items to measure all constructs include reference to the goal behaviour. Most importantly, correct stage classification is essential for the delivery of stage-matched interventions.

Should stage assessment include an objective behavioural measure?

One key issue which has arisen with dietary applications of the model is whether stage classification should be based on entirely subjective assessments (i.e. do people perceive themselves to be eating a low-fat diet) or more objective assessments of behaviour (i.e. a short dietary assessment undertaken by the researchers). Of course, all dietary assessments based on self-reporting are to some extent subjective. The question is whether ‘stage’ is a purely cognitive construct, or involves a behavioural element. Most dietary applications of the model have involved subjective assessments by subjects of whether, for example, they are ‘limiting the fat

in their diet', 'consistently avoiding high-fat foods' or 'eating a low-fat diet' (Curry *et al*. 1992; Glanz *et al*. 1994; Greene *et al*. 1994; Sporny & Contento, 1995; Steptoe *et al*. 1996). However, many of the large proportion of subjects classified in action or maintenance in these studies consumed a diet with more than 30 % of energy from fat (Glanz *et al*. 1994; Greene *et al*. 1994; Sporny & Contento, 1995; Brug *et al*. 1996; Steptoe *et al*. 1996; Ounpuu, 1999*a*) and have been referred to as pseudomaintainers (Greene *et al*. 1994). This problem arises largely from those issues outlined in Table 3 concerning the nature and specification of the goal behaviour. But Prochaska *et al*. (1997) maintain that in order to be classified in action, people must attain the criterion that health professionals have agreed upon for reduction of disease risk (i.e. if lowering fat intake is chosen as the goal: less than 30 % energy as fat) (Rossi *et al*. 1995*b*; Prochaska *et al*. 1997).

The misclassification of most subjects into action and maintenance stages, despite 75 % of these subjects having fat intakes above 30 % of energy, led Greene *et al*. (1994) to develop an approach whereby the subjective algorithm was followed by an objective assessment of five specific fat-reduction behaviours. Subjects who on the basis of the subjective algorithm were classified in action or maintenance, but who failed to meet at least four of the five objective criteria, were reclassified into the preparation stage. While this approach is successful in classifying the majority (87 %) of those with fat intakes above 30 % of energy into preaction stages, a minority (27 %) of those with fat intakes below 30 % of energy were classified in action or maintenance. It might be argued that for screening purposes, it is less problematic to reinforce fat-reducing messages in those already meeting the guideline than it is for those not meeting recommend-ations to lose the possibility of an intervention; however, clearly this classification approach cannot be used as the basis for personalized feedback on how people are changing. Furthermore, the question remains as to the appropriateness of staging on the basis of poorly understood questions, and then of reclassifying, using more objective criteria, only a subgroup of subjects into an arbitrarily chosen stage. In fact, pseudomaintainers have been found to be a heterogeneous group composed of individuals at all earlier stages (Rossi & Rossi, 1993).

Ounpuu (1999*a*) has explored the characteristics of pseudomaintainers and found they were similar to true maintainers in terms of self-efficacy level, but that true maintainers reported lower cons for fat reduction and higher use of all nine processes of change. Although pseudomaintainers were more similar in terms of actual behaviour to precontemplators, pseudo- and true maintainers appeared more similar to each other than to precontemplators when other TTM variables were examined. The similar self-efficacy levels are not surprising, simply suggesting that both pseudo- and true maintainers were confident of maintaining their current perceived low level of fat intake. Have pseudomaintainers already markedly reduced fat intake from extremely high levels to intakes which are still as high as those of precontemplators (38 % energy)? Or is it simply that they are particularly unaware of the characteristics of a low-fat diet and unaware of their own eating habits? Pseudomaintainers comprised >25 % of the total population staged in this study and a similar or higher (Greene *et al*. 1994) proportion in other studies. What remains unclear is how this sizeable group should be handled in the stage classification process. The investigators (Ounpuu *et al*. 1999*a*) concluded that the results suggest the need for individual tailoring within stage of change. Perhaps this implies that TTM variables other than stage are more meaningful in applications to dietary fat reduction?

Further attention must also be paid to the validity of the objective component of any staging classification system. The behavioural algorithm used by Greene *et al*. (1994) incorporated fat reduction behaviours selected from the questionnaire of Kristal *et al*. (1990). Evaluation of the Kristal fat-screening instrument, however, indicates that it is not a sensitive method of identifying high or low fat consumers (Birkett & Boulet, 1995). Use of questions

from such a screener would undoubtedly lead to misclassifications in stage assignment. The same fat screener has also frequently been used as the reference dietary assessment measure (Curry *et al*. 1992; Rossi *et al*. 1994*c*; Sporny & Contento, 1995; Auld *et al*. 1998): that is, as one test of the validity of the staging algorithm. Yet if the reference method is not a sensitive measure of intake, how useful is such a comparison?

More recently, Greene & Rossi (1998) have proposed a new approach to classifying 'true maintainers' that combines subjective and objective assessments: self-report of fat avoidance for more than 6 months, plus two estimations 6 months apart of assessed fat intake below 30 % of energy intake. Only 19 % of 'true maintainers' relapsed, in contrast to 31 % of self-classified maintainers. Such an approach precludes, however, the possibility of rapid stage assessment for large population groups.

Other objective assessments of behaviour as an integral part of staging instruments are rare. During brief phone interviews, CC Horwath and P Gulliver (unpublished results) estimated typical daily servings of milk products before questions focusing on intentions to change. The phone interviews enabled investigators to assist respondents in estimating their usual intake, then, before questions regarding intentions, to ensure they clearly understood both the nature of the goal behaviour and the discrepancy between their current behaviour and the food-based goal. Ling & Horwath (l999*a*,*b*) and A Ling and CC Horwath (unpublished results) used a short self-administered validated food frequency questionnaire to assess intake of fruit, vegetables and cereal foods, as an integral part of stage assessment. Estimates were checked in a subsequent phone interview, during which the goals were clearly described and questions concerning intentions asked. Sorenson *et al*. (1998) also used, as an integral part of determining stage, a seven-item fruit and vegetable screener.

Use of these objective assessments of behaviour appears to largely overcome the major misclassification problem found with subjective assessments of stage. In the studies of Horwath & Gulliver (1998), CC Horwath and P Gulliver (unpublished results), Ling & Horwath (1999*a*, *b*) and A Ling and CC Horwath (unpublished results), the mean intakes of those classified in action and maintenance did meet the behavioural goals, and furthermore Ling & Horwath (1999*b*) found that the majority of individuals classified in these stages met the goals according to an independent dietary assessment measure (three 24 h recalls). Of course, it is not surprising that when a more objective behavioural component is an integral part of the algorithm, stage and intake are associated in this manner. The crucial point is that the problem of having a sizeable group of pseudomaintainers largely disappears with the use of more objectively measured, clearly understood food-based goals.

Auld *et al*. (1998) have taken a dramatically different approach to stage classification, using not only objective behavioural measures, but also questions regarding attitudes and beliefs related to the behavioural goals, the perceived importance of diet–disease links, and willingness to adopt specific dietary practices. The authors contend that attitudes must be added to behaviour and intention in the stage assessment process. However, they note that it was impossible to distinguish between subjects in action and maintenance. Furthermore, this approach made impossible an unambiguous stage classification for 35 % of participants. If we accept the defining characteristics of stage theories put forward by Weinstein *et al*. (1998) (i.e. a stage theory requires a classification system for assigning each individual to only one stage), this classification method is untenable.

An alternative approach has been taken by Glanz *et al*. (1994, 1998*a*,*b*) who view stage status as 'cognitive and self-perceived rather than overtly behavioural'. Once again subjective stage assignment resulted in people being classified in action or maintenance for following a low-fat diet, despite mean fat intakes above the goal level, or for following a high-fibre diet

despite mean fruit and vegetable servings of only half the recommended level. However, what is seen as important is whether people themselves consider that they are following, for example, a low-fat diet. A person classified in action may well fall above 30 % energy as fat, but have adopted some fat-reducing behaviours (e.g. use of reduced-fat milk) and have significantly reduced their percentage energy from fat from a still higher level. Indeed, some evidence supports the contention that people who perceived themselves to have changed (i.e. reported a change in stage) actually did change their eating behaviour, as determined by independent measures of dietary intake (Glanz *et al*. 1998*b*). People thus appear aware of whether they are moving in the right direction with their dietary change, but are likely to consider that they have reached the targets of low-fat or high-fibre eating when they still have a considerable way to go (Brug *et al*. 1994). Although these considerations are undoubtedly valid given the complex nature of dietary change, the essence of a stage model is that people can be divided into those who are and those who are not currently performing the goal behaviour. It is certainly preferable to acknowledge small positive steps taken towards a goal and to encourage further efforts in new areas. However, this tailoring of messages to the particular fat-reducing behaviours that have or have not been achieved, could be undertaken simply on the basis of a dietary assessment without the use of any stage approach, something which has in fact been done (Brug *et al*. 1998*a*). The alternative assessment of stage in relation to each fat-reducing behaviour (e.g. a subject may be in maintenance for trimming fat from meat, but in contemplation for using skimmed milk) (Ni Mhurchu *et al*. 1997) would, for most purposes, be too complex and time-consuming. Using just such an approach, Birkett *et al*. (1993) have indeed confirmed that people tend to be at very different stages for individual fat-reducing behaviours.

Although the originators of this model clearly conceptualize stage as both cognitive and behavioural, and require those in action to be meeting action criteria rather than simply moving towards them, measurement methods consistent with this definition are problematic for low-fat or high-fibre eating. On the basis of currently available evidence, it appears likely that a stage model may be less appropriate for complex dietary changes such as low-fat eating, than for simpler more discrete behaviours such as eating five servings of fruit and vegetables per day, or drinking low-fat milk. Purely cognitive stage assessments of low-fat or high-fibre eating appear to have value as intermediate markers of dietary change (Glanz *et al*. 1998*a*,*b*). Other behavioural models may prove easier to apply to complex goals such as dietary fat reduction (Stafleu *et al*. 1991/2).

Defining dietary goals and stages

An important consideration arising when attempting to determine stage of readiness to change eating behaviour is whether the goal is stated simply as the direction of the desired shift (i.e. 'do you intend to eat more fruit/vegetables?', 'have you limited the fat in your diet?') or as a specified level of intake (i.e. 'do you intend to eat five servings of fruit and vegetables per day?'). While a small number of investigators have taken the latter approach (Laforge *et al*. 1994; Horwath & Gulliver, 1998; Ling & Horwath, 1999*a*,*b*; A Ling and CC Horwath, unpublished results; CC Horwath and P Gulliver, unpublished results), most have not specified the ultimate goal behaviour (Table 1; e.g. Brug *et al*. 1997; de Graaf *et al*. 1997; Campbell *et al*. 1998; Sorenson *et al*. 1998). The eating behaviour of those classified in action and maintenance will vary widely when only the direction of change is specified. As expected, a far higher proportion of people reported preparing to 'eat more fruit and vegetables' (Campbell *et al*. 1998) than were preparing to eat five or more servings per day (Laforge *et al*. 1994). Laforge's algorithm also included a behavioural criterion to define preparation (3–4 servings per day).

Similarly, the proportion in maintenance is higher if people are asked about 'limiting the fat in their diet' as opposed to 'being on a low-fat diet' (Rossi *et al*. 1993*a*).

As previously mentioned, there is no real basis for the use of particular time frames in defining stages for eating behaviour. However, in the absence of evidence for other time frames, it would seem reasonable to test the TTM initially using the same time frames as have been found useful for smoking cessation (Sorenson *et al*. 1998). Use of exactly the same time frames and intentional criteria (Rossi *et al*. 1994*a*,*b*,*c*; Ounpuu, 1997; Horwath & Gulliver, 1998; Ling & Horwath, 1999*a*,*b*) as for smoking cessation, has led to the demonstration that process use, self-efficacy and decisional balance change across the stages in just the manner predicted by the TTM. This provides some support for the usefulness of these time frames; however, further longitudinal analyses using such classification systems are required.

Various modifications of the original stage definitions have been employed in other studies. For example, several investigators (Curry *et al*. 1992; Steptoe *et al*. 1996) defined people in precontemplation, contemplation or preparation as those who were not currently limiting the amount of fat in their diet or had never changed their eating habits to decrease the amount of fat in their diet but had (contemplation and preparation only) thought during the past month about changes they could make. A few dietary staging algorithms have included a behavioural criterion to define preparation (Laforge *et al*. 1994; Horwath & Gulliver, 1998; Ling & Horwath, l999*a*,*b*; A Ling and CC Horwath, unpublished results; CC Horwath and P Gulliver, unpublished results). In the studies of Steptoe *et al*. (1996) and Curry *et al*. (1992), contemplators and those in preparation were distinguished on the grounds of their degree of confidence that they would make some changes during the next month, that is, using a separate construct of the model. Campbell *et al*. (1999) have also highlighted the effects of small differences in wording (e.g. planning to *v*. decided to) on stage classification. In the absence of consistency in staging algorithms for dietary change, cross-study comparisons are impossible.

Since children do not have well-developed methods of time estimation, the only application of the model to children has involved multi-item scales to assess stage (Domel *et al*. 1996). The findings led the investigators to question whether the stage concept itself has any relevance to children. Only two factors (precontemplation and beyond precontemplation) were identified, and no differences were found by stage in either fruit and vegetable consumption or preferences. However, it would be premature to dismiss the model as inapplicable to children on the basis of one study. Many of the items appear nonsensical (e.g. 'I am working on eating more fruit and vegetables to learn about myself'), vague (e.g. 'After all I have done to try and eat more fruit and vegetables, every now and then it still worries me': what is 'it'?) or involve more than one concept which creates difficulty in answering (e.g. 'I have worries about what I eat, but so do other children. Why spend time thinking about them?': does 'them' refer to the worries or the other children?).

In measuring other aspects of the TTM with a view to examining patterns of change across stages, questions should match the goal behaviour referred to in the staging algorithm. This has not always been the case. For example, individuals staged for the goal of dietary fat reduction were asked to respond to decisional balance items concerning 'eating healthy food' (Steptoe *et al*. 1996).

Recommendations for assigning stages

It would appear that the following factors are likely to improve the accuracy of stage classification for dietary change: more clearly specified and easily understood behavioural goals, and

the inclusion of an objective component in the assessment of current behaviour. Ideally this objective measure should have been previously validated as a measure of intake in the population of interest and the resulting stage classification needs to be validated by comparison with an independent assessment of dietary intake. Clearly, food-based goals are more readily understood than nutrient goals. Explanation of what constitutes a serving of a particular food group is considerably easier than describing, for example, a 'low-fat diet'. Furthermore, the sensitivity, specificity and predictive values for algorithms to assess food-based goals (Ling & Horwath, 1999*b*) are comparable to or better than those for dietary fat reduction (Greene *et al*. 1994; Auld *et al*. 1998). A classification scheme must be able to classify unambiguously each individual into one stage, and must be consistent with the fundamental ideas of the TTM which emphasize the tendency for relapse and recycling through the stages.

Stage distributions for eating behaviours

The skewed distributions toward action and maintenance for dietary fat reduction are an artifact arising from the difficulty of subjectively assessing stage for 'nutrient' goals. For fruit and vegetable goals, however, stage distributions are more consistent with what is known about population dietary habits, but encouragingly there appears to be a high degree of interest in starting to eat more fruit and vegetables (Campbell *et al*. 1998; Ling & Horwath, 1999*a*,*b*; A Ling and CC Horwath, unpublished results).

From a small number of studies assessing stage for more than one dietary behaviour, it is clear that agreement between stage of change for different goals is poor (Glanz *et al*. 1998*a*; Ling, 1999). That is, success in meeting one behavioural goal does not necessarily imply motivation to make other dietary changes. A similar lack of agreement in stage classification also occurs across diverse health behaviours (Herrick *et al*. 1997).

Despite variations in classification systems, sex differences are generally consistent in terms of women being more ready to reduce fat intake, increase fruit and vegetable consumption (Curry *et al*. 1992; Lamb & Joshi, 1996; Steptoe *et al*. 1996; Auld *et al*. 1998; Campbell *et al*. 1998; Ling & Horwath, 1999*b*) or try 'healthier eating' (de Graaf *et al*. 1997), but men being more ready to follow cereal-product consumption goals (Ling, 1999; Ling & Horwath, 1999*b*).

Processes

Despite being the oldest part of the TTM, this is the least studied aspect in applications to eating behaviour change. This may be due to poor understanding of the processes themselves and the difficulty of developing valid questionnaires to measure them. Questions to assess processes measure how often the thoughts, events or activities described in the various change strategies are used or experienced (Ounpuu, 1997). Others have used questions that tap attitudes or beliefs about fat reduction and nutrition knowledge and which appear to have low content validity in relation to the original conceptualization of processes (Lamb & Joshi, 1996). For example, 'To reduce the fat in my diet in the next month would be difficult' does not assess process use (Lamb & Joshi, 1996). In developing process questionnaires, it is particularly important not only that items are carefully tested in focus groups, but also that expert judges well versed in the TTM are used to establish item content validity (Rossi & Rossi, 1993).

Aside from the research of Prochaska's group (Rossi & Rossi, 1993; Rossi *et al*. 1994*b*,*d*), investigations of the processes of change are rare (Bowen *et al*. 1994; Ounpuu, 1997; Horwath

& Gulliver, 1998). CC Horwath and P Gulliver, unpublished results). Some researchers have only developed questions to assess four processes, and did not employ factor analytic techniques (Lamb & Joshi, 1996). Such an approach does not permit any conclusions to be drawn concerning whether the same or fewer processes operate in dietary fat reduction as in quitting smoking.

In general, the small number of studies on dietary fat reduction and milk-product consumption (Table 1) confirm the existence of between eight and eleven processes for dietary change, the two broader groupings of experiential and behavioural processes, the increasing use of processes across the stages, and significantly different levels of use of various processes at different stages. Stimulus control appears to be the process used most often for dietary change (Prochaska & DiClemente, 1985; Horwath & Gulliver, 1998; CC Horwath and P Gulliver, unpublished results).

The difficulty in developing discrete scales with a high degree of internal consistency to measure counterconditioning and stimulus control has been a consistent finding across different dietary behaviours (Rossi & Rossi, 1993; Bowen *et al*. 1994; Gulliver, 1998; Horwath & Gulliver, 1998). Clearly more work is needed to refine questionnaires to measure these processes. The existence of discrete reinforcement management and self-liberation processes has also been difficult to validate for eating behaviours (Bowen *et al*. 1994; Gulliver, 1998; Horwath & Gulliver, 1998). However, it is plausible that a different set of processes may operate for eating behaviour change than for quitting smoking, and that different processes may be valid for different dietary changes.

Given the different nature of eating behaviour change as compared with smoking cessation, one key difference observed in patterns of process use is not surprising. Whereas in smoking cessation the overall use of processes begins to decline once in maintenance (Prochaska & DiClemente, 1983), use of dietary change processes continues at high levels in the maintenance stage (Rossi & Rossi, 1993; Bowen *et al*. 1994; Ounpuu, 1997; Gulliver, 1998; Horwath & Gulliver, 1998; P Gulliver and CC Horwath, unpublished results). This confirms the hypothesis that eating behaviour change requires constant vigilance, and may preclude the possibility of reaching a point where no effort is required. The acquisition of exercise appears to be similar (Marcus *et al*. 1992).

In one of the few investigations of the processes of eating behaviour change, findings were exactly as predicted by the TTM: infrequent utilization of all processes by precontemplators, more frequent use of experiential processes in contemplation and preparation, and greater use of behavioural processes in action and maintenance (Gulliver, 1998; Horwath & Gulliver, 1998; P Gulliver and CC Horwath, unpublished results). Careful attention had been paid to item pretesting in focus groups, as well as inter-rater reliability assessments in which items were retained only if all three judges expert in use of the TTM agreed on the process being measured.

Self-efficacy

The self-efficacy construct appears promising as a means of monitoring and predicting stage transitions for dietary change. In cross-sectional studies, self-efficacy has been associated with stage of change for dietary fat reduction (Rossi, 1993; Rossi *et al*. 1994*a*; Sporny & Contento, 1995; Ounpuu *et al*. 1999*b*), milk-product consumption (Horwath & Gulliver, 1998; CC Horwath and P Gulliver, unpublished results), fruit and vegetable consumption (Campbell *et al*. 1999; Ling & Horwath, 1999*a*) and cereal-product consumption (Ling, 1999). Scores were significantly higher in action and maintenance than in the earlier stages. Sporny & Contento (1995) found that self-efficacy dipped in contemplation, but increased in action and then even

further in maintenance. In this latter study, however, maintenance was defined as following the goal behaviour for at least 2 years rather than 6 months and this may contribute to the even higher self-efficacy levels found in maintenance than in action.

There is also some evidence for the multidimensional nature of self-efficacy for eating behaviour change (Rossi *et al*. 1994*a*; Ling & Horwath, 1999*a*; Ounpuu *et al*. 1999*b*), as for smoking (Velicer *et al*. 1990). Other studies, however, have only included one or two item measures of self-efficacy (e.g. Brug *et al*. 1996, 1997; Campbell *et al*. 1998, 1999).

Decisional balance

Across studies of a variety of dietary changes, which include dietary fat reduction (Rossi *et al*. 1994*c*; Steptoe *et al*. 1996; Ounpuu, 1997), and increased consumption of milk products (Horwath & Gulliver, 1998; CC Horwath and P Gulliver, unpublished results), fruit and vegetables (A Ling and CC Horwath, unpublished results) and grains (Ling, 1999), the two factor structure (i.e. pros and cons) for decisional balance was remarkably stable (Prochaska *et al*. 1994). Across all the dietary changes studied, the following consistent pattern emerged: cons higher than pros in precontemplation; pros increase between precontemplation and contemplation; cons lower in action than in contemplation; and usually the pros were higher than the cons in action.

Instead of remaining stable between precontemplation and contemplation as found in most studies of other health behaviours (Prochaska *et al*. 1994), in studies of dietary fat reduction (Rossi *et al*. 1994*c*) and weight control (O'Connell & Velicer, 1988), the cons have been found to increase in contemplation along with the pros. This suggests that when grappling with the decision to change eating habits, considerations of both negative aspects and incentives for change are important.

Sporny & Contento (1995), using health belief model concepts, found that perceived benefits increased across the stages, but that perceived barriers peaked in contemplation then declined in the later stages. The lower perceived barriers and higher self-efficacy of precontemplators compared with contemplators in this study, may be the result of unrealistic expectations. Also drawing on other theories of health behaviour, Glanz *et al*. (1994) found a link between stage of change and both self-efficacy and motivation to lower fat intake.

Are different factors important in producing transitions at different stages?

Only a minority of studies have attempted to address this important defining characteristic of stage models. The cross-sectional nature of the studies means they provide information on whether different factors distinguish those in different stages, but cannot provide conclusive evidence of the importance of different factors in producing different stage transitions.

For dietary guidelines concerning fruit and vegetables and cereal products, Ling (1999) recently tested TTM predictions and found that decisional balance was most important in distinguishing precontemplators from people in the other stages, while self-efficacy was more important in determining whether people were actually meeting dietary goals as oppposed to contemplating or preparing for change. Not only does this make sense (i.e. if one has no interest in changing, confidence in ability to make changes would appear far less relevant than a shift in the way one sees the relative pros and cons of changing; however, once one is fully committed to change, decision-making issues would seem likely to be less important than skills), it is also consistent with longitudinal investigations of self-changers' smoking status (Prochaska *et al*. 1985).

Using variables from a number of behavioural theories, Sporny & Contento (1995) in an application to dietary fat reduction, demonstrated that the factors which most strongly differentiated contemplators from precontemplators were motivational beliefs from the health belief model (including perceived benefits and susceptibility, cues to action), motivation to comply and self-efficacy (negative direction). The variables most strongly differentiating those in action from contemplators were perceived benefits and barriers, health concern, motivation to comply, social modelling and self-efficacy. Those in maintenance were most strongly discriminated from those in action by perceived susceptibility and perceived barriers (negative direction), health concern, social modelling and self-efficacy (positive direction). The finding of Sporny & Contento (1995) that perceived barriers are most important in distinguishing those in the later stages, while perceived benefits are most important in distinguishing those in the earlier stages differs from the work of Ling (1999) and Prochaska *et al*. (1985).

Longitudinal studies

Most of the longitudinal data available comes from intervention studies (not stage-matched) which included an assessment of stage as an indicator of change. From these studies, it appears that baseline stage predicts degree of dietary change (Beresford *et al*. 1997; Greene & Rossi, 1998) and participation in health behaviour change strategies (these appeal most to people who are classified as having greater levels of readiness to change) (Glanz *et al*. 1998*b*) and that movement to later stages was both linked with desirable dietary shifts and was more likely in intervention groups (Glanz *et al*. 1998*b*).

Intervention studies

Campbell *et al*. (1994) compared the effects of a single personalized, staged-matched intervention and a non-tailored intervention. Using a computer software package, tailored interventions were created from subjects' responses to brief measures of stage of change, current dietary intake, motives, barriers, beliefs and self-efficacy for three dietary goals: eating less fat and more fruit and vegetables. The staging algorithms were based on the questions of Prochaska & DiClemente (1983). The non-tailored intervention provided standard risk information about diet and disease and the dietary guidelines. Change was assessed at 4 months post-intervention by a food frequency questionnaire. Total fat intake (g/d) decreased in the tailored group by 10·3 (23 %) compared with 3·6 (9 %) in the non-tailored group and 1·3 (3 %) in the control group. Differences were statistically significant only between tailored and control groups, but not between non-tailored and control groups.

The results are impressive, especially given that only a single mailout of materials was used. The study did not, however, examine the effect of the intervention on stage transitions, or whether baseline stage predicted behaviour change. Most importantly, the study cannot distinguish whether the greater effectiveness of the tailored message was due to its individualized feedback on current eating behaviour and psychosocial variables such as beliefs about susceptibility and motives for change, or whether matching to stage of change was crucial. Others have shown single, individualized dietary-feedback reports to accelerate the rate of fat reduction at 12 months, but to have no long-term effect (Greene & Rossi, 1998).

Tailored interventions are not the exclusive domain of the TTM, or other stage models. A number of studies have evaluated the impact of individual computer-tailored nutrition interventions, including iterative feedback, on dietary intake (Brug *et al*. 1996, 1998*a*,*b*; Kreuter &

Strecher, 1996). In one study, feedback letters were tailored to dietary intake, intentions, attitudes, self-efficacy expectations and self-rated behaviour (Brug *et al*. 1998*a*). Such tailoring achieves some of the characteristics of interpersonal counselling, since much individual information is gathered in order to develop individual dietary advice relevant to a person's eating habits and associated beliefs.

All studies confirmed tailored approaches to be significantly more effective than general nutrition information; however, one study evaluated only the impact on self-reported fat reduction (Kreuter & Strecher, 1996) and another assessed only short-term impact (3 weeks; Brug *et al*. 1996). Another study demonstrating the greater effectiveness of a tailored approach in achieving fat reduction and increased fruit and vegetable intake used a thirty-two item food frequency questionnaire to assess intake (Brug *et al*. 1998*a*). However, all participants in this study were volunteers who had responded to advertisements for free nutrition information, resulting in a study population that was largely female (82 %) and highly educated (42 % had a college degree). The population was thus likely to consist of those most ready to take (or at least consider) action (a common criticism of traditional nutrition education efforts). Pre-contemplators would not respond to such an advertisement. Whether this approach can be replicated in more representative samples would be of enormous interest.

Applications to weight control or diabetes management

The applicability of the TTM to outcomes such as weight control and diabetes control has been explored. However, it must be emphasized that these goals are not behaviours but outcomes influenced not only by a range of dietary behaviours, but by other complex behaviours as well (e.g. physical activity, use of medications and other substances, blood glucose monitoring, insulin administration). Thus attempts to apply the TTM in these situations may be even more problematic than application to the goal of dietary fat reduction.

In applications to weight control, stage classification has been made on the basis of statements about current weight and intentions to lose weight (O'Connell & Velicer, 1988), or about current dieting or intentions to diet (Jeffery *et al*. 1999). Decisional balance items have referred mostly to individuals' perceptions of the consequences of losing weight (O'Connell & Velicer, 1988), but some process items have referred specifically to overeating or binge eating (Rossi *et al*. 1994*d*). It is probably easier, however, for people to appreciate the benefits of actual behaviours such as regular exercise, than to focus only on the pros of losing weight.

Given the difficulty of weight reduction and the numerous contributing factors, it is hardly surprising that a few simple questions regarding whether a woman is currently dieting or intending to diet were of no use in predicting future weight change in the only large prospective study available (Jeffery *et al*. 1999).

Among thirty participants who completed measures at weeks one, five and ten of a 10-week worksite weight control programme, it was found that significant shifts from contemplation to action occurred for those remaining in treatment, that use of several processes increased during the treatment programme and that those who moved from contemplation to action for attempting weight loss reported increased levels of self-efficacy (Prochaska *et al*. 1992*b*). Change processes used during the early portion of treatment were the best predictors of treatment attendance and amount of weight lost during treatment. However, study limitations include the small and non-representative sample, short study period, and use of a goal which is an outcome rather than a behaviour.

If one wishes to apply the TTM to weight control and diabetes management, the best approach is to choose one or more specific behavioural goals likely to improve outcome (e.g. exercise at least three times per week, consumption of less than a specified number of servings per day from a list of high-energy foods; a specified frequency of glucose self-monitoring) (Curry, 1993). Clearly, people will be at different stages of readiness for adhering to different aspects of, for example, a diabetes management regimen (Ruggiero & Prochaska, 1993), or a weight-control programme. Identification of the stage of readiness for adopting various aspects of a programme can enable a focus on different intervention strategies for different aspects of management. If people are encouraged to focus first on an aspect of a regimen for which they are most ready to consider change, they are more likely to experience success and improved self-efficacy. Movement along the stages for individual behaviours can also provide a more encouraging means of monitoring success, rather than focusing only on outcomes such as body weight.

Criticisms of the transtheoretical model

The TTM has attracted a number of criticisms. Bandura (1997) described human functioning as too multifaceted and multidetermined to be categorized into a few discrete stages. For example, he comments that classifying people as precontemplators provides no explanation for why they do not consider making changes. The stage variable, although having received the greatest attention of any aspect of the model, is only one of a much larger number of constructs used to account for intentional behaviour change (Prochaska & Velicer, 1997). Indeed no one has ever claimed that stage assignment itself explains why someone is or is not taking action.

Rejection of the model by Farkas *et al*. (1996) is also based on an analysis of only one of the model's many constructs: the stage construct. A single variable is not a theory, and cannot possibly explain the process of behaviour change. Furthermore, several of the commentaries on that paper (in the same journal issue) have emphasized how 'competitive framing' by Farkas *et al*. (1996) of different models does little to shed light on the process of behaviour change (Shiffman, 1996). A comparison between a single variable drawn from the TTM and multiple variables cannot possibly amount to a reasonable test of the model: multiple variables can almost always account for more variance in future behaviour than a single variable. Furthermore, Farkas *et al*. (1996) develop what is essentially a predictive model for smoking cessation and, unlike the TTM, their model provides no explanation or understanding of why their predictors are important in explaining future behaviour. Nor do their findings have any implications for how to develop more effective interventions. Farkas *et al*. (1996) show that smokers who have quit in the past are more likely to quit in the future, but this is of little value unless we know why. In seeking an explanation, Sutton (1996) comments that is it difficult not to refer to concepts such as motivation, self-efficacy, and stage of readiness to change.

In contrast, Jeffery *et al*. (1999) acknowledge that their focus on 'stage' alone means that they are not assessing the validity of the TTM. However, they argue that the failure of their simple stage classification scheme to predict future outcome calls into question 'the generality of the stages of change classification system across behavioural domains'. The crucial flaw in this study design lies in hypothesizing that stage of readiness 'to diet' should predict not future behaviour, but weight change over 3 years. Models of behaviour should only be used to examine behaviour, not physiological outcomes determined by multiple behaviours, only one of which is referred to in vague terms in the staging algorithm of Jeffery *et al*. (1999).

Another criticism by Bandura (1997) is that a genuine stage theory involves qualitative transformations across stages, an invariant sequence of stages (i.e. stages cannot be skipped) and non-reversibility (i.e. no recycling occurs). This view appears to be at odds with other stage theories, in which it is assumed that people can and do return to earlier stages or can skip stages (Prochaska & Velicer, 1997) and with the defining characteristics outlined by Weinstein *et al*. (1998). Bandura (1997) argues that 'stage thinking' would 'constrain the scope of interventions to promote change', since for precontemplators, the 'prescription for change emphasizes the need to alter their outcome expectations'. This, however, is only one of the approaches used by TTM-researchers in order to stimulate movement from precontemplation.

The fact that the divergent behaviour change prescriptions of Freudian, Skinnerian or existential theories are believed by some of their proponents to be contradictory and incompatible (Bandura, 1997), does not mean, Prochaska & Velicer (1997) argue, that this is necessarily the case. Self-changers, in fact, successfully change using a whole range of such strategies. It makes little sense to suggest that because stimulus control and countering faulty beliefs arise from different psychotherapeutic approaches, that they cannot usefully be integrated in one model.

In practical applications to the development and evaluation of nutrition interventions, TTM approaches can be combined with approaches from other behavioural theories. For example, in stage-matched exercise intervention programmes, Marcus *et al*. (1999) have also drawn on social cognitive theory and decision making in the preparation of stage-specific self-help manuals. Campbell *et al*. (1994) structured their tailored messages according to a framework based on the TTM and the health belief model. These different theories or models of behaviour can be thus be viewed as complementary rather than conflicting. However, when the production of tailored materials draws on a number of theories or models of behaviour, it is impossible to identify whether the superior efficacy of a tailored intervention is associated with constructs from other theories rather than stage *per se* (Marcus *et al*. 1999).

Even though stage-matched interventions can provide tailored material to entire populations, TTM-based interventions may be criticized for addressing problematic health behaviours mainly as an individual problem. That is, they focus on the motivations, perceptions and processes of individuals. However, powerful intervention combinations may be produced by combining individualized TTM-based interventions with interventions aimed at creating environments supportive of healthier behaviours. Since applications of the TTM to promotion of organizational change are currently being explored (D Levesque, personal communication), the model may be useful in promoting change in worksite and school environments.

Conclusions

If we accept one of the simplest defining characteristics of stage theories put forward by Weinstein *et al*. (1998), that a stage theory requires an accurate classification system for assigning each individual to only one stage, we must question the appropriateness of goals which are unclear to participants (such as dietary fat reduction or increased fibre intake) as applications of the TTM. The continuing methodological difficulties encountered by researchers working with these goals suggests that perhaps other dietary applications are more suitable. Essentially the model is concerned with people's behaviour change, yet fat and fibre consumption are not behaviours which people engage in: they are nutritional outcomes of a complex collection of eating behaviours. Perhaps future applications of the model would do better to focus on actual eating behaviours, such as the five-a-day recommendation for fruit and

vegetable consumption. With such goals, the evidence suggests that accurate systems that can classify everyone into just one stage are possible. There are in fact several ongoing projects to promote greater fruit and vegetable consumption that are using the TTM approach (Campbell *et al*. 1998).

Another clear need is for more research on the whole model, rather than on single constructs such as the stages of change. The demonstration of an association between stage and nutrient or food group intake confirms the value of stage as a marker of intake, but is not sufficient to demonstrate the validity of the model. There is a particular paucity of research on the processes of eating behaviour change. Of the very few studies which appear to fulfil Weinstein's first criterion (e.g. Gulliver, 1998; Ling & Horwath, 1999*a*,*b*; A Ling and CC Horwath, unpublished results), only one cross-sectional study has included the whole model (stage, processes, self-efficacy, decisional balance) (Horwath & Gulliver, 1998). The study, has, however, confirmed remarkably similar patterns of change across the stages in the various model constructs to those observed for smoking cessation. There is also some support for the requirement that different factors are important at different stages (Ling, 1999; Sporny & Contento, 1999).

Prospective studies and stage-matched interventions examining TTM hypotheses for dietary change are sparse. Yet only longitudinal research can truly convince us that the TTM is valid for eating behaviour change. In order to conduct such studies, there is a need for valid questionnaires to measure all aspects of the model. Most dietary applications of the TTM are concerned with the nutritional outcome of dietary fat reduction and all of the small number of prospective studies identified deal with either this goal or the even more complex goal of weight control.

Cross-sectional analyses generally support the predicted patterns of between-stage differences in processes, self-efficacy and decisional balance for those dietary goals examined. It must be emphasized, however, that simple cross-sectional comparisons of the characteristics of people classified into different stages are not the most powerful approach if we are interested in testing the validity of the TTM. Investigators of eating behaviour change who choose cross-sectional designs should focus on careful validation of questionnaires, whether patterns of between-stage differences vary from one predictor variable to another, and whether different factors are important in distinguishing different stages.

So, in response to the question; 'does eating behaviour change follow a stage process?', as yet, it appears there is no conclusive answer. The research on dietary applications of the TTM is limited and much of it is hampered by a number of methodological difficulties, not least of which is a focus on complex nutritional goals. The effectiveness of the model as a guide for developing smoking cessation and exercise acquisition (Marcus *et al*. 1999) programmes, and the evidence so far available on dietary applications, however, are sufficiently encouraging to warrant the inclusion of TTM constructs in prospective studies as well as further studies to evaluate the efficacy of stage-matched interventions relative to standardized approaches to promoting eating behaviour change. Only one published stage-matched dietary intervention study has been identified (Campbell *et al*. 1994), and yet such studies will provide the ultimate test of the model in relation to dietary change. It is therefore important to explore the requirements of such intervention studies.

Future directions: designing stage-matched tailored dietary interventions

Three crucial requirements for the design of stage-matched interventions are: (1) that people can be correctly classified according to stage; (2) a good understanding of the factors associated

with different stage transitions for the behaviour of interest; (3) means are available to modify the factors identified as being important in the various stage transitions.

TTM ideas and approaches can undoubtedly be employed in interpersonal counselling situations (Miller & Rollnick, 1991), and may enhance the effectiveness of dietitians' interaction with clients. Interpersonal couselling, however, is expensive and time-consuming since trained counsellors and person-to-person or small group sessions are required. The population shifts in eating behaviour required for disease prevention cannot realistically be accomplished in this way.

One of the greatest strengths of the TTM approach, clearly demonstrated in the smoking cessation intervention studies (Prochaska *et al*. 1993), is that a huge impact can be made with the target population by: (1) contacting large random samples of the population by random-digit-dialling (or random mailouts) to identify those with the problem behaviour (i.e. smokers) and inviting all smokers to participate in a study which addresses relevant issues for those at all stages; (2) subsequently delivering personalized, tailored materials for smokers at all stages of change, where messages are tailored not only to the person's stage of readiness to change, but also to their level of process use, decisional balance and self-efficacy. Tailoring of messages to such an extent can only be realistically achieved through use of computer expert-system technology.

Using this approach, 82–85 % of the entire target group (JO Prochaska, WF Velicer, J Fava and J Rossi, unpublished results), predominantly precontemplators, can be recruited into stage-matched intervention programmes. This contrasts strikingly with the low participation rates typically found with action-oriented approaches. For example, a widely publicized free action-oriented self-help programme resulted in only 4 % of smokers signing up despite a year of recruitment (Orleans *et al*. 1998). The Minnesota Heart Health programme randomly assigned individuals to various recruitment strategies, including personalized letters about home-based programmes for smoking cessation and weight loss, and achieved recruitment rates of 1–5 % and 3–12 % respectively (Schmid *et al*. 1989). Combined with the greater efficacy of the stage-matched approach compared with standardized intervention approaches (Prochaska *et al*. 1993), high recruitment rates result in programmes which achieve an overall impact (recruitment rate × efficacy of intervention) rarely, if ever, equalled elsewhere.

No studies have so far been published which evaluate such a comprehensive approach with eating behaviour change, although long-term studies are currently underway at the University of Rhode Island Cancer Prevention Research Centre to examine stage-matched interventions for dietary fat reduction (G Greene, personal communication).

Perhaps one of the greatest contributions of the TTM smoking cessation research is the development of approaches which are effective in communicating with, recruiting and retaining precontemplators: the group usually overlooked or assumed too resistant to involve in traditional health promotion efforts. Prochaska *et al*. (1997) have been able to retain precontemplative smokers at the same high level as those who started in the preparation stage.

In order to be appropriate for use in large-scale campaigns, accurate stage classification must be able to be achieved rapidly and efficiently, thus presumably via a self-administered instrument. Some of the most accurate stage classification systems so far available for eating behaviour goals have depended for their success on interaction between respondent and interviewer to clarify both current and goal behaviours (Horwath & Gulliver, 1998; Ling & Horwath, 1999*b*). Further work is required to achieve accurate self-administered stage-classification methods for dietary goals. Due to the more complex nature of eating behaviour goals compared with smoking cessation, this may present one of the greatest challenges in the progress towards stage-matched dietary interventions.

An important question deserving further research is the extent of tailoring which is required in order to achieve significant improvements in efficacy over standardized interventions. Smoking-cessation researchers argue the need to individually tailor on the basis of all TTM constructs for maximum efficacy (Prochaska *et al*. 1993). However, the development of sophisticated computer expert-systems for each behaviour goal of interest would often be prohibitively expensive and time-consuming. Setting up such expert systems is impossible in the absence of considerable data on the population norms for each of the model constructs for the target group of interest and requires short validated instruments to assess stage, processes, decisional balance and self-efficacy. Campbell *et al*. (1994) achieved significant dietary fat reduction by individually computer tailoring materials to stage, current dietary intake, motives, barriers, beliefs and self-efficacy. Successful physical activity interventions have been achieved more simply by tailoring to stage using five stage-specific self-help manuals (Marcus *et al*. 1999). The relative efficacy for eating behaviour change of simple stage-matched manuals compared with more individualized computer tailoring is unknown.

The nature of the comparison intervention also requires consideration. If nutrition educators are to adopt a stage approach more widely, we need to establish not only that stage-matched dietary interventions promote more change than would occur in a control group receiving no intervention, but whether they indeed outperform our currently best available standardized materials.

An exciting opportunity for stage-model researchers is the design of nutrition interventions whereby individuals may access tailored materials via the Internet. Although such an approach would undoubtedly miss precontemplators, it could present an economical way to provide effective nutrition messages to all those with Internet access. Such programmes could reach people in their own homes, in schools or in the workplace.

Interventionists need not, however, be limited in their production of stage-matched materials to print media. Being aware of different learning styles, literacy levels and preferences, stage-matched nutrition materials may also take the form of audiotapes, videotapes, or pictorial reminders. Creative interventions to test the effectiveness of stage-matched approaches involving varying degrees of tailoring and carefully evaluated over longer time periods are required.

Acknowledgements

Grateful thanks to Professors Mary Story and Dianne Neumark-Sztainer in Public Health Nutrition at the University of Minnesota for helpful comments on this manuscript and to Dr Allan Blackman for careful proof-reading.

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