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Subgroups Among Smokers in Preparation: A Cluster Analysis Using the I-Change Model

Eline Suzanne Smit[a,b], Stephanie Brinkhues[c], Hein de Vries[b], and Ciska Hoving[b]

[a]Department of Communication Science, Amsterdam School of Communication Research/ASCoR, University of Amsterdam, Amsterdam, The Netherlands; [b]Department of Health Promotion, Maastricht University, Maastricht, The Netherlands; [c]Department of Medical Microbiology, Maastricht University, Maastricht, The Netherlands

ABSTRACT

Background: Investigating potential sub-stages of change could provide important information that could be used to improve the tailoring of smoking cessation interventions to individual smokers' profiles. Smokers in the preparation stage may be most interesting, as they are most likely to participate in smoking cessation interventions. *Objective*: To examine whether Dutch adult smokers in the preparation stage of change, i.e. motivated to quit smoking within one month, can be organized into subgroups. *Methods*: Data from 753 smokers who participated in an effectiveness trial of a web-based, computer-tailored smoking cessation programme were subjected to secondary analysis. Cluster analyses were based on respondents' baseline responses to items on pros and cons of quitting and quitting self-efficacy. Chi-squared tests and ANOVA were used to compare the baseline characteristics of the resulting clusters. Logistic and multinomial regression were used for longitudinal comparisons of clusters with respect to smoking abstinence and stage transition at six-week and six-month follow-ups. *Results*: Four clusters were identified; Classic, Unprepared, Progressing and Disengaged Preparers. Cross-sectional and longitudinal analyses validated these clusters: they differed with respect to the clustering variables, gender, cigarette dependence and educational level. Disengaged Preparers were less likely than Progressing Preparers to report smoking abstinence at six months (OR = 0.28; $p < .05$). *Conclusions*: These results suggest that smoking cessation interventions tailored to the preparation stage of change, i.e. the set of cognitions usually present in preparers, are only appropriate for the subgroup we defined as Classic Preparers. The other clusters might need different interventions as they display different cognition sets.

Introduction

Cigarette smoking is harmful, amongst other conditions it causes cancer, coronary heart disease, stroke, and chronic obstructive pulmonary disease (National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health, 2014; World Health Organization, 2013). It is therefore important that smokers move through the behavioral change process and move from smoking to smoking cessation.

Several theories, such as the transtheoretical model (TTM; Prochaska & DiClemente, 1983) and the integrated model for exploring motivational and behavioral change (I-Change Model; (de Vries et al., 2003), have explained behavioral change in terms of a multistage process. The TTM is perhaps the best known of these theories and it posits that behavioral change involves progress through five stages: precontemplation (i.e. not intending to change within the next six months), contemplation (i.e.

intending to change within the next six months, though not within the next month), preparation (i.e. intending to change within the next month), action (i.e. change that has lasted less than six months), and maintenance (i.e. change that has lasted at least six months) (Prochaska & DiClemente, 1983). The I-change model includes theoretical concepts from several socio-cognitive theories, e.g. the theory of planned behavior (Ajzen, 1985), social cognitive theory (Bandura, 1986), the health belief model (Janz, Champion, & Strecher, 2002) as well as the TTM (Prochaska & DiClemente, 1983). Like the TTM, the I-change model assumes that the most important predictor of behavioral change, i.e. intention, can be defined in terms of precontemplation, contemplation and preparation stages. Like most stage theories of health behavior (Weinstein, Rothman, & Sutton, 1998), both the TTM and I-change theories assume that people in the same stage face similar barriers to change, whereas those in

CONTACT Eline Suzanne Smit ✉ E.S.Smit@uva.nl Department of Communication Science, Amsterdam School of Communication Research/ASCoR, University of Amsterdam, P.O. Box 15791, 1001 NG Amsterdam, The Netherlands.

other stages face other barriers. Consequently, it has been proposed that tailoring interventions to stage of change would improve the chances of participants overcoming the barriers specific to their stage of change and hence the rate of health behavior change (Anatchkova, Velicer, & Prochaska, 2006b).

Stage-tailored interventions only provide the information that is relevant to people in the relevant stage (Dijkstra, de Vries, Roijackers, & van Breukelen, 1998b) and are designed to help people move through the stages and eventually achieve enduring behavioral change. Stage theories of behavioral change assume that people in the preparation and action stages require different types of support from those in precontemplation or contemplation (Cahill, Lancaster, & Green, 2010). For example, it has been hypothesized that smokers in the preparation stage would benefit most from self-efficacy enhancing information, and this is supported by empirical evidence (Dijkstra et al., 1998b; Dijkstra, Conijn, & de Vries, 2006; Patrick et al., 1994). In contrast it is hypothesized that smokers at the contemplation stage need information that will resolve the cognitive conflict they are thought to experience by reducing the perceived disadvantages of quitting (Dijkstra et al., 2006). Stage theories have been used successfully to develop tailored smoking cessation programs (Erol & Erdogan, 2008; Meyer et al., 2008) and interventions aimed at other health behaviors (Johnson et al., 2006; 2008).

Over time, however, doubts have arisen about using stages of behavioral change to determine who will benefit from what type of information (de Vet, de Nooijer, de Vries, & Brug, 2006; Heather, 1991; Littel & Girvin, 2002; Sutton, 2001), and about the relative efficacy of stage- and non-stage-based interventions (Cahill et al., 2010). For instance there is evidence that several distinct subgroups can be identified amongst smokers at the precontemplation, contemplation, preparation and action stages, based on perceptions of the pros and cons of smoking and temptation to smoke (Anatchkova, Velicer, & Prochaska, 2005; 2006a; 2006b; Norman, Velicer, Fava, & Prochaska, 2000; Velicer, Hughes, Fava, Prochaska, & Diclemente, 1995). The first subtype found in these studies was named *classic* and consists of people that are typical of the stage of change into they were classified based on the stages of change algorithm. For instance, *classic contemplators* have been shown to be very tempted to smoke and they report high scores on measures of perceptions of the pros and cons of smoking, which creates cognitive conflict (Anatchkova et al., 2005). The second subtype was named *early*; it consists of smokers who are similar to those in the stage preceding that into which they were categorized. For example, *early contemplators* were found to resemble smokers in precontemplation, they still rate the pros of smoking higher than the cons of smoking and

are more tempted to smoke than classic contemplators (Anatchkova et al., 2005). The third subtype was named *progressing* and consists of smokers that are similar to those in the stage after the stage into which they were categorized, thus *progressing contemplators* resemble smokers in preparation; for them the cons of smoking outweigh the pros, which is indicative of readiness to change, and they are less tempted to smoke than classic contemplators, indicating that any attempt to quit is more likely to be successful (Anatchkova et al., 2005). The fourth subtype that has been identified was named *disengaged* and consists of smokers that show detachment from or disinterest in the cognitive and physiological aspects of smoking (Norman et al., 2000; Velicer et al., 1995), reflected in below average scores for the pros and cons of smoking, and for temptations to smoke (Anatchkova et al., 2005).

A study that aimed to replicate these findings in a non-American sample of smokers at the contemplation stage succeeded in identifying three subgroups: early, progressing and disengaged contemplators (Smit, Hoving, & de Vries, 2010). The results did not overlap completely with the American studies described above, but this is not surprising as American smokers report higher levels of addiction to nicotine for a given stage of change than Dutch smokers (Etter, Perneger, & Ronchi, 1997; Fagerström & Furberg, 2008). To date there has been no attempt to replicate the American findings on smokers in the preparation stage in a non-American sample, although cross-cultural investigation of stages and substages could provide important information that could be used to improve the tailoring of smoking cessation interventions to the profiles of smokers outside the United States. Furthermore, in all the American studies respondents were clustered based on their perceptions of the pros and cons of smoking and temptations to smoke, whereas in a previous study (Smit et al., 2010) cluster analyses were based on the scores on cognitive variables directly related to smoking cessation, i.e. perceptions of the pros and cons of quitting and quitting self-efficacy. This procedure accords with the compatibility principle (Ajzen, 1988) which states that predictors of a desired behavior should be measured in a similar manner to the desired behavior itself, in this case smoking *cessation*. Moreover, several studies based on the I-change model – or its predecessor the attitude-social influence-efficacy model (de Vries & Mudde, 1998) - have indicated the importance of the perceived pros and cons of quitting and quitting self-efficacy as predictors of likelihood and type of transition through the stages of behavioral change (de Vries & Mudde, 1998; Hoving, Mudde, & de Vries, 2006).

The aims of this study were to determine whether Dutch adult smokers motivated to quit smoking within one month could be categorized into subgroups based on their perceptions of the pros and cons of quitting

and quitting self-efficacy and to determine whether any such clusters were comparable to clusters identified in previous research. We also wanted to discuss what implications the empirical findings on subtypes have for the development of smoking cessation interventions. The existence of subtypes within stages of change has both theoretical and practical implications. Information about subtypes could be used to advance the stages of change paradigm by providing a more comprehensive typology system of smokers with varying degrees of readiness to change. From a practical perspective, the different subtypes may require different health communication tactics and hence imply a need for a more refined approach to the development of tailored interventions.

Methods

Procedure

Between December 2009 and June 2010 Dutch adult smokers were recruited for a randomized controlled trial (RCT) of the effectiveness of a web-based, computer-tailored smoking cessation programme. Several recruitment strategies were employed: advertisements in the mass media and on the Internet, online and offline newspaper articles, local radio and television items, posts on a Dutch online social network website (Hyves) and on online smoking cessation forums. Interested smokers could click on a link to the study website, where they could register for the trial and sign an online consent form. After providing informed consent they were randomly assigned to the intervention group (access to the programme) or control group (no access to the programme). To be eligible for the study individuals had to be aged at least 18 years, have access to the Internet and be at the preparation stage of quitting smoking. To assess stage of change respondents were asked to choose the statement that best described them from amongst the following: I do not intend to quit smoking or I do intend to quit smoking but not within six months (precontemplation); I intend to quit smoking within six months (contemplation); I intend to quit smoking within one month (preparation); I quit smoking less than six months ago (action); I quit smoking more than six months ago (maintenance). Respondents were excluded if they were at the precontemplation, contemplation, action or maintenance stage and if they had not smoked during the seven days before the eligibility assessment. Respondents in both groups completed an online baseline questionnaire, in which they were asked to set a quit date that fell in the next four weeks. Follow-up questionnaires were emailed to respondents two days, six weeks and six months after their quit date. Respondents in the control group only completed these questionnaires, whereas respondents in the intervention group received

web-based, computer-tailored feedback messages during and after completing each questionnaire, making a total of four feedback letters (i.e. at baseline, two days after their quit date and at six-week and six-month follow-ups). In total we recruited 753 respondents at the preparation stage of change to the study.

The RCT was approved by the Medical Ethics Committee of Maastricht University and the University Hospital Maastricht (MEC 08-3-037; NL22692.068.08), and is registered with the Dutch Trial Register (NTR1351). Full details about the trial can be found elsewhere (Smit, de Vries, & Hoving, 2012a).

Measurements

All questionnaires were based on the I-change model (de Vries et al., 2003) and had been used in previous studies of Dutch adult smokers (Dijkstra, de Vries, & Roijackers, 1998a; Hoving, Mudde, Dijk, & de Vries, 2010).

Baseline measurement

Age, gender, educational level and nationality were measured at baseline. Cigarette dependence was measured with a Dutch version (Mudde, Willemsen, Kremers, & de Vries, 2006) of the Fagerström Test for Cigarette Dependence (FTCD) (0 = not dependent; 10 = highly dependent) (Fagerstrom, 2012; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). Respondents were also asked to indicate their number of past quit attempts.

Perceptions of the pros and cons of quitting were measured by asking respondents to indicate the extent to which they agreed or disagreed with a series of items using a five-point scale. Perceptions of the pros of quitting were assessed with six items ($\alpha = 0.71$; e.g. If I stop smoking my condition will improve; 1 = no, will not improve; 2 = do not know; 3 = yes, will improve a bit; 4 = yes, will improve; 5 = yes, will improve a lot). Perceptions of the cons of quitting were also assessed with six items ($\alpha = 0.68$; e.g. When I do not smoke it is harder for me to relax; 1 = no, it is not harder to relax; 2 = do not know; 3 = yes, it is a bit harder to relax; 4 = yes, it is harder to relax; 5 = yes, it is a lot harder to relax). Quitting self-efficacy was assessed using nine items with which the respondent could agree or disagree ($\alpha = 0.88$; e.g. Do you think you will manage not to smoke if you are offered a cigarette? 1 = definitely not; 2 = probably not; 3 = maybe; 4 = probably; 5 = definitely).

Follow-up measurement

Smoking abstinence was used as the primary outcome measure. At the six-week follow-up respondents were asked whether they had smoked during the past two

weeks – even if it was only one puff. At the six-month follow-up respondents were asked whether they had smoked since the six-week follow-up questionnaire (i.e. during the past four and a half months) – even if it was only one puff. As stage theories propose that progress through the stages of change indicates a higher probability of achieving enduring behavioral change we used stage transition as a secondary outcome measure. At both follow-up assessments stage of change was assessed by asking respondents to choose the statement that best described them from the following: I do not intend to quit smoking or I do intend to quit smoking but not within six months (precontemplation); I intend to quit smoking within six months (contemplation); I intend to quit smoking within one month (preparation); I quit smoking less than six months ago (action); I quit smoking more than six months ago (maintenance). Based on this information a new variable was computed representing respondents' stage transition since baseline (-1 = negative transition, i.e. transition to contemplation or precontemplation; 0 = no transition; 1 = positive transition, i.e. transition to action).

Analyses

All analyses were done using SPSS 18.0. First, descriptive analyses were conducted to examine baseline sample characteristics.

Second, cluster analysis was conducted to identify similarities and differences between individuals and combine similar individuals into clusters (Norman, Velicer, Fava, & Prochaska, 1998). Cases were grouped on the basis of the following baseline variables: perceived pros of quitting, perceived cons of quitting and quitting self-efficacy (Field, 2000). The squared Euclidean distance was used as metric distance (Field, 2000; Norman et al., 1998) and so the clustering variables were standardized as z-scores. Ward's hierarchical method was used as the clustering algorithm (Field, 2000; Norman et al., 1998). This method aims to group respondents into clusters such that the variance within a cluster is minimized (Field, 2000). Ward's method is widely used in behavioral science, and is one of the more effective methods of cluster analysis (Borgen & Barnett, 1987). As there is no definitive procedure for determining the number of clusters we used several methods (Fagerström, 2002; Norman et al., 1998): (1) inverse scree tests to indicate the optimum number of clusters; (2) visual inspection of cluster profiles to assess shape, level, scatter and interpretability (Cronbach & Gleser, 1953; Prochaska & DiClemente, 1983); (3) cluster analyses of three random subsamples, all drawn independently from the entire sample and consisting of approximately 50% of respondents, to examine the stability of the cluster solutions derived from the entire sample.

Third, the clusters that had been identified were validated cross-sectionally and longitudinally. Two different types of analyses were used to assess their cross-sectional validity: (1) one-way analyses of variance (ANOVA) were used to compare clusters based on age, cigarette dependence and number of past quit attempts and post hoc comparisons were made with Tukey's Honestly Significant Difference (HSD) test, which has good power but also tightly controls the type 1 error rate (Field, 2013); (2) chi-squared tests were used to compare clusters based on gender and educational level. Two different types of regression analysis were used to assess longitudinal validity. First, logistic regression analyses were conducted to assess whether cluster membership predicted smoking abstinence at the six-week and six-month follow-ups, using only complete cases. As the RCT indicated that the intervention had a small effect on smoking abstinence at six-week follow-up (Smit, de Vries, & Hoving, 2012a), we included experimental condition as a potentially confounding variable in these regression analyses. Second, multinomial regression analyses were conducted to assess whether cluster membership predicted stage transition at the six-week and six-month follow-ups, again only complete cases were included. We also carried out a sensitivity analysis using with the Russell standard (West, Hajek, Stead, & Stapleton, 2005): logistic and multinomial analyses were replicated treating respondents with missing outcome data as still smoking and not having made any stage transition, respectively.

Results

Sample characteristics

Table 1 presents baseline sample characteristics and respondents' scores for perceived pros of quitting, perceived cons of quitting and quitting self-efficacy. The mean age of the respondents was 51.7 years (SD = 12.2), slightly more than half (50.9%) were women and many respondents reported educational level (46.2%) was medium. Respondents reported an average cigarette dependency score of 5.00 (SD = 2.5). The control group

Table 1. Baseline sample characteristics (N = 753).

Variables	
Gender (% male; n)	49.1; 370
Age (Mean; SD)	51.7; 12.2
Educational level (% medium; n)	46.2; 348
Cigarette dependence (Mean; SD)	5.0; 2.5
Perceived pros of quitting (Mean; SD)	3.7; .7
Perceived cons of quitting (Mean; SD)	2.5; .8
Quitting self-efficacy (Mean; SD)	3.4; .7
Number of previous quit attempts (Mean; SD)	5.9; 20.0
Experimental condition (% intervention, n)	51.1; 385

and intervention group only differed with respect to quitting self-efficacy level, with the control group scoring slightly lower (M = 3.29; SD = 0.67) than the intervention group (M = 3.42; SD = .72).

Six-week and six-month follow-up data were obtained from 306 (41%) and 206 (27%) of the 753 respondents respectively. Retention at six-week follow-up was predicted by older age (OR = 1.03), female gender (OR = 1.41) and lower addiction level (OR = .89). The only predictors of retention at six-month follow-up were age (OR = 1.02) and addiction level (OR = .92).

Cluster analysis

Inverse scree tests indicated that a three-cluster solution represented the data best. However, as previous research on smokers in the preparation stage has adopted four-cluster solutions (Anatchkova et al., 2006b; Norman et al., 2000) we investigated the interpretability and subsample replicability of both three- and four-cluster solutions.

In both the three- and four-cluster scenarios the clusters differed with respect to the cognitive variables, namely perceived pros, perceived cons and self-efficacy. The four-cluster solution was better replicated across the three subsamples than the three-cluster solution and, furthermore, the distribution of respondents was more even in the four-cluster solution than the three-cluster solution. Examination of interpretability indicated that only the four-cluster solution contained a cluster resembling the 'progressing preparers' identified in previous research (Anatchkova et al., 2006b; Norman et al., 2000). Based on assessment of the clusters' stability, interpretability and comparability with previous research we selected the four-cluster solution for further analysis. The four-cluster cluster means and standard deviations for the cognitive variables perceived pros, perceived cons and quitting self-efficacy are represented in Table 2 and the cluster profiles are shown in Figure 1 (initial sample) and Figure 2
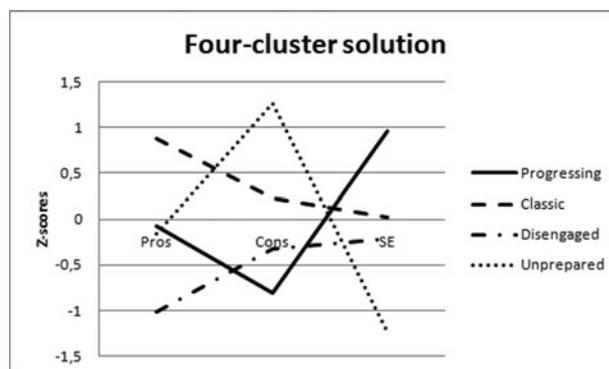

Figure 1. Identified cluster profiles for the four-cluster solution.

(random subsamples). The corresponding results for the three-cluster solution are available in Appendix 1 (Table A1; Figures A1 and A2).

The clusters

Cluster 1 (n = 253). The first cluster was labeled *Classic Preparer*. Classic Preparers scored nearly one standard deviation above the mean with respect to perceived pros of quitting, and reported average scores for the perceived cons of quitting and quitting self-efficacy. Thus, the Classic Preparer has only moderate quitting self-efficacy but considers that the pros of quitting outweigh the cons.

Cluster 2 (n = 120). The second cluster was labeled *Unprepared Preparer*. Unprepared Preparers reported average scores for perceived pros of quitting, scores more than one standard deviation above the mean for perceived cons and scores more than one standard deviation below the mean for quitting self-efficacy. Thus the Unprepared Preparers has very low quitting self-efficacy and considers that the cons of quitting outweigh the pros.

Cluster 3 (n = 187). The third cluster was labeled *Progressing Preparer*. The profile of the Progressing Preparer was characterized by an average score for perceived pros of quitting, a score more than half a standard deviation

Table 2. Cross-sectional comparisons of the four clusters with respect to cognitive variables (z-scores) and other variables.

	1. Classic Preparer (n = 253)	2. Unprepared Preparer (n = 120)	3. Disengaged Preparer (n = 180)	4. Progressing Preparer (n = 187)	χ^2 / F	V / ω	Tukey HSD pattern
Perceived pros [a]	.88, .55	− .16, .87	− 1.02, .72	− .08, .69	273.54[***]	.72	1 > 2, 4 > 3[***]
Perceived cons [a]	.22, .81	1.27, .88	− .33, .59	− .80, .61	218.40[***]	.68	2 > 1 > 3 > 4[***]
Self-efficacy [a]	.02, .83	− 1.24, .70	− .21, .54	.97, .68	241.67[***]	.70	4 > 1 > 3 > 2[***]
Male gender [b]	43.1, 109	35.8, 43	53.3, 96	61.0, 11.4	23.93[***]	.18	.
Age [a]	51.9, 11.4	53.2, 11.6	52.2, 13.3	50.3, 12.1	1.60	.05	ns
Educational level					12.68[*]	.09	.
Low [b]	21.3, 54	28.3, 34	20.0, 36	14.4, 27			
Medium [b]	45.1, 114	44.2, 53	50.0, 90	44.9, 84			
High [b]	33.6, 85	27.5, 33	30.0, 54	40.6, 76			
Cigarette dependence [a]	5.0, 2.4	6.3, 2.2	5.1, 2.4	4.0, 2.4	23.37[***]	.29	2 > 1, 3 > 4[***]
Previous quit attempts [a]	5.1, 7.8	6.8, 16.8	5.7, 19.1	6.8, 31.7	0.35	.05	ns

[a] = Mean, SD; [b] = %, N; V = Cramer's V; ω = Omega; *p < .05; ***p < .001; ns = non-significant; . = not applicable.
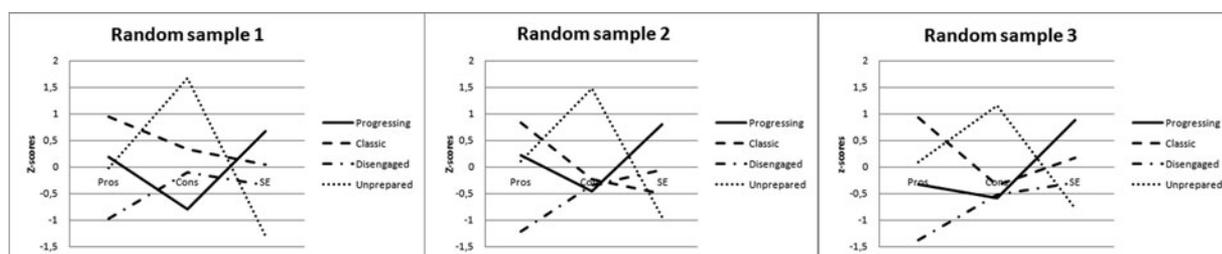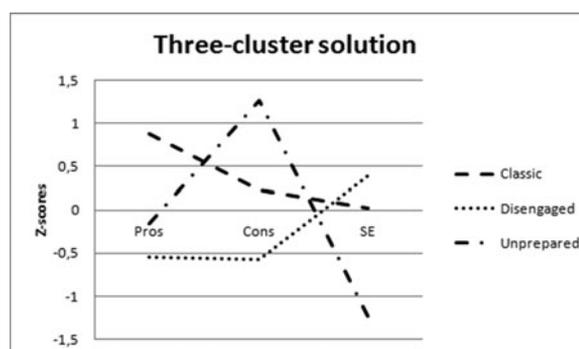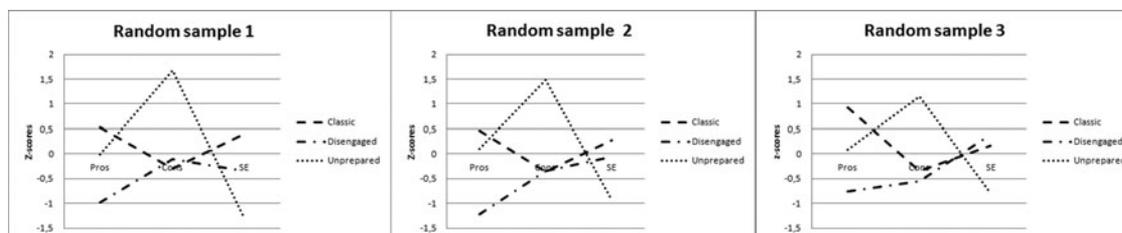
Figure 2. Identified cluster profiles for the four-cluster solution in three random subsamples.

below the mean for perceived cons and a score one standard deviation above the mean for quitting self-efficacy. Thus the Progressing Preparer has fairly high quitting self-efficacy, has an average perception of the pros of quitting and perceives few cons to quitting.

Cluster 4 (n = 180). The fourth cluster was labeled *Disengaged Preparer*. The typical Disengaged Preparer scored one standard deviation below the mean score for perceived pros of quitting and slightly below the mean for perceived cons and quitting self-efficacy. Thus, the Disengaged Preparer has moderate quitting self-efficacy but perceives very few pros to quitting and a moderate number of cons.

Validation

The four clusters differed with respect to gender, educational level and cigarette dependence (Table 2). There were higher proportions of men in the Progressing and Disengaged Preparer clusters than in the classic and Unprepared Preparer clusters. The Unprepared Preparer cluster had the highest proportion of respondents with a low educational level, the Disengaged Preparer cluster had the highest percentage of respondents with a medium educational level and the Progressing Preparer cluster had highest percentage of respondents with a high educational level. Relative to the other clusters the Unprepared Preparers were more dependent on nicotine and Progressing Preparers less dependent. Based on these results, gender, educational level and cigarette dependence were included as potential confounders in subsequent regression analyses.

Of the Classic, Unprepared, Progressing and Disengaged Preparers that completed follow-up questionnaires 28%, 21%, 28% and 19% respectively reported smoking abstinence at six-weeks; the corresponding figures for the six-month follow-up were 16%, 12%, 20% and 9%. The percentages of participants who had made negative, positive or neutral stage transitions by the six-week follow-up were 8%, 67% and 25% respectively; the corresponding figures at the six-month follow-up were 16%, 51% and 33%. Cluster membership was not predictive of six-week abstinence or stage transition at the six-week and

six-month follow-ups (Table 3), but analyses using six-month follow-up data revealed that Disengaged Preparers were less likely to be abstinent than Progressing Preparers (Table 4). Analyses in which missing outcome data were replaced with negative outcomes (data not shown) showed that cluster membership was no longer predictive of smoking abstinence, but revealed that Unprepared Preparers were less likely than Classic and Progressing Preparers to have made a positive stage transition by the six-week follow-up. Furthermore, Disengaged Preparers were more likely than Classic Preparers to have made a negative stage transition by the six-month follow-up.

Discussion

The results of this study suggest that Dutch adult smokers at the preparation of quitting can be divided into four clusters: Classic, Disengaged, Progressing and Unprepared Preparers. These subgroups are comparable to previously identified subgroups, which provides support for the validity of these motivational profiles as a way of subdividing smokers motivated to quit smoking within one month. It also suggests, however, that there are smokers who report an intention to quit within one month, yet are not convinced that the advantages of quitting outweigh the disadvantages. This group of smokers might benefit most from interventions that whose primary aim is to increase perceptions of the pros of quitting and decrease the perceived cons; however stage-based interventions for smokers at the preparation stage typically focus on enhancing self-efficacy. Of the subgroups identified in this study, these Unprepared Preparers might benefit least from such stage-based interventions, as their profile is furthest from that of the Classic Preparer for whom the stage-based interventions were designed. It is possible that factors other than perceptions of the pros and cons of quitting and quitting self-efficacy, such as perceived social influence, are responsible for the high motivation to quit reported by Unprepared Preparers. But as a previous study showed that precontemplators encountered less support for quitting than contemplators (de Vries, Mudde, Dijkstra, & Willemsen, 1998), this is not very likely.

Table 3. Logistic and multinomial regression analyses with smoking abstinence and stage transition at six-week follow-up as dependent variables.

Six-week follow-up	Smoking abstinence (n = 306)				Negative stage transition (n = 24)[1]				Positive stage transition (n = 201)[1]		
			95% CI				95% CI			95% CI	
	R^2	OR	Lower	Upper	R^2	OR	Lower	Upper	OR	Lower	Upper
Reference category: Classic Preparer											
	.087				.13						
Unprepared Preparer		.67	.27	1.69		1.09	.30	3.88	.54	.23	1.31
Disengaged Preparer		.65	.31	1.39		.90	.25	3.23	1.28	.59	2.76
Progressing Preparer		1.06	.54	2.07		.45	.10	1.95	1.05	.51	2.14
Condition[2]		2.27**	1.29	3.97		.44	.16	1.19	1.18	.68	2.07
Cigarette dependence		.97	.86	1.09		1.06	.86	1.31	.97	.86	1.09
Low education level[3]		2.27*	1.04	4.94		2.45	.59	10.14	2.62	.95	7.25
Medium education level[3]		.85	.46	1.57		.56	.19	1.70	.67	.37	1.21
Gender[4]		.65	.38	1.12		1.19	.42	3.38	.51*	.29	.91
Reference category: Progressing Preparer											
Classic Preparer		.95	.48	1.86		2.24	.51	9.75	.95	.47	1.95
Unprepared Preparer		.63	.24	1.71		2.43	.45	13.17	.52	.20	1.35
Disengaged Preparer		.62	.28	1.38		2.00	.39	10.23	1.22	.54	2.74
Condition[2]		2.27**	1.29	3.97		.44	.16	1.19	1.18	.68	2.07
Cigarette dependence		.97	.86	1.09		1.06	.86	1.31	.97	.86	1.09
Low education level[3]		2.27*	1.04	4.94		2.45	.59	10.14	2.62	.95	7.25
Medium education level[3]		.85	.46	1.57		.56	.19	1.70	.67	.37	1.21
Gender[4]		.65	.38	1.12		1.19	.42	3.38	.51*	.29	.91
Reference category: Unprepared Preparer											
Classic Preparer		1.49	.59	3.76		.92	.26	3.30	1.84	.77	4.44
Progressing Preparer		1.58	.58	4.26		.41	.08	2.24	1.93	.74	5.04
Disengaged Preparer		.98	.35	2.72		.83	.19	3.63	2.36	.89	6.24
Condition[2]		2.27**	1.29	3.97		.44	.16	1.19	1.18	.68	2.07
Cigarette dependence		.97	.86	1.09		1.06	.86	1.31	.97	.86	1.09
Low education level[3]		2.27*	1.04	4.94		2.45	.59	10.14	2.62	.95	7.25
Medium education level[3]		.85	.46	1.57		.56	.19	1.70	.67	.37	1.21
Gender[4]		.65	.38	1.12		1.19	.42	3.38	.51*	.29	.91

[1]Reference category: no stage transition (n = 75); [2]Reference category: standard care; [3]Reference category: high education level; [4]Reference category: male; *$p < .05$.

The first support for the four subgroups came from cross-sectional comparisons, as they differed with respect to gender and educational level. The Progressing and Disengaged Preparer clusters had a higher proportion of men than the Classic and Unprepared Preparer clusters. In addition the Unprepared Preparers were less educated than all the other subgroup whereas the Progressing Preparers were more educated. Moreover, Unprepared Preparers were more dependent on cigarettes than the other three clusters whereas the Progressing Preparers were less dependent; this is in line with findings from a previous study indicating that Unprepared Preparers smoke the most cigarettes per day (Anatchkova et al., 2006a). The finding that Unprepared Preparers were relatively less educated than other Preparers – combined in this and in most previous studies with greater nicotine dependence (Siahpush, McNeill, Borland, & Fong, 2006), and with less favorable smoking-related attitudes and lower intentions to quit (Springvloet et al., 2015) – suggests that it might be necessary to target Unprepared Preparers differently from smokers in other clusters or stages. Higher levels of nicotine dependence are a negative predictor of quitting

success (Vangeli, Stapleton, Smit, Borland, & West, 2011), so Unprepared Preparers may – in addition to behavioral support – benefit particularly from pharmacological support to attenuate physical withdrawal symptoms (Hajek, Stead, West, Jarvis, & Lancaster, 2009). Unfortunately previous studies of smokers at the preparation stage did not compare clusters with respect to gender and educational level (Anatchkova et al., 2006b; Norman et al., 2000), making it impossible to compare our findings with earlier research.

Additional support for the four clusters came from the longitudinal validation. The Disengaged Preparers were less likely to be abstinent at six-month follow-up than the Progressing Preparers – independently of the observed effect of educational level on smoking abstinence. This is not surprising, as in this and previous studies suggest that neither the pros nor cons of quitting are important to Disengaged Preparers (Anatchkova et al., 2006b; Norman et al., 2000), which may make them indifferent to cessation and hence unlikely to make progress towards it. On the other hand, it is possible that Progressing Preparers are smokers who going through the behavior change

Table 4. Logistic and multinomial regression analyses with smoking abstinence and stage transition at six-month follow-up as dependent variables.

Six-month follow-up	Smoking abstinence (n = 206)				Negative stage transition (n = 31)[1]				Positive stage transition (n = 98)[1]		
	R^2	OR	95% CI Lower	95% CI Upper	R^2	OR	95% CI Lower	95% CI Upper	OR	95% CI Lower	95% CI Upper
Reference category: Classic Preparer											
	.096				.10						
Unprepared Preparer		.64	.15	2.63		2.49	.54	11.44	.71	.23	2.19
Disengaged Preparer		.58	.18	1.84		1.73	.52	5.71	.44	.19	1.03
Progressing Preparer		2.05	.76	5.55		1.33	.36	4.89	.58	.24	1.37
Condition[2]		1.04	.46	2.35		.64	.26	1.60	1.20	.61	2.33
Cigarette dependence		1.07	.89	1.28		.86	.69	1.05	.91	.78	1.05
Low education level[3]		4.19*	1.41	12.50		2.30	.61	8.70	1.05	.39	2.85
Medium education level[3]		1.24	.47	3.30		2.02	.71	5.75	1.17	.57	2.43
Gender[4]		1.08	.48	2.40		1.07	.43	2.63	1.18	.61	2.29
Reference category: Progressing Preparer											
Classic Preparer		.49	.18	1.32		.75	.21	2.77	1.73	.73	4.10
Unprepared Preparer		.31	.07	1.37		1.87	.41	8.61	1.23	.38	4.00
Disengaged Preparer		.28*	.09	.95		1.30	.41	4.12	.76	.31	1.86
Condition[2]		1.04	.46	2.35		.64	.26	1.60	1.20	.61	2.33
Cigarette dependence		1.07	.89	1.28		.86	.69	1.05	.91	.78	1.05
Low education level[3]		4.19*	1.41	12.50		2.30	.61	8.70	1.05	.39	2.85
Medium education level[3]		1.24	.47	3.30		2.02	.71	5.75	1.17	.57	2.43
Gender[4]		1.08	.48	2.40		1.07	.43	2.63	1.18	.61	2.29
Reference category: Unprepared Preparer											
Classic Preparer		1.57	.38	6.51		.40	.09	1.85	1.41	.46	4.34
Progressing Preparer		3.22	.73	14.21		.53	.12	2.45	.81	.25	2.64
Disengaged Preparer		.91	.19	4.39		.69	.17	2.86	.62	.19	1.99
Condition[2]		1.04	.46	2.35		.64	.26	1.60	1.20	.61	2.33
Cigarette dependence		1.07	.89	1.28		.86	.69	1.05	.91	.78	1.05
Low education level[3]		4.19*	1.41	12.50		2.30	.61	8.70	1.05	.39	2.85
Medium education level[3]		1.24	.47	3.30		2.02	.71	5.75	1.17	.57	2.43
Gender[4]		1.08	.48	2.40		1.07	.43	2.63	1.18	.61	2.29

[1]Reference category: no stage transition (n = 62); [2]Reference category: standard care; [3]Reference category: high education level; [4]Reference category: male;
 $*p < .05$.

process again, after a recent quit attempt, and hence are well past primary decision making and already more confident and ready to change than other Preparers, especially Disengaged Preparers. That no additional significant results were identified might be due to the relatively small sample size, which resulted from the high attrition rates. This explanation is supported by the results of analyses replace missing outcome data with negative outcomes. These analyses showed that, as expected, Unprepared Preparers were less likely to have made a positive stage transition by the six-week follow-up than Classic and Progressing Preparers. These analyses extended the results from the complete-case analysis by showing that by the six-month follow-up Disengaged Preparers were more likely than Classic Preparers to have made a negative stage transition – and thus less likely to be abstinent

The results of this study suggest that for the approximately one third of respondents that were labeled Classic Preparers, stage-based smoking cessation interventions - i.e. interventions tailored to the set of cognitions usually present in preparers - are appropriate. However such interventions may not be appropriate for the

remaining two thirds, who do not share the set of cognitions on which they are predicated. This argument follows earlier expressions of doubt about stage-based tailoring of health behavior change interventions (de Vet et al., 2006; Heather, 1991; Littel & Girvin, 2002; Sutton, 2001). Rather than providing all smokers in preparation with an intervention that is solely intended to enhance their self-efficacy (e.g. by offering effectance-relevant feedback; Williams et al., 2011), it may be better to offer the different preparation stage subgroups different interventions. The Unprepared Preparers, for instance, might benefit more from interventions aimed primarily at increasing the perceived pros of quitting and decreasing the perceived cons (e.g. by providing information; Michie, Hyder, Walia, & West, 2011), whereas Progressing Preparers might gain more from interventions that help them translate their positive intentions into action (e.g. support for action planning; Elfeddali, Bolman, Candel, Wiers, & de Vries, 2012). It has already been suggested that targeting different subgroups of smokers separately might lead to better information provision and be more cost-effective (Anatchkova et al., 2006a; Erol & Erdogan, 2008; Meyer

et al., 2008), but before such subgroup-based interventions can be developed the subgroups identified in this study must first be replicated. This is particularly important as their predictive value was limited. For now, we suggest that rather than assuming that smokers at the same stage would benefit from tailored communications based on the assumption that they share the same psychological constructs (Dijkstra et al., 2006; Johnson et al., 2006; 2008; Prochaska et al., 2008), smokers should be provided with information tailored to their individual beliefs about the pros and cons of quitting and quitting self-efficacy, regardless of their behavioral change stage. It has been shown that this approach is potentially (cost-)effective (Dijkstra et al., 1998b; Smit, de Vries, & Hoving, 2012a; Smit, Evers, de Vries, & Hoving, 2013; Stanczyk et al., 2014; te Poel, Bolman, Reubsaet, & de Vries, 2009).

Limitations

The following limitations must be taken into account. First, sample sizes were relatively small due to the relatively high attrition rates that are common to this and other web-based smoking cessation intervention studies (Shahab & McEwen, 2009; Smit, Hoving, Cox, & de Vries, 2012b). The small sample may explain the limited effects of cluster membership on smoking abstinence and stage transition at the two follow-ups, so as well as the complete-case analysis, we also conducted an analysis using negative outcomes in place of missing outcome data in order to test the robustness of the results of the longitudinal validation analyses. This revealed additional significant results that were in line with findings from complete-case analysis and predictions derived from stage theories.

Second, we used a slightly different definition of the preparation stage of change from that adopted in the TTM (Prochaska & DiClemente, 1983) and the earlier, American studies (Anatchkova et al., 2005; Anatchkova et al., 2006a; 2006b; Norman et al., 2000). In line with critiques of the TTM definition of the preparation stage (Sutton, 2001; West, 2005) we defined all smokers who reported that they were willing to quit smoking within one month as preparers regardless of their previous history of quit attempts. The same definition has been used in a study conducted to identify clusters within the contemplation stage (Smit et al., 2010), but it may limit the extent to which our results can be compared with those based on the TTM definition.

Third, the clustering variables used in this study were related to smoking *cessation*, whereas those used in the earlier American studies were related to smoking (Anatchkova et al., 2005; Anatchkova et al., 2006a; 2006b; Norman et al., 2000). However, both theoretical and empirical considerations (Ajzen, 1988) and empirical evidence of an inverse relationship between quitting self-efficacy and temptation to smoke suggest that the perceptions of the pros and cons of quitting can be considered comparable to perceptions of the cons and pros of smoking, and similarly quitting self-efficacy can be considered comparable to temptation to smoke. Hence comparison of results from studies using the different variables appears feasible. Lastly, cluster analysis is an exploratory procedure and depends on the researcher's subjective interpretation of the data; however we used multiple methods of determining the number of clusters in order to reduce this problem (Fagerström, 2002; Norman et al., 1998).

Fourth, data on smoking status at the two follow-up assessments were based solely on self-reports and it could be argued that the failure to perform any biochemical test of respondents' smoking status may have led to an overestimation of smoking abstinence rates. However, a previous study that used saliva swab tests for cotinine to validate self-reported smoking abstinence showed that in all cases where the respondent underwent a cotinine test their smoking status was confirmed (Smit, Candel, Hoving, & de Vries, 2016). Moreover, earlier studies have shown that self-reported smoking status is often a fairly accurate measure of actual smoking status (Patrick et al., 1994). Finally, although smokers' first attempt to quit smoking might not always be successful (Hughes, Keely, & Naud, 2004), seeking help online relatively anonymously may prevent them from feelings of failure and embarrassment, and the tendency to provide socially desirable answers. We therefore believe that over-reporting of abstinence was not a significant factor in our study.

Conclusions

This study extends the evidence for the existence of subgroups of smokers at the preparation stage of change. Stage-based smoking cessation interventions may be appropriate for the one third of smokers identified in this study as Classic Preparers. The other three clusters may benefit more from interventions tailored at subgroup level, or from information tailored to individual smokers' beliefs, regardless of their sub-stage of change; there is already data suggesting that this approach can be cost-effective.

Glossary

Stages of change: the five stages of behavioral change, i.e. precontemplation, contemplation, preparation, action, and maintenance.
Tailoring: adjusting an intervention according to the user's personal characteristics and situation, e.g. only providing information that is relevant to a particular stage of change.

Clusters: subgroups of similar individuals; in this study the clusters were defined on the basis of perceptions of pros and cons of quitting smoking and quitting self-efficacy.

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Conflict of interest

Hein de Vries is scientific director of Vision2Health, a company that licenses evidence-based innovative computer-tailored health communication tools.

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