British Journal of Addiction (1991) 86, 1119–1127

RESEARCH REPORT

The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire

TODD F. HEATHERTON,[1] LYNN T. KOZLOWSKI,[2] RICHARD C. FRECKER[3] & KARL-OLOV FAGERSTRÖM[4]

[1]*Department of Psychology, Harvard University, 33 Kirkland Street, Cambridge, MA 02138, USA,* [2]*Program in Behavioral Health, Pennsylvania State University, University Park, PA 16802, USA,* [3]*Addiction Research Foundation, 33 Russell Street, Toronto, Ontario M5S 2S1, Canada &* [4]*Pharmacia Leo Therapeutics AB, Box 941, S-251 09 Helsingborg, Sweden*

Abstract

We examine and refine the Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978). The relation between each FTQ item and biochemical measures of heaviness of smoking was examined in 254 smokers. We found that the nicotine rating item and the inhalation item were unrelated to any of our biochemical measures and these two items were primary contributors to psychometric deficiencies in the FTQ. We also found that a revised scoring of time to the first cigarette of the day (TTF) and number of cigarettes smoked per day (CPD) improved the scale. We present a revision of the FTQ: the Fagerström Test for Nicotine Dependence (FTND).

Introduction

The FTQ was developed in 1978 to provide a short, convenient self-report measure of dependency on nicotine (Fagerström, 1978). The eight items were derived from theoretical notions of reliance on nicotine (see Fagerström and Schneider [1989] for a current version of the FTQ). A review of the literature by Fagerström and Schneider (1989) found that 14 of 16 different data sets relating biochemical markers to the FTQ found statistically significant correlations. Carbon monoxide and nicotine may yield stronger correlations than nicotine, perhaps because the nicotine measures are more variable due to the relatively short plasma half-life of nicotine.

Use of the FTQ has been questioned because of perceived psychometric deficiencies, including a multifactorial structure, low levels of reliability and poor item selection (Heatherton *et al.*, 1989; Lichtenstein & Mermelstein, 1986; Lombardo, Hughes & Fross, 1988; Pomerleau, Majchrezak & Pomerleau, 1989; Pomerleau *et al.*, 1990). For example, Lichtenstein & Mermelstein (1986) found that the FTQ was multifactorial, with only one of the factors contributing significantly to the explanation of variance; this factor consisted of two items: 'time to the first cigarette of the day' (TTF) and 'average daily consumption of cigarettes' (CPD). Further, Lichtenstein & Mermelstein (1986) found that the FTQ has low internal consistency (coefficient alpha = 0.55 for one sample, and 0.51 for the other), as was also found by Pomerleau *et al.* (1990; 0.58 for one of their samples and 0.41 for a different sample). Since some of the FTQ items correlate as highly with biochemical and behavioural measures (if not more highly) as the total score (Lichtenstein

& Mermelstein, 1986), it is possible that some items add little but error variance to the total scores.

Time to the first cigarette of the day (TTF). Time to the first cigarette of the day is theoretically important to the prediction of nicotine dependence (Heatherton *et al.*, 1989; Kozlowski, Director & Harford, 1981). Due to the relatively short half-life of nicotine, dependent smokers have depleted plasma levels of nicotine upon arising. These smokers are likely to experience discomfort unless they quickly have their first cigarette. TTF has been found to be an excellent predictor of biochemical measures (cotinine, nicotine and carbon monoxide; Heatherton *et al.*, 1989) and also predictive of successful smoking cessation (Kabat & Wynder, 1987; Kozlowski *et al.*, 1981). Heatherton *et al.* (1989) found that a four category scoring of TTF ($\leq$5, 6–30, 31–60, 61+) was superior to the two category scoring method used in the FTQ ($\leq$30 vs $>$30) for predicting biochemical indices of smoking.

Cigarettes per day. The number of cigarettes smoked per day is a face valid measure of dependence on nicotine, and early studies assumed that dependence was a direct function of smoking rate (Brantmark, Ohlin & Westling, 1973). CPD has been shown to relate to disease risk (e.g. USPHS, 1979) and to exposure to tobacco constituents (Kozlowski & Herling, 1988; Hill, Haley & Wynder, 1983). However, although CPD has been found to predict abstinence in some studies (e.g. Hall *et al.*, 1984) it has not predicted abstinence in others (e.g. Fagerström, 1982b).

The FTQ uses three categories for CPD (1–15, 16–25, 26+) which may be inappropriate because it categorizes those who smoke 20 cigarettes per day with those who smoke 25 cigarettes per day. This categorization format may obscure the digit bias in self-reported cigarette consumption between those who purchase packages of 20's versus 25's (Kozlowski, 1986; Kozlowski, Heatherton & Ferrence, 1989).

Nicotine yield. Standard tar and nicotine yields do not provide very good estimates of what smokers are getting from their cigarettes (e.g. Kozlowski, Frecker & Lei, 1982; Maron & Fortmann, 1987) since all cigarettes can be subject to so-called compensatory smoking (i.e. more intensive smoking to compensate for reduced standard tar and nicotine yields) (e.g. Rickert & Robinson, 1981; Fagerström, 1982a; Robinson, Young & Rickert, 1981). Thus, machine-rated yields for cigarettes may tell us little about dependence; it is the obtained yield that is important.

Further, some smokers may be unsure of nicotine yield, especially in countries—such as the USA—where cigarette manufacturers do not publicize yield rate on packages (Kozlowski & Heatherton, 1990). A study on awareness of tar yields conducted in the UK found that reporting of tar categories is not particularly accurate, except for the lowest tar group (Peach, Shah & Morris, 1986).

Inhalation. The FTQ has three levels for inhalation (not inhale, inhale sometimes and always inhale). This item has been criticized on the grounds that it may not discriminate degrees of dependency because almost everyone always inhales. Hughes, Gust & Pechacek (1987) found that 95% of 1006 smokers inhaled and Pomerleau *et al.* (1990) found 93.3% of their sample (of 150) always inhales. Thus, almost every smoker obtains two points towards dependence from this one measure, and therefore the question may not be very useful.

However, dependence on tobacco relies on the smoker inhaling the smoke from the cigarette; it is important to ensure that smokers are actually obtaining a dose from their cigarettes to count them as dependent smokers. In general, smokers are able to report accurately whether they inhale or not (Herling & Kozlowski, 1988), although it does not seem that smokers are accurate in estimating the 'depth' of their inhalations (Stepney, 1982).

Other questions. The remaining FTQ questions derive from theoretical notions about the behavior of high dependent smokers. They are face valid measures of difficulty refraining from smoking (where forbidden or if ill) and increased smoking in the morning. These items have received the least empirical attention, and their concurrent validity is largely unknown. However, whereas measures like CPD are highly related to physiological measures of smoking, these other questions may be more important as behavioral indices. That is, the smoking behavior of highly dependent smokers may indeed be different from that of low dependent smokers, independent of physiological indices. Such behaviors may be particularly important to the issue of smoking cessation.

HSI as an alternative measure

Since two of the FTQ questions account for the majority of variance in total scores, TTF and CPD (Lichtenstein & Mermelstein, 1986), Heatherton *et al.* (1989) proposed that these two items alone might serve as an alternative to the FTQ. For example, these two questions are more closely related to measures of dependence and withdrawal than are the other FTQ items (Heatherton *et al.*, 1989). Further, as discussed in the preceding section, the FTQ scoring method for TTF and CPD may also inadvertently limit the predictive power of these constructs. Heatherton *et al.* (1989) developed a Heaviness of Smoking Index (HSI) which consists simply of TTF and CPD. However, these are scored differently in the HSI than in the FTQ, with the HSI having four categories for both TTF ($\leq$5, 6–30, 31–60, 61+) and CPD (1–10, 11–20, 21–30, 30+) and the FTQ having only two TTF categories and three CPD categories. We present data in the current study which compares the predictive abilities of the FTQ and the short form HSI.

The overall goal of this project was to examine the best way to use and score items from the FTQ in order to predict biochemical measures of heaviness of smoking and to develop an improved version of the scale, to be called the Fagerström Test for Nicotine Dependence (FTND).[1] To this end we administered questions about smoking behaviors and obtained saliva samples from visitors to the Ontario Science Centre.

Methods

Subjects

Our sample consisted of 254 adult visitors to the Ontario Science Centre. Subjects ranged in age from 17–77 (M=33.5, Standard Deviation (SD)=12.7), with 111 being male and 143 being female. Subjects smoked an average of 20.7 cigarettes per day (range 3–75, SD=10.5) and smoked their first cigarette of the day, on average, at 47.2 minutes (range 0–720, SD=86.8). The average FTQ score for this sample was 5.2 (SD=1.9).

Procedure

Questionnaires on various aspects of smoking were administered to all subjects. Within this questionnaire, all subjects were asked "At present, how long after waking do you wait before having your first cigarette (in minutes)?" and "How many cigarettes do you smoke per day at present?" in addition to completing the intact FTQ.

Respondents were recruited at the Ontario Science Centre by means of a large sign announcing 'A Study of Smoking Habits'. No mention was made of smoking abstinence and all subjects were unpaid volunteers who participated between 10.00 a.m. and 3.30 p.m. Subjects provided a breath sample for CO testing and a saliva sample for salivary cotinine (a stable metabolite of nicotine; Abrams *et al.*, 1987; Jarvis *et al.*, 1987; Kozlowski & Herling, 1988) and salivary nicotine testing. Subjects placed a cotton dental roll inside their cheek and allowed it to collect saliva while they filled out the questionnaires. Subjects then placed the dental roll directly into a sealed red-top vacutainer. The experimenter then transferred the dental roll to an empty syringe and attempted to extract as much saliva as possible back into the red-top vacutainer. Subjects who did not appear to provide a sample containing at least 1.0 mg of saliva were asked to provide an additional sample. The salivary extracts were analyzed in a pressurized clean air laboratory at the Addiction Research Foundation, using capillary-column gas chromotography (Jacob, Wilson & Benowitz, 1981). Unfortunately, insufficient saliva samples for 8 subjects were obtained and they are not therefore included in those analyses of saliva nicotine or cotinine.

Results

FTQ 1: TTF

The FTQ measure of TTF consists of two categories (within 30 minutes=68.5% vs. greater than 30 minutes=31.5%).[2] There were considerable differences between later and early smokers on the biochemical indices. As may be seen in Table 1, both the log transformations[3] and raw data values for CO and salivary cotinine differ between those who have their first cigarette of the day within 30 minutes and those who delay their first cigarette for more than 30 minutes. The HSI scoring method uncovers differences within each of the FTQ groups. For example,

[1]We preferred the name Fagerström Test of Nicotine Dependence (FTND) to the Fagerström Tolerance Questionnaire because the latter was deemed too imprecise.

[2]These numbers refer to the percentage of subjects selecting this response.

[3]Logarithmic transformation were used because of the disparate cell sizes and heterogeneity of variance. This issue was especially relevant for TTF measures.

Table 1. *TTF measures scored by FTQ and HSI methods on biochemical measures*

Measure	FTQ Scale		HSI Scale			
	>30	≤30	61+	31–60	6–30	≤5
CO	13.1	23.4	11.3[a]	14.5[a]	22.0	26.5
SD	7.1	9.3	6.1	7.5	9.0	9.2
Log CO	1.10	1.35	1.04	1.14	1.33	1.41
SD	0.23	0.18	0.22	0.22	0.18	0.16
Cotinine	193.0	336.0	157.4[a]	219.7[a]	320.4	367.9
SD	101.8	152.2	92.9	100.0	155.1	142.2
Log Cotinine	2.22	2.48	2.13	2.28	2.45	2.53
SD	0.28	0.23	0.26	0.27	0.24	0.20
Cell n's	75	169	30	45	116	53

Means within FTQ and HSI sharing common subscripts are not significantly different. (Fisher's test, $p<0.05$).

there were significant differences between those who had their first cigarette of the day within 5 minutes and those who waited more than 5 minutes but not more than 30 minutes in CO, salivary cotinine and nicotine. There were similar differences between the other HSI categories, suggesting that it may be profitable to use finer distinctions of TTF than those used in the FTQ.

FTQ 2: forbidden cigarettes

The second FTQ question asks smokers whether it is difficult to refrain from smoking in places where it is forbidden (no=71.3% vs. yes=28.7%). Those individuals who report difficulties are assessed one point. Smokers who found it difficult to refrain from smoking in places where it was forbidden did not differ from those who did not find it difficult in salivary cotinine (301.7 ± 155.5 ng/ml vs. 287.9 ± 152.9, p=ns). Logarithmic transformation did not alter this result. These groups did differ, however, in CO level, with those who have difficulty refraining having higher CO values (22.7 ± 10.4 ppm) than those who do not report difficulties (19.1 ± 9.5 ppm, $t244=2.6$, $p<0.01$).

FTQ 3: which cigarette would you most hate to give up?

Those checking that they would most hate to give up the first cigarette of the morning (11.0%) are given one point whereas those who say any other cigarette are given zero points (89.0%). These groups did not differ on any biochemical measures. Logarithmic transformations did not change the results.

FTQ 4: CPD

The FTQ has three categories of CPD, with zero points awarded for 1–15 (36.6%), one point awarded for 16–25 (44.9%) and two points awarded for 26 or more (18.5%). This method of scoring produced significant effects for all of the dependent measures. Post-hoc tests revealed significant differences between all pairwise means for CO, but not for cotinine (16–25 vs. 26+, p=ns). Logarithmic transformations did not affect these outcomes. The lack of significant differences between the two heaviest smoking groups may be due to the inappropriate grouping of those who smoke 20 cigarettes per day with those who smoke 25 cigarettes per day. The HSI scoring method uncovered significant differences between these two groups in CO, cotinine, and nicotine. Thus, although either scoring method revealed many between group differences, the FTQ method may group 20 and 25's together inappropriately. Such a finding supports the recommendations of the US Department of Health and Human Services (1988).

FTQ 5: smoke more in the morning

Individuals who report smoking more in the morning than during the rest of the day (21.3%) obtain one point on the FTQ, whereas individuals who do not report smoking more in the morning (78.7%) do not receive any points. These groups differed on CO (24.2 ± 9.9 vs. 19.1 ± 9.6, $t244=3.48$, $p<0.0006$) and salivary cotinine (343.7 ± 143.9 vs. 277.9 ± 153.3, $t244=2.78$, $p<0.006$).

FTQ 6: smoke if ill

Individuals who report smoking if they are so ill that they spend most of the day in bed (29.9%) receive one point on the FTQ whereas no points are awarded to individuals who do not report doing so (70.1%). Those who smoke when ill were heavier smokers: CO (23.5 ± 9.7 vs. 18.8 ± 9.6, $t246 = 3.55$, $p < 0.0005$), and salivary cotinine (340.7 ± 145.8 vs. 271.3 ± 152.3, $t246 = 3.31$, $p < 0.002$).

FTQ 7: nicotine yield

The FTQ has three categories for nicotine yield, corresponding roughly to low yield (0 points–38.6%), medium yield (1 point–39.4%) and high yield (2 points–22.0%). An analysis of variance revealed no differences between these groups on any dependent measure. To further investigate the relation between nicotine yield, we conducted simple regression and polynomial regression using FTQ nicotine category and actual nicotine values to predict all dependent measures. There was no significant relation between nicotine rating and any dependent measure.

FTQ 8: inhale

Only one smoker of our sample of 254 adults reported not inhaling their cigarettes (0.4%, FTQ = 0 points). Therefore we included that person with those who said they sometimes inhaled (7.2%, FTQ = 1 point) to examine whether they differed from those who report always inhaling (92.5%, FTQ = 2 points). There were no biochemical differences between the two groups.

Individual item summary

An examination of the proportions of individuals obtaining points for each question reveals that very few individuals gain points from FTQ items two (trouble refraining, 28.7%), three (most hate to give up morning cigarette, 11.0%), five (smoking more in the morning than the rest of the day, 21.3%), and item six (smoke when ill, 29.9%). In contrast, the vast majority of subjects gained points for inhalation (99.6%), and most subjects got points for nicotine yield (62.4%), CPD (63.4%) and TTF (68.5%).

TTF, CPD, smoking more in the morning, trouble refraining when forbidden, and smoking when ill appeared to have the greatest between group differences in biochemical measures. The other three questions uncovered no biochemical differences. Further, it was clear that the HSI scoring method for CPD and TTF uncovered differences in biochemical that were obscured by the FTQ scoring method.

FTQ whole scale vs. HSI measures

The results for the individual item analysis prompted us to construct a number of models to try to come up with the best way to score the FTQ (how to score each item, how many items to include). We report the results for eight models only, including the best five models (models four to eight).[4] These models are summarized below:

Model One	FTQ 1,2,3,4,5,6,7,8
Model Two	FTQ 1,2,3,5,6,8(R)
Model Three	FTQ 1,4
Model Four	FTND: HSI TTF, CPD; FTQ 2,3,5,6
Model Five	HSI TTF, CPD; FTQ 5,6
Model Six	HSI TTF, CPD; FTQ 5
Model Seven	HSI TTF, CPD; FTQ 6
Model Eight	HSI TTF, CPD

Note that the inhalation question has been revised in model two. This revised scoring gives one point for always inhaling and zero points for sometimes or never inhaling. The remainder of the items are scored as in the original FTQ whereas the HSI TTF and CPD items are scored into four categories. Model Eight corresponds to the HSI scale developed by Heatherton *et al.* (1989) and consists only of TTF and CPD whereas Model Four is the revision of the FTQ scale which we recommend (i.e. it is the FTND).

We conducted a series of regression analyses using the various models to predict each of the biochemical measures. The proportion of variance explained for each dependent measure can be found in Table 2. An examination reveals that any modification of the FTQ improves the predictive ability on all dependent measures. Further, M-4, M-6 and M-8 appear to be the best models, which suggests that the HSI scoring of TTF and CPD is important for the best models. The HSI scale (Heatherton *et al.*, 1989) was most frequently the best predictor, occasionally improved by FTQ item 5 or 6.

[4]Models 1 to 3 were included to show the results for the original FTQ scorings.

Table 2. *Comparing the adjusted R^2 for the various models*

Items	Model M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8
CO	23.9	26.8	29.4	28.4	30.1	32.1	29.6	31.4
Log CO	25.5	29.9	33.2	31.9	34.1	36.6	33.8	36.1
Cotinine	17.5	19.8	21.6	21.0	24.2	25.6	24.2	25.6
Log cotinine	18.5	23.6	25.6	24.6	28.5	30.0	28.2	29.5

Index:
Model 1 FTQ: 1,2,3,4,5,6,7,8
Model 2 FTQ 1,4,5,6,8(R)
Model 3 FTQ 1,4
Model 4 FTND: HSI TTF CPD; FTQ 2,3,5,6
Model 5 HSI TTF, CPD; FTQ 5,6
Model 6 HSI TTF, CPD: FTQ 5
Model 7 HSI TTF, CPD; FTQ 6
Model 8 HSI TTF, CPD

Internal consistency. One of the major complaints about the FTQ is its low levels of internal consistency. This may be due partially to the relatively few number of items in the FTQ, since measures of internal consistency are dependent on test length. The average reported reliability for the FTQ is 0.51 (see our earlier citations), which is below traditional standards. In the current study, coefficient alpha for the FTQ was computed to be 0.48 (which is close to previous findings), whereas it was 0.61 for the FTND (Model 4 from above). This is a considerable improvement considering that fewer items usually leads to lower reliability.

Factor structure. Lichtenstein & Mermelstein (1986) conducted a principal components analysis of the FTQ and discovered that the scale was multifactorial. However, they found that only the first factor explained a significant proportion of variance (20%) and consisted of only two items (TTF and CPD), raising the possibility that the FTQ items might not form a unitary set. We conducted an iterated principal axes factor analysis on the eight FTQ items and found that, in fact, they do not form a homogenous set. For example, the MSA (measure of sampling adequacy; cf. Kaiser, 1974) values for FTQ nicotine and inhalation ratings were under 0.60, indicating an unacceptable ratio of inter-item correlation to partial correlation coefficients (total scale mean MSA=0.65, a value described by Kaiser as mediocre). This factor analysis revealed two factors: Morning smoking (TTF, smoking more in the morning, hate to give up morning cigarette) and cigarette consumption (CPD, smoke if ill, trouble refraining). FTQ nicotine rating and inhalation did not load on either factor (loadings were less than 0.15). Thus, our analysis leads to similar conclusions as those reached by Lichtenstein & Mermelstein.

We then conducted an iterated principal axes factor analysis of the FTND items and found that all of the items loaded on a single factor, with only FTND item 3 ('hate to give up morning cigarette') loading less than 0.30 (loading=0.23). A second factor did not have an eigenvalue over 1.0 and consisted only of FTND item 3 (loading=0.34). The overall MSA value was 0.70, considered within the acceptable 'real world' range by Kaiser (1974). Thus, we are satisfied that the FTND items form a homogenous set.

Discussion

Our exploration of the FTQ scale has revealed that for the large part, the FTQ is a valid measure of heaviness of smoking as measured by biochemical indices. The precise scoring of the FTQ items affected the overall sensitivity of the scale, with modifications of TTF and CPD appearing to be most important. We must stress, however, that we have no information on the relationship of FTQ or FTND or HSI to the ability to give up smoking in either the short or long run. Further research is needed to determine how these items and scorings relate to the key behavioral issue of smoking cessation. The current research has some limitations (i.e. a select sample), and these results may not extend to more representative populations.

We conclude that the FTQ is a useful tool for identifying individuals who have the greatest concentration of tobacco products and who therefore might be at greater risk for disease. However, modifications of FTQ scoring can improve the scale's overall quality (Pomerleau *et al.*, 1989, 1990). Pomerleau *et al.* (1990) looked at the ability of different components of the FTQ to predict cotinine levels and suggested that none of the subscales provided consistent improvement over FTQ scores. We find that revisions of the scoring of

Table 3. *Items and scoring for Fagerström Test for Nicotine Dependence (FTND)*

Questions	Answers	Points
1. How soon after you wake up do you smoke your first cigarette	Within 5 minutes	3
	6-30 minutes	2
	31-60 minutes	1
	After 60 minutes	0
2. Do you find it difficult to refrain from smoking in places where it is forbidden e.g. in church, at the library, in cinema, etc.?	Yes	1
	No	0
3. Which cigarette would you hate most to give up?	The first one in the morning	1
	All others	0
4. How many cigarettes/day do you smoke?	10 or less	0
	11-20	1
	21-30	2
	31 or more	3
5. Do you smoke more frequently during the first hours after waking than during the rest of the day?	Yes	1
	No	0
6. Do you smoke if you are so ill that you are in bed most of the day?	Yes	1
	No	0

the most important questions on the FTQ (TTF & CPD) and the omission of inhalation and nicotine rating provide both higher face and predictive ability than the FTQ.

The present results indicate that the inhalation question adds little to the FTQ. Even though people need to inhale to gain a dose of nicotine, the inhalation question did not receive overwhelming support from the current study. One possible explanation for this finding is that because very few individuals fail to inhale, the between-group comparisons are not particularly powerful. Research has shown that individuals can accurately estimate whether they inhale or not (Herling & Kozlowski, 1988), although it has yet to be shown how useful these estimates are. The usefulness of the inhalation item is also called into question because smokers who do not inhale are unlikely to be seen in treatment, which is where the majority of research that uses the FTQ takes place. Considering these problems together, it seemed prudent to eliminate the inhalation question in any revision of the FTQ.

Similarly, the validity of the nicotine rating item was also not supported by the present analysis. We examined numerous methods of scoring nicotine ratings and tried many different types of statistical analyses; all of our efforts were met with failure. The major problem with nicotine yield is that the machine ratings correspond rather poorly with the resultant yield of a smoked cigarette. Because compensatory smoking methods can render any low yield cigarette a high yield cigarette (Fagerström, 1982a; Kozlowski *et al.*, 1989) individual differences in smoking style exert a greater influence on nicotine obtained than the machine-rated nicotine yield.

Fagerström acknowledged early that the FTQ might be improved by modification, and our goal was to arrive at such modifications. We propose a revised scoring for the FTQ, called the Fagerström Test for Nicotine Dependence (FTND). The FTND can be found in Table 3.

The FTND consists of six of the original items (nicotine rating and inhalation have been eliminated) with revised scoring for two of the items (TTF and CPD). Although the other items did not add appreciably to the prediction of biochemical levels, they may relate to the behavioral issue of smoking cessation. Because we did not have any measures of smoking cessation in the current study, we consider this the highest priority for future studies on the FTND. An additional reason for choosing to keep some of the other FTQ items is that they may be useful for patient-doctor discussions about nicotine dependence. That is, the behavioral measures (such as having difficulty

refraining from smoking or smoking when ill) may provide insight for the patient regarding their need to smoke.

Both TTF and CPD are modified in the FTND according to the HSI scoring method (Heatherton *et al.*, 1989). In the current study, the HSI was uniformally the best predictor of biochemical measures. Thus, often the HSI is an acceptable replacement for the full-scale FTND.[5] We advise, however, using the full-scale FTND when issues of smoking cessation are relevant, and until direct tests are available of the relative merits of the two scales.

In summary, the FTND corrects some of the psychometric and conceptual problems of the FTQ. The FTND has acceptable levels of internal consistency, and is closely related to biochemical indices of heaviness of smoking. The HSI method of using only CPD and TTF also received considerable support from the current analysis. When time or resources are limited, it might be most profitable to ask and score only these two items. Further, future work is needed which compares directly the HSI and FTND, especially as they relate to smoking cessation. Thus, future use of the revised FTND should help us refine our knowledge of the dependency on tobacco and the means of measuring it.

Acknowledgements

We thank Marilyn Pope, Renate Kraskins, and Helma Nolte for their assistance with this project.

References

ABRAMS, D. B., FOLLICK, M. J., BEINER, L., CAREY, K. B. & HITTI, J. (1987) Saliva cotinine as a measure of smoking status in field settings, *American Journal of Public Health*, 77, pp. 846–848.

BRANTMARK, B., OHLIN, P. & WESTLING, W. H. (1973) Nicotine-containing chewing gum as an antismoking aid, *Psychopharmacology*, 31, pp. 191–200.

FAGERSTRÖM, K.-O. (1978) Measuring degree of physical dependency to tobacco smoking with reference to individualization of treatment, *Addictive Behaviors*, 3, pp. 235–241.

FAGERSTRÖM, K.-O. (1982a) Effects of a nicotine-enriched cigarette on nicotine titration, daily cigarette consumption, and levels of carbon monoxide, cotinine, and nicotine, *Psychopharmacology*, 77, pp. 164–167.

FAGERSTRÖM, K.-O. (1982b) A comparison of psychological and pharmacological treatment in smoking cessation, *Journal of Behavioral Medicine*, 5, pp. 343–351.

[5]We note that researchers should consider collecting the raw TTF and CPD data so that regression analyses can be conducted, see Heatherton *et al.*, 1989.

FAGERSTRÖM, K.-O. & SCHNEIDER, N. G. (1989) Measuring nicotine dependence: a review of the Fagerström Tolerance Questionnaire, *Journal of Behavioral Medicine*, 12, pp. 159–181.

HALL, S. M., HERNING, R. I., REESE, T. J., BENOWITZ, N. I. & JACOB, P. (1984) Blood cotinine levels as indicators of smoking treatment outcome, *Clinical Pharmacology and Therapeutics*, 6, pp. 810–814.

HEATHERTON, T. F., KOZLOWSKI, L. T., FRECKER, R. C., RICKERT, W. S. & ROBINSON, J. (1989) Measuring the heaviness of smoking using self-reported time to the first cigarette of the day and number of cigarettes smoked per day, *British Journal of Addiction*, 84, pp. 791–800.

HERLING, S. & KOZLOWSKI, L. T. (1988) The importance of direct questions about inhalation and daily intake in the evaluation of pipe and cigar smokers, *Preventative Medicine*, 17, pp. 73–78.

HILL, P., HALEY, N. J. & WYNDER, E. L. (1983) Cigarette smoking: carboxyhemoglobin, plasma nicotine, cotinine and thiocyanate vs. self-reported smoking data and cardiovascular disease, *Journal of Chronic Disease*, 36, pp. 439–449.

HUGHES, J. R., GUST, S. W. & PECHACEK, T. F. (1987) Prevalence of tobacco dependence and withdrawal, *American Journal of Psychiatry*, 144, pp. 205–208.

JACOB, P., WILSON, M. & BENOWITZ, N. L. (1981) Improved gas chromatographic method for the determination of nicotine and cotinine in biologic fluids, *Journal of Chromatography*, 222, pp. 61–70.

JARVIS, M. J., TUNSTALL-PEDOE, H., FEYERABEND, C., VESLEY, S. & SALOOJEE, Y. (1987) Comparison of tests used to distinguish smokers from nonsmokers, *American Journal of Public Health*, 77, pp. 1435–1438.

KABAT, G. C. & WYNDER, E. L. (1987) Determinants of quitting smoking, *American Journal of Public Health*, 77, pp. 1301–1305.

KAISER, H. F. (1974) An index of factorial simplicity, *Psychometrika*, 39, pp. 31–36.

KOZLOWSKI, L. T. (1986) Pack size, reported cigarette smoking rates, and public health, *American Journal of Public Health*, 76, pp. 1–2.

KOZLOWSKI, L. T., DIRECTOR, J. & HARFORD, M. (1981) Tobacco dependence, restraint, and time to the first cigarette of the day, *Addictive Behaviors*, 6, pp. 307–312.

KOZLOWSKI, L. T., FRECKER, R. C. & LEI, H. (1982) Nicotine yields of cigarettes, plasma nicotine in smokers, and public health, *Preventive Medicine*, 11, pp. 240–244.

KOZLOWSKI, L. T. & HEATHERTON, T. F. (1990) Self-report issues in tobacco, *Behavioral Assessment*, 12, pp. 53–75.

KOZLOWSKI, L. T., HEATHERTON, T. F. & FERRENCE, R. (1989) Pack size, reported cigarette smoking rates and the heaviness of smoking, *Canadian Journal of Public Health*, 80, pp. 266–270.

KOZLOWSKI, L. T., HEATHERTON, T. F., FRECKER, R. C. & NOLTE, H. E. (1989) Self-selected blocking of vents on low-yield cigarettes, *Pharmacology Biochemistry & Behavior*, 33, pp. 815–819.

KOZLOWSKI, L. T. & HERLING, S. (1988) Objective measures, in: DONOVAN, D. M. & MARLATT, G. A. (Eds) *Assessment of Addictive Behaviors* (New York, Guilford Press).

LICHTENSTEIN, E. & MERMELSTEIN, R. J. (1986) Some methodological cautions in the use of the tolerance questionnaire, *Addictive Behaviors*, 11, pp. 439–442.

LOMBARDO, T. W., HUGHES, J. R. & FROSS, J. D. (1988) Failure to support the validity of the Fagerström Tolerance Questionnaire as a measure of tolerance to nicotine, *Addictive Behaviors*, 13, pp. 87–90.

MARON, D. J. & FORTMANN, S. P. (1987) Nicotine yield and measures of cigarette smoke exposure in a large population: are lower yield cigarettes safer?, *American Journal of Public Health*, 77, pp. 546–549.

PEACH, H., SHAH, D. & MORRIS, R. W. (1986) Validity of smokers' information about present and past cigarette brands-implications for studies of the effects of falling tar yields of cigarettes on health, *Thorax*, 41, pp. 203–207.

POMERLEAU, C. S., MAJCHREZAK, M. I. & POMERLEAU, O. F. (1989) Nicotine dependence and the Fagerström Tolerance Questionnaire: a brief review, *Journal of Substance Abuse*, 1, pp. 471–477.

POMERLEAU, C., POMERLEAU, O. F., MAJCHREZAK, M. I., KLOSKA, D. D. & MALAKUTI, R. (1990) Relationship between nicotine tolerance questionnaire scores and plasma cotinine, *Addictive Behaviors*, 15, pp. 73–80.

RICKERT, W. S. & ROBINSON, J. C. (1981) Estimating the hazards of 'less hazardous cigarettes', II. Study of cigarette yields of nicotine, carbon monoxide and hydrogen cyanide in relation to levels of cotinine, carboxyhemoglobin and thiocyanate in smokers, *Journal of Toxicology and Environmental Health*, 7, pp. 391–403.

ROBINSON, J. C., YOUNG, J. C. & RICKERT, W. S. (1981) A comparative study of the amount of smoke absorbed from low yield (less hazardous) cigarettes. Part one—non-invasive measures, *British Journal of Addiction*, 77, pp. 383–398.

STEPNEY, R. (1982) Are smokers' self-reports of inhalation a useful measure of smoke exposure?, *Journal of Epidemiology and Community Health*, 36, pp. 109–112.

US DEPARTMENT OF HEALTH AND HUMAN SERVICES (1988) *The health consequences of smoking. Nicotine Addiction: A Report of the Surgeon-General* (Rockville, MD, US DHSS).

US PUBLIC HEALTH SERVICE (1979) *Smoking and health: a report of the Surgeon-General* (Washington, DC, US Department of Health, Education and Welfare).