ASSESSMENT OF SMOKING BEHAVIOR

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The nature of smoking risk is first reviewed and a classification of procedures for assessing smoking behavior is presented. Areas requiring assessment include not only the traditionally measured smoking rate, but also the substance used and topography of consumption. Each of these areas may be assessed through a variety of self-report, observational, or indirect techniques. These techniques as well as some of their advantages and disadvantages are presented. Recently published (1975 to mid-1978) data-based smoking research appearing in four journals (*Addictive Behaviors*, *Behavior Therapy*, *Journal of Applied Behavior Analysis*, and *Journal of Consulting and Clinical Psychology*) is then reviewed with respect to measurement reliability and the use of multiple measures. Results show a strong tendency to assess only the risk area of smoking rate and a low frequency of appropriate measurement reliability checks, especially during baseline and treatment phases. Some of the implications of these results are discussed.

DESCRIPTORS: assessment, smoking behavior, methodology

The applied significance of smoking behavior is hard to overestimate. Cigarette smoking has been found to be responsible for roughly 325,000 deaths each year from cancer of the lung, bladder and oral cavity, cardiovascular disorders, including coronary heart disease (CHD) and atherosclerosis, and pulmonary diseases such as chronic obstructive pulmonary disease (COPD), bronchitis, and emphysema (USPHS, 1975, 1977, 1979). Smoking is directly linked to approximately 90% of all lung cancer, 30% of all atherosclerosis, 75% of all bronchitis, and 80% of all emphysema (USPHS, 1977). Further, it is associated with a decrease in exercise tolerance, especially in angina patients (Aronow, 1973), fetal damage, CHD sudden death, and impaired survival rate in patients with acute myocardial infarction (Goldsmith and Aronow, 1975). The economic costs of smoking are equally staggering. It is esti-

lated that smoking is related to over one-tenth of the total hospital and medical expenses in the United States, with the combined cost of smoking-related sickness and decreased productivity (lost work output and absenteeism) raising this total into the billions of dollars (USPHS, 1977). In addition, the health risk to nonsmokers (*e.g.*, passive smoking) may also be significant, especially if there is a preexisting cardiovascular or pulmonary condition (USPHS, 1975). Taking these, and other facts into account, the World Health Organization has concluded that the control of smoking is the single most important preventive health measure that developed nations can take (WHO, 1975).

The control of smoking risk is clearly an important goal, but it is by no means an easy one to achieve. Recent literature reviews have consistently concluded that smoking treatment is characterized by good initial success but very high rates of "relapse" (Bernstein and McAlister, 1976; Frederiksen and Simon, 1979; Lichtenstein and Danaher, 1976). However, these same reviewers also conclude that a behavioral approach to the analysis and modifi-

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cation of smoking behavior is likely to be the most productive. Not only are behaviorally based techniques as effective as any other approaches (see above reviews), but an applied behavior analytic approach also provides a systematic framework and methodology for the analysis of variables controlling smoking behavior. However, central to the success of any approach is the development and use of comprehensive assessment techniques and strategies (*cf.* Epstein and McCoy, 1975).

The current paper will focus on issues relevant to the comprehensive assessment of smoking behavior *per se* (as contrasted to situational variables that may influence smoking). As a first step, the nature of smoking risk and its implications for the assessment of smoking behavior will be reviewed. The range of assessment procedures that have been or can be used to monitor some aspect of smoking behavior will then be presented. These procedures will be placed within a consistent framework that covers areas of smoking risk as well as the procedures that can be used to assess each area. In addition, some of the practical and methodological considerations in the use of these procedures will be summarized. Next, some of the current assessment practices employed in recently published (1975 to mid-1978) data-based smoking studies from four selected journals will be reviewed with regard to measurement reliability and to the use of multiple assessment techniques. Finally, some of the implications of these results for the assessment of smoking behavior will be discussed.

On the Nature of Smoking

The procedures used in the assessment of a behavior must, of course, flow from an understanding of the nature of the behavior itself. For some behaviors the rate of occurrence is the primary datum of interest. In other circumstances the response topography assumes critical importance. To understand the important parameters of "smoking behavior," we must

first consider the nature of smoking. While there may be moral or aesthetic objections to smoking, it is clear that the overwhelming problem with this behavior is one of health risk.

The health risks associated with smoking are due mainly to two classes of elements in cigarette smoke, particulate matter and gases. The most harmful particulate substances are "tar," the probable carcinogen and compound most responsible for lung tissue damage (*e.g.*, COPD), and nicotine, an apparent contributor to atherosclerotic cardiovascular disease (USPHS, 1975). But total particulate matter forms only 10% of the tobacco smoke; the remaining 90% consists of a number of gases, the most harmful of which is carbon monoxide (CO) (USPHS, 1977). Carbon monoxide, an odorless, colorless, asphyxiant gas resulting from incomplete combustion of the tobacco, is felt to be the agent most responsible for the cardiovascular diseases (*e.g.*, CHD, atherosclerosis) associated with smoking (Aronow, 1973; Wald and Howard, 1975).

Smoking risk has frequently, though not universally, been related to the *dose* of these harmful elements (USPHS, 1975, 1977, 1979). That is, the greater amount of tar, nicotine, and CO introduced into and retained by the body, the greater the health risk thought to be assumed by the smoker. Dosage has typically been assessed by calculating the rate of smoking. However, the analysis of rate alone is incomplete. Tobacco products differ widely in their yields of tar, nicotine, and harmful gases such as CO. Smoking a pack of low tar, nicotine, and CO cigarettes is quite probably not equivalent to smoking the same number of high tar, nicotine, and CO cigarettes (USPHS, 1975, 1977, 1979). Further, the way in which a person smokes (smoking topography) is also important. For example, two smokers may smoke the same brand of cigarettes, at the same rate, but differ markedly in the topography of consumption. One smoker may take three times as many puffs, each of which are twice as long and inhaled deeply. These two smokers would clearly not

suffer the same health risk (USPHS, 1975, 1977, 1979). Likewise, they are likely to be exposed to differing doses of nicotine, a substance which some investigators feel is critical to the maintenance of smoking (Gritz, Baer-Weiss, & Jarvik, 1976) and is consequently an important consideration in the functional analysis of smoking behavior.

It is also important to remember that these three components (substance, rate, and topography) *interact* to produce their effect. Changes in one component may result in positive, negative, or little change in other components (*cf.* Frederiksen and Martin, 1979). The net effect of any change must be assessed and not assumed. Behavior analysis techniques are especially appropriate in the systematic evaluations of these potential interactions.

If it could be assumed that intervention would result in smoking abstinence maintained over time, it could be argued that simply measuring smoke rate would be adequate for assessing treatment effects. Unfortunately, the long-term maintenance of treatment effects with smoking behavior is largely unknown. The evidence that is available is anything but universally positive (Bernstein and McAlister, 1976; Frederiksen and Simon, 1979; Lichtenstein and Danaher, 1976). In short, it has *not* been demonstrated that smokers remain at zero smoking rate following treatment. On the other hand, it would be a mistake to consider every individual still engaging in smoking behavior following treatment as a "failure." These individuals' smoking rates, topography, and/or substance may have changed in such a way as to reduce overall health risk. Considering that most smokers will not be abstinent following therapy and that rate alone is an inadequate measure of health risk, it follows that an adequate assessment of smoking behavior must be comprehensive, that is, the assessment must consider what is smoked (substance), the way in which it is smoked (topography), and the frequency of consumption (rate). Within each of these three areas the use of self-report, observational, and

indirect measurement procedures will be considered.

MEASUREMENT PROCEDURES

Smoking Rate

Smoking rate refers to the number of cigarettes (or other units) smoked within a predefined time interval. Although this general computational formula has been relatively uniform, methods for estimating cigarette frequency as well as the time intervals used to compute rate have differed across studies. Three general classes of procedures have been used to estimate cigarette frequency: self-report, observational measures, and indirect measures.

Self-report. Self-report includes all techniques in which smokers record their smoking rate. In a review of 40 behavioral studies on smoking reduction, Frederiksen and Simon (1979) found that approximately 95% used some form of self-report. The popularity of self-report is probably derived from the fact that the smokers are in the best position to monitor their smoking behavior in a variety of situations and over time.

The simplest self-report rate measure is the questionnaire. With this technique, smokers are asked to estimate the number of cigarettes they typically smoke per unit time using past behavior as the primary reference. Questionnaire information has been used in survey research (Eiser and Sutton, 1977) as a prebaseline rate measure for subject assignment, to evaluate the effects of other monitoring methods (McFall and Hammen, 1971; McFall, 1970) and as a follow-up method in smoking control research (Delahunt and Curran, 1976; Lando, 1975a). It has the advantages of being an easy, efficient, and minimally restrictive procedure for gathering data. However, questionnaires rely on retrospective self-assessments, thus raising questions about the accuracy of the obtained data. Such reports are open to bias, distortion, or deliberate falsification.

A second self-report measure is self-monitoring. This procedure requires two distinct behav-

iors. The subject must first discriminate the occurrence of the target behavior, *e.g.*, smoking. This discrimination must then be recorded in some way. Measurement error may, of course, enter into either (or both) of these steps. Recording procedures have differed on a number of potentially important dimensions including: (a) the nature of information recorded, *e.g.*, number of cigarettes smoked (Barton and Barton, 1978; Lando, 1975a; McFall, 1970), time of each cigarette (Delahunt and Curran, 1976; Frederiksen and Frazier, 1977; McGrath and Hall, 1976), situational factors associated with smoking (Brockway, Kleinmann, Edleson, and Gruenewald, 1977; Dericco, Brigham, and Garlington, 1977; Epstein and Collins, 1977), (b) the nature of the recording device, *e.g.*, wrist counters (Chapman, Smith, and Layden, 1971; Katz, Heiman, and Gordon, 1977), pocket counters (Levinson, Shapiro, Schwartz, and Tursky, 1971), index cards (Gordon and Hall, 1973), booklets (Lando, 1975a; Marston and McFall, 1971) and slips attached to cigarette wrappers (Brockway *et al.*, 1977; McGrath and Hall, 1976), (c) the timing of recording, *e.g.*, prior to lighting up (Frederiksen, Epstein, and Kosevsky, 1975; Rozensky, 1974), (d) the schedule of recording, *e.g.*, continuous, daily, or weekly (Frederiksen *et al.*, 1975), and (e) the schedule of returning data to the experimenter, *e.g.*, daily (Frederiksen and Simon, 1978a), weekly (Danaher, 1977; Katz *et al.*, 1977), or longer (McFall, 1970; Norton and Barske, 1977). It seems clear that variations in recording requirements and scheduling hold much potential for differential control of self-monitoring accuracy and reactivity as previous research has already demonstrated (*e.g.*, Frederiksen *et al.*, 1975; McFall, 1970; Rozensky, 1974). The advantages of the self-monitoring procedures include their flexibility (in terms of what can be recorded) practically (low in cost and easy to use for the experimenter), and potential accuracy. However, although these procedures may be practical for the experi-

menter, they may be burdensome (high response cost) for the subject. Such response cost may lead to decreased smoking ("reactivity") or it may simply lead to decreased recording accuracy (or even increased subject attrition). In the absence of some assessment of self-monitoring accuracy it is difficult to tell which is the case. Thus, self-monitoring procedures hold much potential, but they cannot simply be taken at face value.

Observational measures. Direct observation in the subject's natural environment has, of course, been one of the hallmarks of a behavior analytic approach. The benefit of representativeness is clear, but observation of smoking presents a number of practical problems. For the most part, direct observational approaches have involved the recording of the subject's smoking behavior by a participant observer (informant). Probably because it is virtually impossible for such an observer to consistently record the subject's behavior 24 hours per day, observational measures have been used primarily as a reliability check for self-monitoring data. The training of such observers has varied from highly skilled "professional staff" (Frederiksen and Simon, 1978b) to minimally trained friends of the subject (Best, 1975; Katz *et al.*, 1977; Lando, 1977). Unfortunately, there are virtually no data available on the relative accuracy of the various observers or any potential reactivity that might be associated with the observation procedure. An alternative which sidesteps this issue somewhat is to conduct observations in a controlled laboratory setting. While one may gain greater accuracy, the representativeness of the sample may be questioned.

Indirect measures. These measures are supposedly either correlated with consumption or are by-products of smoking. Examples include a specially designed cigarette case that advances a counter each time the case is opened (Azrin and Powell, 1968; Powell and Azrin, 1968), a cigarette store run by experimenters from which the subjects are instructed to buy all cigarettes

(Frederiksen *et al.*, 1975; Marston and McFall, 1971), and the use of a neighbor or family member participant observer who would check the number of cigarettes in the subject's possession in the morning and in the evening, then derive the subject's rate by subtracting the difference (Conway, 1977).

Relatively new and promising indirect procedures have involved the analysis of chemical by-products of smoking. For example, CO has been measured in either expired alveolar air (COa) (Horan, Hackett, and Linberg, 1978; Hughes, Frederiksen, and Frazier, 1978; Lando, 1975*b*), or blood samples (COHb) (Frederiksen and Martin, 1979; Norton and Barske, 1977). Additionally, thiocyanate (SCN) which is in tobacco has been shown to be related to smoking rate (Brockway *et al.*, 1977; Vogt, Selvin, Widowson, and Hulley, 1977). Thiocyanate can be collected from blood urine or saliva samples (Brockway, 1978). While blood SCN samples have been more typically employed, recent data (Prue, Martin, and Hume, Note 1) indicate that saliva SCN may be the superior sampling method due to its apparently greater sensitivity, stability, and relative freedom from drawbacks such as the invasiveness of blood sampling. One disadvantage of saliva SCN assessment is that it may reflect SCN levels of foods consumed which contain cyanate compounds. Another biochemical procedure that can be used for validation of smoking pattern is nicotine analysis (*e.g.*, Gritz *et al.*, 1976). This can be accomplished through the assessment of nicotine or its metabolite, cotinine. The specific advantages and disadvantages of these procedures vary from measure to measure. However, as a group the physiological measures have the advantage of objectivity and, in most cases, direct relevance to health risk (*e.g.*, CO) and/or the functional analysis of smoking behavior (*e.g.*, nicotine). The disadvantages generally lie in the areas of obtrusiveness and high cost. Further, a measure may be affected by a variety of parameters other than simply the smoking rate (*e.g.*, time

since last cigarette, brand used, consumption of certain foods).

Still another form of indirect monitoring is unobtrusive measurement, which requires that the subjects be totally unaware of when and how their behavior is being monitored. There have been only a few reports of unobtrusive measurement to date. Auger, Wright and Simpson (1972) collected cigarette butts to estimate rate in certain locations. Other suggested methods have included detection of cigarette burns on clothing or fingers, yellow stains on teeth or fingers, and the use of deception by having a confederate offer the subject a cigarette (Frederiksen and Simon, 1979). Although the unobtrusiveness of these procedures is probably a plus from the point of reactivity, they are generally untried procedures of unknown accuracy.

Substance

Substance variables include the class of smoking material (cigarette, pipe, cigar), as well as the brand of tobacco product consumed (*e.g.*, filtered, Brand X). Assessment of these substance variables may be conducted using self-report, observational, and indirect measurement procedures.

Self-report. Self-report of substance used may be obtained either retrospectively or continuously. Retrospective data usually involve answering a question such as: "What brand have you been smoking in the last month?" Continuous or systematic self-monitoring consists of the smoker recording substance at each use of tobacco use. Although retrospective self-report is typically used (*e.g.*, Berecz, 1976), some recent work has incorporated continuous self-monitoring of substance variables (*e.g.*, Frederiksen, Note 2). The accuracy of self-report has generally gone unassessed, but it may be argued that individuals can probably report this variable accurately unless they are frequently switching substances. In some circumstances (*e.g.*, contracting for a sub-

stance change) falsification may also be a problem.

Observational. These methods of assessing substance include direct observations of consumption of the tobacco product. This can be done either in a laboratory or other controlled setting, or in the natural environment. This type of substance assessment is generally overlooked in favor of self-report measures, although it has been used in conjunction with self-report of substance in some laboratories (*e.g.*, Frederiksen *et al.*, 1977). This procedure can serve as a convenient and unobtrusive check on the accuracy of self-reports.

Indirect. Measurement by indirect methods consists of assessment of smoking by-products. For example, cigarette butts or discarded pipe tobacco containers can be collected, or the experimenters or informants can observe what type of tobacco product the individual carries (*e.g.*, Martin and Frederiksen, Note 3). Under the right conditions, such measurement may be unobtrusive, thereby minimizing measurement reactivity. Such procedures can also be very practical and easy to use.

Topography

A third important area is the manner in which the person smokes, or smoking topography (Frederiksen *et al.*, 1977). Although there is potentially a wide range of topographical components that could be assessed, a number of specific variables have already been defined. They include puff frequency (number of times that a cigarette is in contact with smoker's lips and flaring), puff duration (duration of each puff), inter-puff interval (time between puffs), amount of tobacco used (difference between weight of tobacco before and after the smoking episode; may also be expressed as percentage of total tobacco weight consumed), cigarette duration (elapsed time between lighting and extinguishing the tobacco product), puff volume (total volume of air and smoke inhaled into the smoker's lungs; see Robinson and Forbes, 1975,

for one procedure), puff intensity (puff volume divided by puff duration), and puff distribution (location on cigarette where each puff was taken, *i.e.*, proximal or distal end). As in rate and substance assessment, the different components of smoking topography may be assessed either through observational, self-report, or indirect measurement procedures.

Self-report. These measures of smoking topography may be obtained through procedures similar to those discussed for self-report of substance and rate. Retrospective self-report has been observed for depth of inhalation (Russell, Wilson, Patel, Cole, and Feyerband, 1973; Vogt, 1977) number of puffs and amount of tobacco used (*e.g.*, Vogt, 1977). While this sort of self-report is easy to obtain, there are virtually no data to support its accuracy. Quite the contrary, data from our own laboratory tend to indicate that smokers are poor observers of their own smoking topography (Martin and Frederiksen, Note 3). Continuous self-monitoring has been used for number of puffs, cigarette duration, and amount of tobacco used (Frederiksen, Note 2). Here again the accuracy and/or reactivity of this procedure remain unknown. Further, some variables, *e.g.*, puff volume, may only be estimated in the absence of sophisticated apparatus.

Observational. Direct observation of smoking topography has been largely confined to laboratory settings (Frederiksen *et al.*, 1977; Frederiksen and Simon, 1978a; Robinson and Forbes, 1975). The laboratory setting allows for precise control of stimulus condition and the use of instrumentation, *e.g.*, videotape, timers. These advantages must be balanced against the possibility of unrepresentativeness of a laboratory sample. Unfortunately, this latter point has not been systematically researched. The other alternative is *in vivo* observations. Unobtrusive observations in the smoker's natural environment have also been reported (Frederiksen and Simon, 1978b). This particular single-case study used unobtrusive observations of puff frequency, puff duration, and cigarette duration as measures of

response generalization concomitant with treatment. Such *in vivo* assessments are possible, however, they are probably practical only for research purposes.

Indirect. Weighing the cigarette before and after smoking provides an indirect measure of amount of tobacco used. This is important for two reasons. First, it allows an estimate (albeit crude) to be made of the harmful tobacco constituents that entered the smoker's body. Second, it allows an estimate of the smoke that circulates in the smoker's environment, which may add to both the smoker's health risk and to that of nonsmokers in the vicinity (Frederiksen and Martin, 1979; USPHS, 1975).

A second class of indirect measures are the acute physiological effects of tobacco consumption on the smoker. The analysis of alveolar carbon monoxide (COa) (Hughes *et al.*, 1978) preceding and following smoking can provide meaningful data as to the relative harmfulness of specific smoking styles. For example, Frederiksen and Simon (1978a) and Martin and Frederiksen (Note 3) have assessed COa as a function of varying puff durations, puff frequencies, and cigarette durations. Robinson and Forbes (1975) have also looked extensively at the relative health risks of different smoking topographies, principally puff volume and puff intensity, using COa, tar, and nicotine analysis. Analysis of nicotine uptake as a function of puff distribution and frequency (Gritz *et al.*, 1976) has also been conducted using urine samples and gas chromatography assays. Thiocyanate and cotinine analysis comprise two additional biochemical measures which may be used to reflect tobacco exposure as a function of varying smoking topographies. The limitations of the physiological assessment procedures are somewhat specific to each measure. However, in general these measures are obtrusive, influenced by multiple parameters of smoking behavior, sometimes highly variable (*e.g.*, nicotine), and may be expensive to obtain. On the other hand, they tend to be objective and potentially useful as a source of feedback to the smoker on the

level of smoking exposure and consequent health risk.

ASSESSMENT IN CURRENT SMOKING RESEARCH

In the first section of this paper the importance of a comprehensive approach to smoking assessment was emphasized and a range of techniques that can be used were presented. In this second section the specifics of current assessment efforts in recently published smoking research will be reviewed.

Measurement Reliability

Some assessment of the reliability of measurement is a basic requirement. This is especially true when the data in question are subject to easy falsification (*e.g.*, self-monitoring). Reliability checks should be distributed throughout all experimental phases. Further, the procedures used in calculating any reliability coefficients should be reported along with the coefficient itself. The specific variables assessed were (1) frequency and distribution of reliability checks, (2) reporting of coefficient calculation procedures, and (3) reporting of reliability coefficient(s).

Multiple Measures

A second important methodological concern in smoking assessment is the need for multiple measures. An adequate assessment of smoking risk must take into account what is smoked, smoking rate, and the topography of consumption. As the above review indicated, it is also possible to assess these three areas using multiple procedures (*e.g.*, self-report, observational, indirect). The variables of areas assessed (substance, rate, topography) and procedures used (self-report, observational, indirect) were both scored.

Sampling Procedure

Four journals, publishing smoking research, were sampled: *Addictive Behaviors* (AB), *Be-*

havior Therapy (BT), *Journal of Applied Behavior Analysis* (JABA), and *Journal of Consulting and Clinical Psychology* (JCCP). The sample consisted of all data-based studies published between January 1975 and August 1978. Reviews of the literature or discussion articles presenting no new data were excluded from consideration. This 3½-year sample included a total of 30 data-based studies.

Two masters level research assistants randomly divided the identified studies and independently scored them on the variables described above. The research assistants were aware that the reliability of their scoring would be assessed later. Following the completion of the original scoring, 6 of the 30 studies (19%) were randomly selected for independent rescoring by the other assistant. The only sampling constraint was that at least one study be selected from each journal for rescoring.

An observation consisted of each instance of the variables listed above. An agreement was scored if both observers agreed that a particular variable was reported in a study or agreed on a specific quantity reported. A disagreement was scored if one observer reported that a variable was reported and the other did not, or if there was any discrepancy on reported quantities. Percentage of agreement was calculated as $\text{agreement} / (\text{agreements} + \text{disagreements}) \times 100$. The percentage of agreement was 100% for each of the five variables.

RESULTS

The greatest number of articles (12) were contributed by AB and JCCP, while BT contributed 5 and JABA contained the fewest with only a single study. Treatment-oriented articles were much more prevalent (70%) than other types of data-oriented studies, although the proportions were equal in AB and close in BT.

Measurement Reliability

Only 18 of the 30 studies (60%) reported any attempt to assess measurement reliability.

Of these 18 studies, 12 (67%) attempted to check reliability during posttreatment only. Put another way, only 6 of the 30 studies sampled (20%) attempted to assess measurement reliability during either baseline or treatment phases. When reliability was checked, it was typically through some sort of corroboration (either by informant report or physiological measurement) of reported abstinence (13 of 18 studies, 72%). In only 5 of 18 studies (28%) was an actual coefficient of reliability reported. In all five of these reports, some variant of percentage of agreement was employed.

Multiple Measures

The case for multiple measures extends to both the assessment of multiple risk areas (substance, rate, and topography) as well as the use of multiple assessment procedures or "channels" (self-report, observational, indirect). With respect to risk areas, 24 of 30 studies (80%) assessed smoking rate only. The remaining 6 studies (20%) were equally divided among assessing rate and substance (2 studies), rate and topography (2 studies), and rate, substance, and topography (2 studies). Thus, whereas all 30 studies assessed the risk area of smoking rate, only 6 (20%) assessed at least one other risk area.

With respect to assessment channels used, 28 of the 30 studies (93%) employed some form of self-report of smoking rate. Of these 28 studies, 10 (36%) used self-report alone, 14 (50%) employed self-report and observational measures, and 4 (14%) used both self-report and indirect measures. The risk area of substance was assessed in 4 studies (14% of the total sample). In three of these studies observational measures were employed whereas the fourth study used a self-report measure. Of the four studies reporting topography (14% of the total sample), two used self-report channels, one used an observational measure of topography, and one employed both observational and indirect measures of topography.

DISCUSSION

In the present paper we have presented the case for comprehensive assessment of smoking through the use of multiple risk area and multiple procedure measurement. The importance of a thorough behavioral analysis of the variables relevant to smoking behavior and health risk due to smoking cannot be overestimated. Whether smoking is viewed from either a health risk or a behavioral analysis standpoint, systematic and consistent assessment of substance and topography variables along with smoking rate is critical. Yet our review of smoking research demonstrates that the measurement of multiple risk areas is a rare event, occurring in only 20% of the studies reviewed. Further, only two studies (7% of the sample) assessed at least one variable from each risk area. Clearly the modal practice is the assessment of smoking rate alone. This is indeed unfortunate because the assessment of substance (*i.e.*, brand smoked) is not significantly more difficult than the assessment of smoking rate. The assessment of topography, at least in a laboratory setting, is also a relatively simple procedure.

As the first section of this paper indicated, each risk area (substance, rate, topography) can be assessed through multiple procedures or "channels" (self-report, observation, indirect measures). To a certain degree methodological and practical weaknesses in one channel can be compensated for by strengths in another approach. Such multiple channel assessment could have a beneficial impact on our overall methodology. The clearest example of the potential of this approach is the use of informant reports and/or physiological assessment to "validate" self-reported smoking rate. Yet even this single practice is not followed in over a third of the studies reviewed. The logically recommended practice of multiple channel assessment in multiple risk areas is essentially unused.

The use of multiple measures is, of course, not without drawbacks. Multiples measures add significantly to the costs and complexity of as-

essment. One might argue that if the ultimate goal of an intervention is total abstinence (a zero smoking rate) then the measurement of smoking rate alone is sufficient. In many ways this argument seems to have guided our previous measurement efforts. However, such an argument is unsound. First, many smokers do not achieve permanent abstinence; second, and perhaps more significantly, it ignores the importance of a functional analysis of variables controlling smoking behavior. Smoking is *not* a dichotomous variable. Smokers vary on a number of dimensions that are not adequately assessed by a smoking/nonsmoking distinction or the simple analysis of smoking rate. A smoker consuming one pack of ultra-low nicotine cigarettes, and taking very brief puffs does not uptake the same amount of nicotine as another smoker consuming one pack of high nicotine cigarettes, at ten deep puffs per cigarette. Equating these individuals by labeling them both as "smokers" or even specifying their individual rates of one pack per day ignores a host of variables (*e.g.*, nicotine uptake, CO uptake, "tar" uptake) that may be critically important from both a functional analysis and health risk standpoint (Frederiksen and Martin, 1979; Frederiksen and Simon, 1979).

A second concern with the use of multiple measures is that two measures may point to disparate conclusions. For example, one measure of smoking rate may point to a consumption pattern of 20 cigarettes per day while the other measure indicates a rate of 27 cigarettes. On one level this dilemma can be addressed by the *a priori* establishment of one of the measures as the "primary" datum for that parameter and the concomitant analysis of the other measure as a "secondary" measure. However, on a more basic level, these disagreements become an important topic for research in and of themselves. Historically there has been a conspicuous lack of research on the important topic of the assessment of smoking behavior. A related point has to do with the practice of employing one measure of a variable during one phase of the study

then switching to another measure during subsequent phases. For example, an investigator may employ continuous self-monitoring during the baseline and treatment phases of a study only to rely on retrospective self-reports perhaps obtained via telephone or mail, during follow-up. Such a practice introduces unnecessary bias and should be avoided.

The assessment of measurement reliability at least once in every condition has been an important practice in behavioral research. However, only 60% of the studies attempted to check measurement reliability at all, and of those only a third employed reliability assessment in the baseline or early treatment phases. When reliability is checked, it is typically some sort of corroboration of reported abstinence; other checks have been considered "nice but not necessary." Needless to say, such an approach is unlikely to facilitate accurate measurement.

In reviewing current practices in the behavioral assessment of smoking, it becomes clear that there is a need for improvement. Particularly striking is the excessive reliance on poorly validated self-report of smoking rate as the primary datum. Clearly, smoking rate is an important risk-related behavioral variable, but it is only a part of the picture. What is smoked and the topography of consumption are also critical considerations. Of equal concern is the widespread failure to systematically collect data on the reliability of the subjects' self-report, particularly during baseline and treatment phases. One can, of course, maintain that the studies reviewed are unrepresentative of current assessment practices. However, this seems unlikely. A recent (but less detailed) examination of measurement procedures in smoking modification research (Frederiksen and Simon, 1979) led to essentially the same conclusions as the current review.

Some Recommendations

The assessment of smoking behavior is clearly an area in need of considerable refinement. It

is vital that future research be directed toward such basic assessment issues as the development of new approaches, evaluating the accuracy and reactivity of various current measurement procedures, and determining the important interrelationships. However, even in the absence of such research on smoking, there are immediate steps which can be taken:

1. The assessment of smoking behavior should include measures of rate, substance, and topography. At the present time probably the best compromise assessment package would involve the continuous self-monitoring of rate (possibly with daily mail-in of data), self-report of substance, and the laboratory-based observation of topography (occurring at least once in each experimental phase). This approach is probably not significantly more difficult than current "rate only" procedures, yet it adds important information.

2. The assessment procedures should be held constant throughout all phases of the study (baseline, treatment, and follow-up). For example, the experimenter should avoid switching from continuous self-monitoring during baseline and treatment phases to retrospective self-report during follow-up. By the same token, the experimenter should hold constant the procedures used to gather reliability data.

3. The reliability of each of the measures should be assessed during each phase of the study. If possible, multiple measures of each of the areas (rate, substance, topography) should be collected on a continuous basis. In the absence of continuous reliability measurement, occasional "checks" can be employed. At the present time the use of participant observers and/or indirect measures may be the most practical procedures.

4. When possible, physiological measures should be included. CO seems particularly useful in this respect given its objectivity, sensitivity to experimental manipulation, and potential as a source of client feedback (*cf.* Frederiksen and Martin, 1979). In addition, saliva SCN appears to show great promise as a check on smoking

rate, and in the assessment of degree of tobacco exposure, and health risks (Prue, Martin, and Hume, Note 1).

In the introduction to this paper we argued that applied behavior analysis has much to offer the area of smoking research, from a methodological as well as treatment perspective. Yet the weight of the data clearly indicates that this potential is unrealized. In an area where comprehensive measurement procedures are both critical and available, their use is a low-frequency occurrence. Indeed, even some of the most basic requirements for sound measurement are widely ignored. This need not be the case. Applied behavior analysis can likely have an important impact on smoking-related problems, and the comprehensive assessment of smoking behavior is the place to start.

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