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MEASURING DEGREE OF PHYSICAL DEPENDENCE TO TOBACCO SMOKING WITH REFERENCE TO INDIVIDUALIZATION OF TREATMENT

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Abstract-The validity of the Tolerance Questionnaire, intended to measure physical dependence to nicotine, was tested in three experiments. The indicators of physical dependence employed in the three experiments were (1) A withdrawal response defined as change in body temperature, (2) Degree of acquired increase in tolerance defined as heart rate increase for regular smokers while smoking a cigarette and (3) Initial tolerance defined as heart rate increase For ex-smokers while smoking a cigarette. Significant correlations between physical dependence, as measured by the Tolerance Questionnaire, and degree of acquired increase in tolerance and the temperature withdrawal response was round. The results suggest that smokers' degree of physical dependence can be estimated. Its significance for individualizing smoking withdrawal treatment is subsequently discussed.

Working at a smoking withdrawal clinic one comes in contact with many types of smokers whose sole common denominator is their inability to stop smoking on their own. A fairly consistent proportion of individuals seeking help (around 30% at a 1 yr follow-up) can stop smoking regardless of the type of smoking withdrawal treatment or consultation given (e.g. Hunt & Matarazzo, 1973). In the long run there are seldom more than 35–40% who manage to remain abstinent. In spite of the enormous scientific efforts during recent decades, the clinician's armamentum in smoking withdrawal has not improved much. Research usually centers around group studies which evaluate specific methods on representative categories of subjects. Instead it would be more fruitful to tailor the consultation or treatment to each individual. This strategy has been found successful with alcoholics (Hunt & Azrin, 1973; Sobell & Sobell, 1973; Sobell *et* al., 1976). Conducting such research is much more complex, however, and the number of variables which can be manipulated has swamped many a beginning investigator.

One organism variable which is relevant in individualized programming of smoking cessation is the degree of physical dependence exhibited by the smoker, which can be defined "as a state produced by chronic drug administration, which is revealed by the occurrence of signs of physiological dysfunction when the drug is withdrawn; further, this dysfunction can be reversed by the administration of the drug" (Schuster & Johanson, 1974). The physical dependence, which is by no means simple to disentangle from psychic dependence, has been observed by many smoking withdrawal clinicians and smokers, and clearly touched upon in studies such as Kozlowski ***et al.*** (1975) and Schachter (1977) where it was shown that some, but not all smokers could regulate their nicotine intake when the nicotine content in cigarettes was manipulated without their knowledge.

The distinction between physical and psychic dependence does not necessarily imply that it is more difficult for the more physically dependent smoker to quit the habit, but rather that the nature of the consultation might be affected if it were possible to measure this variable before treatment is begun.

Exploratory observations from the Uppsala County's Smoking Withdrawal Clinic gave rise to the hypothesis that individuals who were more physically dependent were less successful in giving up smoking when treated in a particular manner.

With the purpose of testing a questionnaaire (The Tolerance Questionnaire) intended to measure physical dependence to nicotine, a series of three studies was designed.

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Since validation of the criterion per se, physical dependence, is impossible, different indicators of physical dependence was used. In the first study physical dependence, as measured by The Tolerance Questionnaire, was studied in relation to a withdrawal response, body temperature. It was assumed that the well known changes in peripheral temperature as an effect of smoking (e.g. Auge, 1973; Larsson *et* al., 1961) in some way communicate with the more internal temperature of the body. Since internal body temperature is more stable and easier to record it was preferred. Body temperature has also been found to be affected in the early phase of abstinence to drugs such as opiates and barbiturates (Maynert, 1968). In the second study, acquired increased tolerance (Kalant *et al.*, 1971) among regular smokers was employed as an indicator of physical dependence. and in the third study, initial tolerance (Kalant *et* al., 1971) among ex-smokers was employed as an indicator of physical dependence. As dependent variable in studying acquired increased and initial tolerance autonomic activation was used. operationalized as heart rate (HR) acceleration since many researchers, around 90 publications. have found increases in HR following smoking (e.g. Herxheimer *et al.*, 1967; Mathers *et al.*, 1949: Roth. 1956).

EXPERIMENT I

Method

Subjects

Twenty-six subjects. 9 men and 17 women. participated in the experiment. On the average they had smoked 23 yr ranging from 9 to 41 yr. Their mean age was 39, ranging from 24 yr to 60 yr. Their mean cigarette consumption was 21/day. All subjects were clients at a smoking withdrawal clinic.

Procedure

Measurement of physical dependence. As independent variable eight questions about the smoking habits were formulated (The Tolerance Questionnaire). The questions were formulated according to the principles of addiction and seemed to have face validity to physical dependence of the drug studied.

The Tolerance Questionnaire

1. How many cigarettes a day do you smoke? (It was assumed that high frequence of using the drug pointed to more physical dependence.)
2. What brand do you smoke'? (It was assumed that brands which hold a higher dose of' nicotine pointed to more physical dependence.)
3. Do you inhale'? Always Sometimes Never (Making the nicotine more effective by inhalation pointed to more physical dependence.)
4. Do you smoke more during the morning than during the rest of the day? (Smoking more in the morning when the level of nicotine in the body is very low indicated greater physical dependence.)
5. How soon after you wake up do you smoke your first cigarette'? (Smoking almost directly after getting up in the morning was taken as a sign of physical dependence.)
6. Which cigarette would you hate to give up'? (Rating the first cigarette in the morning as the most precious one pointed to physical dependence.)
7. Do you find it difficult to refrain from smoking in places where it is forbidden, e.g. in church, at the library, cinema etc.'? (Little external and relatively more internal stimulus control manifested as frequent urges in e.g. churches pointed to more physical dependence.)
8. Do you smoke if you are so ill that you are in bed most of the day? (Smoking while ill is taken as a sign of physical dependence.)

For scoring instructions see Appendix 1. The questionnaire was mailed to the clients and filled in at home before the first visit to the smoking withdrawal clinic.

Body temperature. The clients' body temperature was recorded within a week before and within two days after smoking termination. The temperature was taken orally (for 1 min) during visits to the clinic with a UNI-TEMP (Bio-Medical Sciences, Fairfield, N.J.). Variations due to time of day and menstrual cycle were taken into consideration.

Results

As an effect of smoking termination half of the 26 smokers showed increase and the other half showed decrease in body temperature. However, when the withdrawal response (defined as difference in body temperature before and after smoking termination) was calculated and correlated with the questionnaire a product-moment correlation coefficient of -0.55 (d.f. = 25, $P < 0.01$) was obtained. This negative relationship means that the body temperature of the more physically dependent smokers tended to decrease upon cessation whereas the less physically dependent smokers showed an increase in temperature. When the subjects were divided at the median, into a more physically dependent and a less physically dependent group, a slight, but insignificant, difference in body temperature before smoking termination was observed, 36.98°C and 36.81°C respectively. After smoking termination the groups had virtually the same temperature, 36.85°C and 36.89°C. The mean value of the difference in temperature pre-post smoking termination was 0.02°C, ranging from −0.8°C to +0.8°C, SD. = 0.33, and the mean score of the questionnaire was 7.16, ranging from 2 to 11, S.D. = 1.90. Since the amount of cigarettes smoked is one possible explanation of the results which can compete with the interpretation in terms of different physical dependence, a partial correlation coefficient was calculated according to Guilford (1956). With amount of cigarettes smoked partialled out, the coefficient was almost the same, -0.54.

Discussion

These results indicate that smokers differ in degree of physical withdrawal upon smoking cessation. They also support the hypothesis that the smokers' degree of physical dependence is detectable with eight simple questions. The data pointed to a slight difference in temperature between more or less physically dependent smokers which disappeared after smoking termination.

The results of this study prompted further testing of the questionnaire in relation to acquired increase in tolerance measured as increase in HR in response to smoking. If the questionnaire is to be useful it has to demonstrate its validity with an indicator which can be obtained before smoking cessation.

EXPERIMENT 2

Method

Subjects

Nineteen subjects, 5 men and 14 women, participated in this study. They had smoked 18 yr (range 5–40) on the average. Their mean age was 36 (range 19-62). The mean cigarette consumption was 19/day. Half of the subjects were clients at the smoking withdrawal clinic, while the other half were personnel at the hospital where the clinic is located.

Procedure

Heart-rate recording. The subjects began the trial by sitting in a chair while a stable HR was established, filling in the questionnaire simultaneously. For measuring HR a detector was placed on the chest and secured with a band around the body. The HR could be continuously recorded by the experimentator on a meter display. The HR value consisted of the mean of the last 5 sec. Acquired increase in tolerance was defined as the peak HR value recorded subtracted by the baselevel HR. The apparatus was a Cardiometer, manufactured by Cardionics AB, Stockholm, Sweden.

Smoking. Once the HR was stable, the subjects proceeded to smoke a cigarette containing 1.2 mg nicotine, with an interpuff interval of 1.5 sec until the cigarette was finished, which took around 165 sec. Observations were made to insure that the subjects inhaled and took puffs of about equal size.

Measurement of physical dependence. For measurement of physical dependence, see Exp. 1.

Results

The correlation coefficient between HR increase and the Tolerance Questionnaire score was -0.69 (d.f. = 18, $P < 0.01$), which means that the more physically dependent smokers had a smaller increase in HR that the less physically dependent. The increase in HR varied between 3 and 33 beats/min. and the average increase was 15.2 beats/min.. S.D. = 8.10. The mean score of the questionnaire was 6.2 ranging from 2 to 10, S.D. = 2.50. As in Exp. 1, the cigarette consumption can be a third variable interfering with the above correlation between tolerance and the physical dependence. When the amount of cigarettes smoked was partialled out (Guilford, 1956) the relationship was somewhat attenuated, -0.58 (d.f. = 18, $P < 0.01$) which still is a clear relationship between the questionnaire and acquired tolerance. There was no correlation between HR increase and the base-level of HR.

Discussion

From the data gathered it seems fairly safe to say that the questionnaire provides a quantitative measure of degree of physical dependence among regular smokers when body temperature and HR increase are employed. An interesting question, which also can further test the questionnaire's credibility is whether or not the above difference in tolerance can be attributed to different initial (congenital) tolerance exhibited by the individual. One way of testing this question could be to experiment with people who have never smoked. However, since non-smokers can not complete the questionnaire, ex-smokers were considered more appropriate candidates. In regards to initial tolerance it is particularly interesting to study the manner in which ex-smokers' tolerance to nicotine is related to the degree of physical dependence they manifested while smoking regularly. In keeping with the results already obtained ex-smokers who scored high on physical dependence on the Tolerance Questionnaire should show relatively minor physiological changes. Such a study would also control for factors due to habituation or other artifacts related to regular smoking in the two experiments described above.

EXPERIMENT 3

Method

Subjects

The 15 ex-smokers included in this study had abstained for a minimum of 3 months. Occasional cigarettes were tolerated if less than once a month. Other forms of tobacco were not allowed. The subjects had been ex-smokers for 4.5 yr on the average, ranging from 3 months to 11 yr. The mean age was 35, ranging from 21 to 48.

Procedure

The procedure was the same as in Exp. 2. Some deviations from Exp. 2 must however be mentioned. It was not possible to test all subjects in the same environment, nor were all subjects able to finish a whole cigarette (a deviation which do not mean so much as the whole HR increase often takes place within the first 5 puffs), and on some subjects the pulse was taken manually on the arm. The depth of the inhalations varied more than in Exp. 2.

Results

The correlation coefficient between HR increase and the questionnaire was -0.40

(d.f. = 14, n.s.) which means that ex-smokers exhibit differences in tolerance which tend to be related to their past smoking patterns. The average HR increase was 26 beats/min, SD. = 10.2, ranging between 17 and 56. The mean score of the questionnaire was 5.7, S.D. = 1.70, ranging from 3 to 10.

Discussion

The results indicate that differences in tolerance may exist long after discontinuing the smoking habit. The result can be interpreted in two ways. First, that the past smoking habits have created different degrees of remaining tolerance or second, that inherited (congenital) factors play a significant role. Personally I adhere to the last interpretation and think of the congenital factors as one of many determinants of the level of preferred drug consumption. The result must be interpreted with caution since the correlation was not significant, partly due to the difficulty of recruiting subjects for the somewhat aversive task, and bad control over the experimental conditions.

GENERAL DISCUSSION

From the above experiments it is evident that smokers and ex-smokers within their groups, show differences in their response to the two indicators of physical dependence, withdrawal response and tolerance. Consistent and significant correlations from these indicators to the questionnaire (intended to measure physical dependence) have been established. For HR increase in experiment 2 about half of the variation can be attributed to the Tolerance Questionnaire. It seems clear that the physically dependent component seen by many writers (e.g. Schachter, 1977) can be approximated by the 8 questions employed here. The advantage with this scale compared to Tomkins (1 966, 1968) addiction factor developed by Ikard *et al.* (1969), which predictive validity have been questioned (Leventhal & Avis, 1976), is the questions focusing on observable behaviours instead of judging degrees of diffuse emotions.

The reasons for the variations in the physiological responses which were measured in these experiments are beyond the scope of this paper to untangle. This task is more appropriate for a pharmacological approach which could discuss the role of the various mechanisms of tolerance and habituation at different levels, whether it be physiological, pharmacological or chemical. It deserves to mention however, that the variations in body temperature should not be looked for only at the central level e.g. hypothalamic regulation. It may well be a peripheral phenomenon, e.g. vasodilation or constriction with increase or decrease in peripheral temperature and corresponding variations in internal body temperature.

It is a sad fact that most of the existing methods considered to be aids in smoking withdrawal are not proven to be more effective than the multitude of flourishing methods. In order to develop clinically more effective programs we should not disregard the existing methods but employ them differentially with each individual according to expectations of effective strategies, the problems encountered, differences in source of motivation and psychic stability, physical dependence etc. The more physically dependent smokers will probably do better with other methods than those which are employed for the majority of the smokers. For carrying out selective treatment of physical dependence it must be measurable before withdrawal starts. The questionnaire can hopefully be of some help in this task. It could also be worth incorporating into clinical withdrawal research since it can probably account for some of the variation in outcome and give hints to which treatment is effective for smokers with different degrees of physical dependence.

The ultimate validity, or let me say utility of the questionnaire has to be demonstrated in a treatment study where the active components are varied according to the principles of drug addiction, while the physical dependence of the subjects are measured. Some of the methods which should be evaluated, are step wise reduction of cigarettes or substituting cigarettes with e.g. nicotine chewing gum.

The precision of the questionnaire is of course far from perfect and could perhaps be improved if observation of the smoking behavior per se and an analysis of the time intervals or stimulus control of the smoking habit was carried out. It is possible that the more physically dependent smokers inhale more deeply, have shorter interpuff intervals, and are not so dependent upon external situations as the less physically dependent. The more physically dependent smokers should relay more on internal cues and smoke with more regular time intervals.

Once an alcoholic, always an alcoholic-once a smoker, always a smoker are phrases often heard, which communicate the warning that if one inhalation of smoke or a drink of alcohol is taken, the old craving is fully reestablished and all means of control are lost. There is not much scientific evidence in favor of those phrases, but on the contrary, if there is a bipolar continuum of rapidly reestablished craving loss of control and its opposite in the other end of the continuum it can be assumed, rather audaciously, that those estimated as highly physically dependent are those most vulnerable.

From the third experiment the author observed that it was the more physically dependent smokers who were most reluctant to take the test of smoking because of the possible danger of becoming a smoker again. One way in which physical dependence could dispose the individual to relapse is through long term derangement of homeostasis following drug withdrawal. In the area of opiate addiction Himmelsbach (1941) reported that the autonomic reactivity of postaddicts is slightly greater than that of normal subjects for over 6 months after withdrawal of morphine. This investigation also found that 4-6 months were required for stabilization of body weight, basal metabolic rate, blood pressure, hematocrit reading, sedimentation rate and specific gravity of the blood. A way of identifying those individuals who will be more likely to smoke heavily and have difficulties in giving up the habit could be to let non-smokers smoke and to measure their initial tolerance via HR increase. It must be kept in mind, however, that physical dependence is only one of several factors that aggravates smoking termination. In spite of the possible utility. such a test could as well do more harm than good by providing them with a first cigarette.

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APPENDIX I

Scoring the Tolerance Questionnaire

Higher points are always given for answers indicating more addiction. In the first question smokers are divided as light -15 cigarettes, moderate 16–25, and heavy 26- smokers. In the second question the brands are classified into three categories with low, medium and high nicotine level. In the third question the frequency of inhalations are divided into three categories. The rest of the questions are scored zero or one, with one point for yes answer on question 4. In the fifth question one point is assigned to smoking within 30 min. In the sixth question one point is assigned for answering "the first cigarette in the morning". The seventh and eighth questions are scored with one point for yes answer.

The questionnaire has a range of 0–1 1 points, with 0 indicating minimum physical dependence and 11 points maximum physical dependence.