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Smoking and Vigilance

The Effects of Tobacco Smoking on CFF as Related to Personality and Smoking Habits

Dick Waller and Sten Levander *

Laboratory for Psychology and Psychophysiology, Department of Psychiatry, Karolinska Hospital, S-104 01 Stockholm, Sweden

Abstract. The effects of tobacco smoking on vigilance (Critical Flicker Fusion, CFF) measured by a computerized forced-choice interactive technique, was studied in a group of 28 male moderate smokers. Subjects participated in a Smoking (S) and a Non-Smoking (NS) condition each of 1 h duration. CFF performance was measured during fifteen 2-min trials in each condition. In the S condition subjects smoked three puffs during each of five pauses between five successive trials. Vigilance was significantly improved by smoking. An initial sharp increase in CFF performance was noticed with a maximum 8 min after the first puff. Performance was significantly higher in the S condition compared to the NS condition up to 20 min after the last puff. Two extreme groups, based on differences in CFF performance between the S and NS condition were compared by questionnaires on personality and smoking habits. The most improved group had significantly higher scores in an extraversion scale. Ratings of the effect of smoking on level of alertness indicated that the objective effect of increased vigilance had no counterpart on the subjective level.

Key words: Tobacco smoking – Vigilance – CFF – Personality – Smoking habits

Studies of the effects of nicotine and tobacco smoking on mental performance in man have yielded inconsistent results. Smoking was shown to counteract the impairment normally occuring over time in monotonous visual reaction time tasks but it did not improve performance above the initial level (Frankenhaeuser et al. 1971). In another study Myrsten et al. (1972) found that smoking improved simple reaction time also in a tense and "loaded" and thus not monotonous situation. Tarrière and Harteman (1964) reported that tobacco smoking prevented deterioration in signal detection tasks requiring sustained vigilance over time. Improvement in reaction time and vigilance is consistent with EEG studies on human subjects indicating that smoking enhances cortical arousal (Ulett and Itil 1969; Philips 1971). On the other hand nicotine tablets impaired performance in a complicated stressful reaction time task used by Warwick and Eysenck (1968). Cotten et al. (1971) also noted a negative effect of smoking on reaction time and Heimstra et al. (1967) found that smoking failed to counteract or alleviate the effects of fatigue during sustained performance in a simulated driving situation.

Measures of Critical Flicker Fusion (CFF), the fusion frequency of flickering light have been used in some smoking studies. This measure reflects the number of impulses that the retinal-cortical system can process in unit time and has frequently been used as an indicator of cortical arousal (Levander and Lagergren 1973). CFF performance is impaired by fatigue, sedative drugs and hypoxia and is improved by stimulant drugs. CFF performance especially if measured repeatedly over time may thus be assumed to indicate degree of vigilance. Inconsistent results concerning effects of tobacco smoking and nicotine have been obtained also in studies of CFF. Improved CFF performance after tobacco smoking has been reported by Larson et al. (1950) and Warwick and Eysenck (1963), and after oral administration of nicotine by Warwick and Eysenck (1963, 1968). Garner et al. (1954) found large individual differences in the effects of smoking on CFF in a group of 55 smokers. Smoking had no effect on CFF in 22 subjects while 20 subjects

* Dr. Sten Levander was responsible for the construction of the computerized technique for CFF measurement and for the adaptation of this technique to the present experiment. Further he initiated and supplied the technology for the infra-red pupillography

Offprint requests to: Dick Waller

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showed an improvement and 10 subjects an impairment in performance. Individual differences in smoking effects on CNS as reflected in EEG have also been found, some subjects showing a stimulant and others a depressant effect (Murphree et al. 1967).

One reason for the inconsistencies may be the complicated dose (Armitage et al. 1969) and phase (Philips 1971) effects of smoking. Another reason may be related to smoking habits. In a study by Myrsten et al. (1975) the effects of smoking on reaction time and on heart rate were associated with the habitual preference to smoke in high versus low-arousal situations. Individual differences in effects of smoking have also been related to personality. A stimulant effect was noted in extravert subjects and a depressant effect in introvert subjects in a study by Ashton et al. (1974). On repetition of the experiment in some subjects the direction of change was consistent.

The main purpose of the present investigation was to examine the influence of tobacco smoking on vigilance as indicated by CFF performance. In earlier studies, the method of limits has been used. This method has however been criticized for being influenced by various non-sensory factors, for instance response bias (Clark 1966). The signal detection procedure recommended by Clark requires a large number of stimulus presentations and is unsuitable for the study of phasic changes in CFF thresholds. In the present study a new CFF method based on a computerized forced-choice interactive technique was used. The theoretical rationale for this psychophysical technique as applied to vernier visual acuity is described in Levander and Lagergren (1973). The method appears to be less sensitive to response bias than the method of limits but still allows estimation of CFF thresholds in short time intervals. The present experiment was designed to allow a precise study of the time course of the effects of smoking by measuring CFF performance in repeated short periods over an hour in a smoking and a non-smoking session. The effects of smoking on CFF were related to self-reported personality variables and smoking habits.

Materials and Methods

Subjects and General Design

The subjects (Ss) were 28 male university students. Their age ranged from 20 – 30 years (mean 24.0). They were all moderate smokers with a mean consumption of 12.8 cigarettes per day, ranging between 7 and 17. All Ss were inhalers. Ss were paid for participating in a Smoking (S) and a Non-Smoking (NS) condition, each of 1 h duration. Ss were tested on separate days in the two conditions but on the same time of the day. The time between conditions varied from 2 – 13 days (mean 7.5 days). Half of the Ss were tested with the condition order S-NS (Order I) and the other half with the reversed order, NS-S (Order II). Ss were matched to testing order according to three variables: 1) nicotine strength of their preferred cigarette brand, 2) situational preference (preference to smoke in high or low arousal situations) and 3) testing time.

Vigilance Test

Critical Flicker Fusion (CFF) was measured by a computerized forced-choice interactive technique with a high test – retest reliability and small training effects (Levander 1975, unpublished data). The stimulus consisted of three lights arranged in a triangle, with one light flickering and two steady. The task of the Ss was to determine the position of the flickering light and to respond by pressing the corresponding button on a box with three buttons oriented triangularly like the stimuli. The position of the flickering light was chosen randomly by the computer for each stimulus presentation. The stimuli were administered over 15 trials, each of 2 min duration with a maximum stimulus presentation time of 5 s and an interstimulus interval of 1 s. Stimulus presentation and recording of responses were performed automatically, on-line, by a minicomputer (PDP 8/L). The frequency of the flickering light of successive stimuli (i.e. the difficulty of the task) was changed continuously according to the performance of the subject. After two correct responses the frequency was increased and after one incorrect response the frequency was decreased. Over time the series of frequency values reflects the CFF threshold level and variability. The results were calculated as the mean of the frequency values in Hz of the successive stimuli. Higher values correspond to better performance. (For a detailed description, see Levander 1975, unpublished data.)

Personality Inventories

Multi-Component-Anxiety Inventory (MCA) is a self-report instrument for measuring different aspects of trait anxiety (Schalling et al. 1975). The inventory consists of three subscales denoted Somatic Anxiety (SA), Psychic Anxiety (PA) and Muscular Tension (MT). The SA-items concern autonomic disturbances such as sweating, palpitations and blushing as well as some types of "psychological" disturbances such as panic attacks, restlessness and vague distress. The PA-items concern anticipatory anxiousness, social insecurity and fear of negative evaluation. The MT-items are related to muscular tenseness (Schalling 1978).

The Marke-Nyman Temperament Inventory (MNT) includes three scales: Validity (Val), in which low scores indicate high neuroticism, Stability (Stab), in which low scores indicate high extraversion-sociability, and Solidity (Sol), in which low scores indicate high extraversion-impulsiveness.

Impulsivity Scales. Two personality scales for measuring variables related to impulsivity were included, the Impulsiveness (I) and the Monotony avoidance (M) scales. The I-items concern a tendency to act on the spur of the moment without considering the consequences and the M-items concern a need for change and novelty, preference for strong stimuli and an adventurous life (Schalling 1977).

Smoking Habit Questionnaires

In the *Smoking Situational Preference Scale (SSPS)* Ss rated their desire to smoke in different types of situations. In the *Activation-Deactivation Adjective Check-List (AD-ACL)* Ss rated their desire to smoke in different positive and negative states of mind representing high or low activation. In the *Smoking Effect Scale-Positive (SES-P)* Ss rated how often smoking increases different states of mind (i.e. calmness, alertness). The *Smoking Effect Scale-Negative (SES-N)* concerns how often smoking decreases different states of mind (i.e. stress, anxiety). Questions concerning smoking motives, cigarette consumption and habits of inhalation were also included. (For a detailed description of the smoking habit questionnaires, see Waller 1975.)

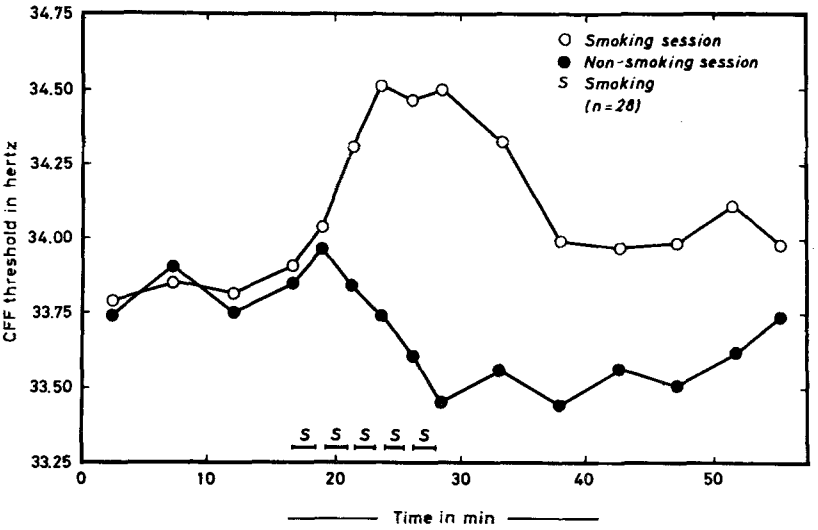

Fig. 1
Mean CFF performance during 15 successive measurements in a Smoking condition and a Non-Smoking condition ($N = 28$)

Subjective Ratings

At the end of each session Ss were instructed to rate their level of alertness and desire to smoke during that session. Ratings of alertness were made on a four point scale ranging from "not tired at all" to "very tired", while ratings of desire to smoke were made on a five point scale ranging from "no desire at all" to "very strong desire". After the S condition Ss also rated the effect of smoking on level of alertness on a four point scale ranging from "not at all more alert" to "much more alert".

Procedure

The S and NS conditions were indentical except for smoking. The sessions took place in a quiet and dimly lit room with the measurement equipment in an adjoining room. The subject was seated in a comfortable, slightly reclined chair. They were instructed not to smoke and to avoid coffee, tea, alcohol and drugs 2 h before the experiment. Each condition was preceded by 15 min of dark adaptation. During this time Ss were familiarized with the CFF technique and the smoking routine. Ss were instructed to keep concentration at a high level throughout the experiment. Then electrodes for autonomic recordings were applied and the experiment started. Heart rate and skin conductance were continuously recorded in both conditions (to be reported separately). In all 15 CFF trials each of 2 min duration were included in each condition. The first four trials were preceded by 2-min pauses. The following five trials were preceded by 1-min pauses and the last six trials were preceded by 2-min pauses. In the S condition Ss smoked three puffs on a fresh cigarette during the 1-min pause preceding each of the CFF trials 5–9.

To avoid negative effects such as dizziness, nausea or cough from a too strong brand or too deep inhalation or disappointment from getting a too weak brand, Ss were allowed to smoke their preferred brand and to inhale in their usual manner. The rate of smoking was controlled. Subjects were instructed to take three puffs during a 1-min pause. The nicotine content of the cigarettes varied between 0.9 and 1.7 mg/cig (mean 1.4 mg/cig).

Results

CFF Performance

Means for CFF performance during each of the 15 successive trials in the Smoking (S) and the Non-Smoking (NS) condition are shown in Figure 1 and *t*-values of differences between means are given in Table 1. An initial marked improvement in CFF performance was noticed with a maximum 8 min after the first puff. Performance was significantly better in the S condition compared to the NS condition from 5 min after the first puff (trial 6) to 20 min after the last puff (trial 14).

Table 1. Means (M) and Standard Deviations (SD) for CFF measures (in Hertz) in a Smoking condition and a Non-Smoking condition, and *t*-values for differences between means

Trial	CFF *Smoking condition* ($n = 28$)		CFF *Non-Smoking condition* ($n = 28$)		*t*	*P*
	M	SD	M	SD		
1	33.77	1.60	33.74	1.71	−0.15	NS
2	33.85	1.63	33.90	1.90	0.20	NS
3	33.81	1.64	33.74	1.76	−0.36	NS
4	33.91	1.42	33.85	1.99	−0.27	NS
5	34.03	1.82	33.97	1.84	−0.32	NS
6	34.30	2.00	33.84	2.01	−1.78	<0.10
7	34.47	1.94	33.74	2.05	−3.19	<0.01
8	34.45	2.07	33.60	2.18	−3.44	<0.01
9	34.46	2.02	33.45	2.08	−4.36	<0.001
10	34.31	1.91	33.56	2.30	−3.69	<0.001
11	33.98	2.01	33.44	2.18	−2.43	<0.05
12	33.98	1.85	33.56	2.26	−1.84	<0.10
13	33.99	1.98	33.49	2.21	−2.24	<0.05
14	34.12	2.12	33.62	2.19	−2.07	<0.05
15	33.96	2.11	33.73	2.13	−1.15	NS

CFF performance was averaged over trials for the pre-smoking (1, 2, 3, 4) trials (Period 1), for the smoking (6, 7, 8, 9) trials (Period 2) and for the post-smoking (11, 12, 13, 14) trials (Period 3).

A 2 (order) × 2 (condition) × 3 (period) analysis of variance yielded a significant condition × period

interaction, $F(2,52) = 10.77$, $P < 0.01$. In Period 1 performance was almost identical in the S and the NS conditions. In Period 2 and Period 3 performance was slightly impaired in the NS condition while in the S condition a marked improvement in performance was noticed during Period 2 followed by a slight impairment in Period 3. Separate t-tests showed a significant difference in performance between conditions for Period 2 ($t = 3.14$, $P < 0.01$) and Period 3 ($t = 2.56$, $P < 0.05$). The improvement in performance from Period 1 to Period 2 in the S condition was also significant ($t = 3.27$, $P < 0.01$). Order had no significant influence on the effects of smoking on performance. The performance of those who had the testing order S-NS, was almost identical to that of those who had the reversed testing order. Change in CFF performance from Period 1 to Period 2 in the S condition did not correlate significantly with level of performance in Period 1. The magnitude of smoking induced change was thus unaffected by the pre-smoke CFF level.

Personality and Smoking Habits

In order to study the influence of personality and smoking habits on CFF performance two extreme groups were formed. Ss on whom smoking had the most positive effect on CFF performance were selected to form a Performance Improvement (PI) group ($N = 8$), and Ss at the other extreme were selected to form a No Performance Improvement (NPI) group ($N = 8$). The effect of smoking on CFF performance was calculated for each S by subtracting the difference in mean performance between Period 2 and Period 1 in the S condition from the difference between mean performance in Period 2 and Period 1 in the NS condition. In the PI- and NPI-groups, t-tests of differences between means in personality and smoking habit variables were performed. There were no significant differences between the groups as to scores in the Somatic Anxiety, Psychic Anxiety, Muscular Tension, Impulsiveness, Monotony Avoidance, Validity and Solidity scales. Scores in the Stability scale were significantly lower in the PI-group ($t = 2.37$, $P < 0.05$), which indicates that the improved Ss rated themselves as more extraverted.

The two extreme groups did not differ with regard to ratings of subjective effects of smoking, smoking motives, habits of inhalation, cigarette consumption and nicotine content in their preferred brand. Ss in the PI-group rated lower preference for smoking in quiet situations ($t = 1.90$, $P < 0.10$) and when feeling relaxed and calm ($t = 1.89$, $P < 0.10$).

Subjective Ratings

The objective effect of increased vigilance had no counterpart on the subjective level. All Ss but one in each extreme group rated "no effect at all" of smoking on level of alertness during the experiment. Ss in the NPI-group rated on an average a moderate desire to smoke in the NS condition, while subjects in the PI-group rated very low desire to smoke in that condition. The difference was significant ($t = 2.58$, $P < 0.05$). In the S condition no significant difference was noted; both groups rated on an average a moderate desire to smoke. There was also no difference between the two groups in ratings of alertness in the S and NS conditions.

Discussion

The main result in the present study was that tobacco smoking significantly improved CFF performance in habitual smokers, who had abstained from smoking for 2 h. This finding is in line with some of the earlier studies of the effects of tobacco smoking on CFF. In the present study, however, a new psychophysical technique of measuring CFF was used which is probably less influenced by response bias than the method of limits used in earlier studies of smoking effects on CFF.

The design of the study made it possible to follow variations in vigilance during 1 h. An initial marked increase in performance was obtained with a peak effect after 3 min of smoking (8 min after the first puff). The significant improvement in performance was present until 20 min after the last puff. A similar time pattern was reported by Warwick and Eysenck (1963). According to these authors, a peak effect was noted approximately 7 min after the first puff, and the improvement was still noticeable about 20 min after the last puff.

It is interesting that these durations of effects roughly correspond to the duration of increased CNS activation after smoking as indicated by EEG (Philips 1971; Knott and Venables 1977). The fact that the smoking effect was present 20 min after the immediate rewarding experience of handling the cigarette and of the taste and smell sensations associated with smoking, might indicate that the effects of smoking on CFF performance are not primarily due to psychological factors. The CFF method used in this study, assumed to be relatively insensitive to response bias also suggests that the effects of smoking on CFF performance was not mediated by motivational factors. However, there is a possibility that smoking can improve CFF performance via an increase in pupil size. This was checked in a control study on six male moderate smokers. The diameter of the pupil was measured by infrared pupillography once a minute during 25 min in a smoking and a non-smoking condition. No effects of smoking on pupil size was noticed.

In the non-smoking condition, a marked impairment in performance was noted during Period 2. In this period, CFF trials were preceded by short 1-min pauses, and the impairment is probably due to fatigue. During Period 3, in which trials were preceded by longer pauses, performance improved slightly. The impairment during Period 2 was effectively counteracted by smoking which is in line with what Tarrière and Harteman (1964) and Frankenhaeuser et al. (1971) reported for mental performance. These results are interesting in view of the findings in a recent study on the effect of smoking and abstinence on EEG (Knott and Venables 1977). These authors found that abstinence was characterized by a state of cortical hypoexcitation, and that tobacco smoking increased cortical excitation, which was interpreted as indicating increased vigilance and attention. It should be noted, however, that in the present study, in contrast to that by Frankenhaeuser et al. (1971), smoking actually improved performance above the initial level.

The marked effects of smoking on CFF in the present study as well as the similarity in time pattern with the EEG studies suggest that smoking has a centrally stimulating effect. However, the increased vigilance during the smoking session was not accompanied by the experience of increased alertness as indicated by the subjective ratings. This finding emphasizes the importance of using objective techniques when studying smoking motives.

In view of the large individual differences in effects of smoking on EEG (Ashton et al. 1974), and on CFF in an earlier study (Garner et al. 1954), some personality questionnaire scales were administered in the present investigation in order to study interactions between smoking effects and personality. When the group of Ss who showed the largest improvement in CFF was compared with the group of Ss who showed the smallest improvement during smoking, the only significant difference was in the same direction as that reported by Ashton et al. (1974), i.e. the stimulant effect of smoking was higher in the more extravert Ss. These authors suggested that the slower rate of smoking in extravert individuals might be responsible for the result, but the present findings cannot be explained in this way, since rate of smoking was controlled.

According to Eysenck (1967), extraversion is related to a tendency to habitual low cortical arousal. He suggested that the consistently higher scores in extraversion obtained in groups of heavy smokers may be related to the CNS stimulating effects of smoking. These effects could be more rewarding for habitually hypo-aroused extraverted individuals than for more introverted individuals (Eysenck 1967; Schalling 1977). Thus, in the present study, the more extraverted (hypo-aroused) PI-group might be expected to perform worse than the NPI-group during Period 1, before smoking, whereas there was a tendency in the opposite direction. The relation between extraversion and habitual low cortical arousal, however, has been most marked for the impulsivity component (Schalling 1978) whereas the extraversion scale differing between the two groups in the present study, Stability, concerns the sociability rather than the impulsivity component.

There were some differences in smoking habits between the two extreme groups. The most improved (PI) group rated a higher habitual preference to smoke during high arousal than the NPI-group. Since the CFF measurements were made in a monotonous, quiet and calm situation this appears inconsistent with Myrsten et al. (1975) who found that smoking improved vigilance in a low arousal situation only for low arousal smokers. However, the test situation might have been more relaxed and less demanding in the latter study. In the present study subjects were strongly prompted to keep concentration at a high level throughout the experiment and to try hard to withstand drowsiness and boredom. Further, many subjects experienced the task as difficult and this might also have contributed to an increased level of stress as compared with the Myrsten et al. (1975) study.

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