Original Investigations

Effects of Cigarette Smoking on Learning and Retention

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Abstract. Verbal rote learning was studied on 10 habitual smokers in a smoking and non-smoking session. Smoking induced a significant decrease in the number of correct responses on the learning task as compared to non-smoking values. The impaired learning coincided in time by an increased arousal as measured by heart rate. A test of recall 45 min after the end of the learning period, when the pre-smoking arousal level had been restored, showed that retention was better in the smoking condition than in the non-smoking condition. The results were interpreted in terms of Walker's theory (1958) postulating a relationship between arousal level and consolidation of memory.

Key words: Cigarette Smoking – Arousal – Learning – Memory.

In a study by Andersson and Post (1972) it was shown that smoking a nicotine-containing cigarette had an adverse effect on the learning of nonsense syllables, whereas a nicotine-free cigarette had no noticeable effects. The impairment lasted for a period of 30 min following smoking and coincided in time with an increased arousal level as measured by heart rate. The experiment was based on data from animal studies (Bovet-Nitti, 1969; Garg, 1969, 1970; Garg and Holland, 1967, 1968; Morrison and Stephenson, 1969) showing a facilitating effect of nicotine on learning. The obtained results were interpreted in terms of a theory advanced by Walker (1958) relating consolidation of the memory trace to action decrement and arousal. This theory originates from consolidation theories (Hebb, 1949; Müller and Pilzecker, 1900) according to which the memory trace must undergo a neural reverberative process before it becomes a stable part of long-term memory. Walker has extended these theories by proposing that the consolidation of the memory trace is accompanied by a temporary inhibition of recall, serving to protect the trace against disruption. Under conditions of high arousal the increased nonspecific neural activity is assumed to produce a more intense consolidation leading to improved long-term memory but also to a less accessible trace in the short term. His ideas have been supported by results from animal studies (Walker, 1956, 1958; Walker and Motoyooshi, 1962; Walker and Paradise, 1958) as well as by human experiments using paired-associate learning (Kleinsmith and Kaplan, 1963, 1964; Walker and Tarte, 1963). The human experiments showed that high arousal during learning was related to poor immediate recall but high recall after one week, while the reverse trend was found with low arousal level.

Since there is evidence that cigarette smoking produces increased cortical arousal (Philips, 1971; Ulett and Itil, 1969) as well as increased autonomic arousal and adrenal medullary activity (Frankenhaeuser et al., 1970; Frankenhaeuser et al., 1968) it provides a suitable tool for testing this hypothesis. At the same time the role of smoking on learning processes can be examined. The aims of the present experiment were to check whether the results from the previous study by Andersson and Post (1972) could be verified and to analyze the relationship between arousal, learning and retention in more detail. Verbal rote learning and retention were studied under a smoking and a non-smoking condition. The hypothesized enhancement of long-term recall by high arousal was checked by a delayed retention test. Finally a physiological variable, heart rate, was recorded in order to provide an independent measure of the effects of smoking. This variable is clearly of some relevance to a discussion of arousal changes although it cannot be employed as a direct measure of arousal.

Thus the relationships between the two dependent variables are examined on a broader basis and pointed out only where it seems appropriate to do so.
Methods

Subjects, Design and Procedure. Ten male university students participated in the experiments. Their ages ranged from 20–25 years (mean 22.1 years) and their body weights from 58–70 kg (mean 68.5 kg). They were all habitual smokers with a daily consumption of 5–15 cigarettes.

Each subject came to an introductory session, a smoking session, and a non-smoking session. The experimental sessions were counter-balanced and spaced at intervals of 5–7 days.

In the introductory session the subject was instructed to refrain from smoking as well as intake of drugs or alcohol from 11.00 p.m. on the night preceding an experimental session. The learning task was presented, and each subject had 10 min of training on a list of 25 nonsense syllables. The experimental session started at 9.00 a.m. or 10.00 a.m., each subject having both his experimental sessions at the same hour. After arriving in the laboratory the subject has a light breakfast (tea and toast) and then the learning period (40 min), comprising 20 trials, started. After trial 10 there was an 8-min pause during which the subject worked on a jig-saw puzzle, and at the end of this period a final trial on the learning task was performed. Heart rate was recorded at fixed intervals throughout the session.

Cigarette Smoking. The cigarette used was a filter cigarette of the brand Virginia King which contains 2.1 mg nicotine (according to current information from the Swedish Tobacco Company).

Verbal Rote Learning. Two lists of nonsense syllables of equal difficulty were used and rotated within sessions. Each list comprised 25 syllables, each consisting of a consonant, a vowel, and a consonant (e.g., buf, neb, etc.). The syllables had previously been rated by Swedish students as having a low association value (Bauer, personal communication).

The syllables were projected one at a time on a screen individual standpoint. It was found that the observed group relationships even hold for individuals. Nine of ten subjects showed a performance decrement after the 8-min pause and seven of ten subjects showed an improvement after the 45-min pause in the smoking condition compared to the non-smoking condition. Furthermore, the changes observed in the opposite direction to this trend were of a very small magnitude, suggesting a generally consistent effect across subjects.

Heart Rate. Mean heart rate during smoking and non-smoking conditions is shown in Fig. 3. There was no difference in heart rate between conditions before the 8-min pause. After smoking, however, a sharp and significant increase in heart rate was recorded \( (r = 4.79, df = 9, P < 0.001) \) followed by a progressive decline during the course of the session. Only a slight elevation remained after the 45-min pause. In the non-smoking session heart rate remained relatively stable over time.

Statistical comparisons between the two conditions with regard to heart rate were based on values