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RAPID COMMUNICATION

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Comparison of the effects of nicotine on a fixed rate and a subject-paced version of the rapid information processing task

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Abstract In a modified "subject-paced" rather than fixed rate version of a rapid information processing (RIP) task, the presentation rate of the stimuli is continuously adapted to the individual performance level. Thus, this modified task version probably assesses a continuous "speed function" rather than mere "vigilance". In order to compare the two task versions more directly, we carried out a study which assessed the effects of a regular nicotine cigarette and the nearly nicotine-free cigarette NEXT on both task versions under the same experimental conditions. The dominant alpha frequency pointed to a greater arousal evoked by the subject-paced RIP version compared with the fixed rate version. With the fixed rate version, smoking nicotine cigarettes reduced reaction times, whereas with the subject-paced version, processing rate was improved. Additionally, smoking NEXT decreased craving less than smoking the regular cigarettes. It was concluded that the two task versions are sensitive to different cognitive functions. Whereas the subject-paced version was more sensitive to effects on the speed of processing, the fixed rate version was more sensitive to effects on reaction time.

Key words Rapid information processing · Vigilance performance · Nicotine

Introduction

Among modifications of the original Bakan task (1959) two different versions of a rapid information processing task are used to study the effects of stimulants on vigilance or speed performance. The fixed rate presentation of the task stimuli can be considered as a vigilance task and has often been used by Wesnes and Warburton (1983). No comparison has yet been made with the subject-paced version of this task used in our laboratory (Bättig and Buzzi 1986; Hasenfratz et al. 1989, 1991, 1993b, 1994; Hasenfratz and Bättig 1993a, b, 1994a, b; Michel and Bättig 1989). In a recent review by Koelega (1993), these studies were not included because "the subject-paced character and especially the different measures of performance preclude comparison with the usual type of vigilance task".

The subject-paced task version is indeed different from the commonly used vigilance tasks for several reasons. The main performance parameter of the subject-paced version is the continuously assessed presentation rate which reflects the maximal individual processing rate, whereas the number of hits and errors are not dependent measures since they are used to continuously adapt the rate of stimulus presentation. Thus, the main function assessed is a "speed function" rather than "vigilance". Further, the task instructions emphasize primarily the processing speed and only secondarily the reaction time to the individual stimuli. Thus, the effects on the reaction times can be expected to be less clear than those on processing rate.

Further, the subject-paced version allows the individual processing rate to fluctuate widely between minimal and maximal presentation rates.Thereby, ample room is given both for improvements and for impairments. On the other hand, with the fixed rate version improvements cannot be detected when subjects perform close to the maximum of the hit probability, which is more likely to be the case at the beginning than towards the end of a trial.

The comparison of the two versions carried out in this study involved smoking the habituated brand cigarette or the nearly nicotine-free cigarette NEXT (nicotine < 0.08 mg, tar 9.3 mg) and the analysis of a pre- and a post-smoking trial. In order to avoid carry-over effects, the two test versions involved a between-group design, whereas the two cigarettes were tested with a crossover within-group design. According to several earlier studies, NEXT cigarettes fail to induce any nicotinic arousal on physiological and electrocortical parameters but reduce the craving to smoke smilarly to habituated regular

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cigarettes, although they were rated lower in taste and acceptability than the subjects' habitual brand cigarettes (Hasenfratz et al. 1993a; Baldinger et al. 1995a, b).

Materials and methods

Subjects

Twenty female smokers between 20 and 40 years old and smoking at least 15 cigarettes/day with a nicotine yield of at least 0.6 mg/cigarette were recruited through newspaper advertisements. They were split into two groups performing the rapid information processing task either in the subject-paced or fixed rate version. On testing days, they were required to abstain from smoking and drinking caffeine-containing beverages upon getting up until the beginning of the sessions (between 8 and 10 a.m.). Their fee consisted of a fixed sum of SFR 50 (US $ 33) plus an efficiency bonus.

The rapid information processing (RIP) task

The subject-paced RIP task

This required the subjects to watch single digits (1–8) presented in a pseudorandom order for 80 ms on a computer screen, and to press a button whenever three consecutive digits were either odd or even. The presentation rate (initially 90 digits/min) increased after each correct response (hits) and decreased after each commission (false response) or omission error by a change in the interstimulus interval in steps of 33 ms. There was no emphasis on reaction time and the computer considered all responses correct that were given up to the end of the next stimulus following a target stimulus. In order to motivate the subjects to keep their processing rate at the maximal level, SFR 0.05 (US $ 0.03) was given for each digit processed above a minimum of 1800 digits per trial, which lasted 20 min.

Fixed rate RIP task

The presentation rate of the single digits remained constant at 100 digits/min throughout the 20 min of the task. The performance parameters were the number of hits and the mean reaction time to hits. In order to increase motivation the subjects earned SFR 1 (US $ 0.67) for each performance percent above 50% hits.

Cigarettes

In a balanced sequence the subjects smoked in one of the two sessions their habituated cigarette and in the other session the nearly nicotine-free cigarette NEXT.

Physiological parameters

Blood pressure, electrocardiogram, finger and ear pulse amplitude and arrival time, frontal electromyogram, respiration, body movement, EEG, and electro-oculogram were measured as described elsewhere (Hasenfratz et al. 1993a).

Biochemical parameters

Saliva cotinine during the training session was assessed using the methods described earlier (Hasenfratz et al. 1993a; Jacober et al. 1995) and the CO concentration of the expiratory air at the beginning of the experiment (abstinence compliance) and before and after each smoking period were assessed using the EC50 Micro Smokerlyzer (Bedfont Instruments, England).

Subjective parameters

Subjective ratings were assessed using an 18-cm long horizontal analog scale presented on a computer screen. The cursor was positioned on the scale using a trackball. The positions of the cursor were then automatically transformed to a 0–100 scale. [Subjective performance: "How would you judge your task performance?" (left end labelled with: poor; right end labelled with: good); the following questions were labelled with not at all – very much: enjoyment: "Did youg enjoy the task?"; disagreeableness: "Did you find the task disagreeable?"; effort: "Did you put much effort into doing the task?"; craving: "How much would you like to smoke now?; taste: How good did the cigarette taste?"; pleasure: "How much did you enjoy the cigarette?"; stimulation: "Were you stimulated by smoking?"; dizziness: "Do you feel dizzy now?"; sickness: "Do you feel sick now?"; strength: "How strong did you find the cigarette?" (weak-strong)].

The Fagerström Tolerance Questionnaire (Fagerström 1978) was filled out by the subjects in the training session.

Procedure

In a training session the subjects were familiarized with the laboratory situation and practised the RIP task three times. The first trial was done without smoking, the second and the third trial while smoking habitual or test cigarettes. No physiological parameters were recorded. After that, each subject took part in two test sessions where they smoked their habitual or the test cigarettes between two trials and during the second trial. In one session always the same type of cigarette was smoked and the order of the type of cigarettes was balanced over the sessions.

After the subject's arrival at the laboratory the electrodes were attached and carbon monoxide in the expiratory air was measured. Continuous recordings of the physiological parameters started with a first 5-min rest period. Then the first 20-min RIP task period was started, which was followed by a second 5-min rest period. Then subjective performance was rated and after a second respiratory CO measurement a cigarette was lit. After the subjects finished the cigarette, respiratory CO was measured again and subjective ratings of smoking were assessed. Then, the same sequence (5-min rest, 20-min task, 5-min rest) was repeated. After the last rest phase subjective ratings of performance and smoking as well as respiratory CO were assessed again.

Data processing and statistics

For the performance parameters, the values were aggregated to 2-min blocks. Physiological data sets were reduced as described elsewhere (Hasenfraz et al. 1993a).

These reduced data sets as well as all other subjective and biochemical parameters were submitted to analyses of variance (ANOVAs) (BMDP 2V) with the grouping factor RIP version (V: fixed rate/subject-paced), and the within-factors type of cigarette (C: habitual/NEXT), trial 1 versus trial 2 (S: no smoking-trial/smoking-trial) and pre- versus post-trial rest phases (N).

For all significance levels (Greenhouse-Geisser probabilities were considered where appropriate.

Results

Sample characteristics

The sample characteristics revealed no significant differences between the two groups with respect to age, cigarette consumption, preexperimental saliva continine and Fagerström Index.

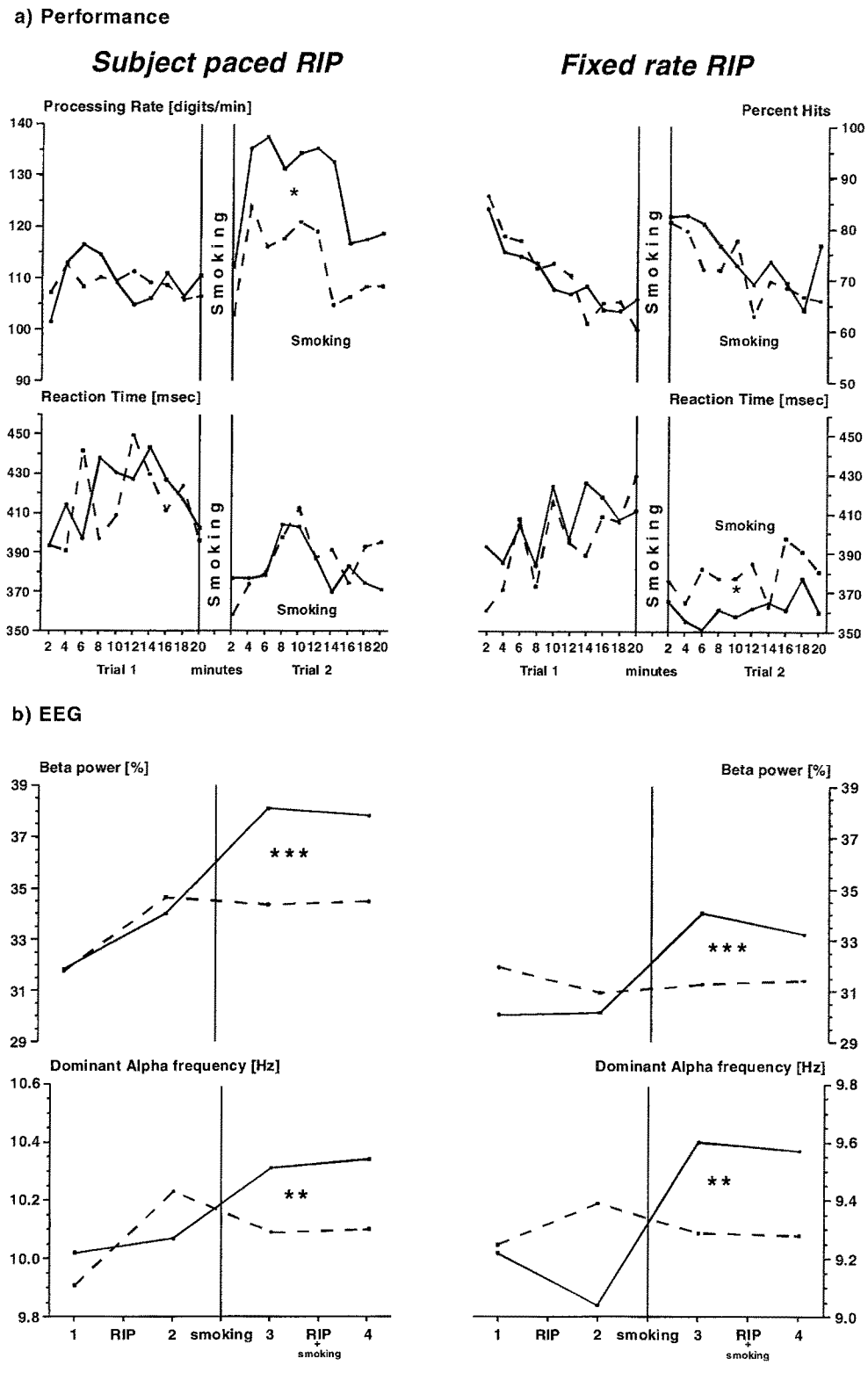

Fig. 1 Performance (**a**) and EEG parameters (**b**) of the subject-paced and the fixed rate RIP version with habitual (*solid lines*) and NEXT cigarettes (*broken lines*). * $P<0.05$, ** $P<0.01$ and *** $P<0.001$ for the difference between the types of cigarette

a) Respiratory CO increased significantly after smoking [S: $F(1,18)=69.18$, $P<0.001$] but similarly with both cigarettes.

b) Nicotinic actions verified by C×S interactions (Fig. 1a, b) appeared as increases of heart rate, systolic and diastolic blood pressure, processing rate (subject paced), reaction time (fixed rate), beta power, alpha peak and the rating of performance (all Fs>5.45, $P<0.05$) and decreases in delta and theta power, the ratings of craving and dizziness (all Fs>6.87, $P<0.05$).

c) A main effect of the task version appeared only for dominant alpha frequency, which was around 10.2 Hz in the subject-paced RIP version and around 9.3 Hz in the fixed rate RIP version [factor V: $F(1,17)=6.30$,

$P<0.05$]. The two RIP versions did not differ with respect to diagreeableness and effort of the task.

d) Nicotinic actions as a function of the RIP version and verified by C×S×V interactions, appeared as a greater decrease in theta power with the habitual cigarettes in the fixed rate than in the subject-paced version. Whereas in the subject-paced version a significant decrease in beta frequency with the habitual cigarettes and an increase with the NEXT cigarettes was observed, the effects were reversed in the fixed rate RIP version. A greater enjoyment of performance was observed in the subject-paced version with both types of cigarettes in the second trial. In the fixed rate version, the second trial was rated more enjoyable only with the habitual cigarettes, whereas with the NEXT cigarettes the first trial was more enjoyable (all Fs>6.16, $P<0.05$).

Discussion

The different RIP versions affected neither cardiovascular parameters nor any other vegetative functions. The higher dominant alpha frequency indicated greater electrocortical arousal with the subjected-paced RIP version than with the fixed rate version. Thus, the subject-paced version seemed to be more challenging even though both task versions were subjectively rated similarly with respect to the effort needed.

Concerning the ratings of the two cigarettes, the habitual cigarettes reduced craving and were able to induce smoking pleasure compared with the NEXT cigarettes. This contradicts earlier results with these cigarettes, showing their reduction of craving to be nearly identical to that of habituated medium nicotine cigarettes (Hasenfratz et al. 1993a; Baldinger et al. 1995a, b). This might suggest that in stressful cognitive situations the intake of nicotine plays an important role as an improver of mental performance whereas in relaxed smoking situations, chemosensory stimulation and the smoking act alone are sufficient to reduce cigarette craving. In addition, strength and taste were rated higher for the habitual cigarettes, as was also seen in the earlier experiments with NEXT cigarettes. Whether this is a consequence of nicotine yield is not conclusive, as the habitual cigarettes were the subjects' own brand cigarettes, which delivered the accustomed taste, strength and flavor in contrast to an unaccustomed cigarette (NEXT). Nevertheless, the NEXT cigarette and the habitual brand cigarettes were smoked in a similar fashion, as confirmed by a similar CO uptake.

The comparison of the performance parameters of the two RIP-task versions revealed that they were affected by nicotine in a different manner. Reaction time to hits decreased in both task versions from the pre- and non-smoking trial 1 to the post- and smoking trial 2, but only in the fixed rate version was this decrease significantly greater with the habitual brand cigarette than with the NEXT cigarette, thus pointing to enhanced attention with nicotine.

These results are in line with several earlier results. Warburton's group generally found significant nicotine induced decreases in reaction time (Wesnes and Warburton 1983, 1984a, b; Edwards et al. 1985), whereas with our version this was sometimes the case, but sometimes not.

For the processing rate, the main performance parameter of the subject-paced version, a greater increase was found for the habitual brand cigarettes than for the NEXT cigarettes. This is in line with several earlier studies (Hasenfratz and Bättig 1993b; Hasenfratz et al. 1989, 1991). Thus, nicotine was able to increase the individual maximal processing rate.

In the fixed rate version, nicotine failed to affect the number of hits, one of the two main performance parameters of this task version. This result contradicts the results of Warburton's group, who usually found a relative increase in the percentage of hits after nicotine or at least prevention of a fatigue-induced decrease (Wesnes and Warburton 1983, 1984a, b). However, there was at least one study using the same task, which also failed to find significant increases in the number of hits, whereas the reaction times decreased after smoking as compared with non-smoking (Petrie and Deary 1989).

From the present results it can be concluded that the subject-paced version of the RIP-task is more sensitive in detecting nicotine effects on information processing speed than on reaction times, as the effects on processing rate are more consistent than those on reaction time. On the other hand, the fixed rate version seems to be more sensitive in detecting nicotine effects on reaction time, as this parameter is more consistently affected than the number of hits.

In conclusion, we agree with Koelega (1993) that the two RIP task versions assess different aspects of changes in information processing. However, these different aspects were both sensitive to nicotine, thus underlying the notion put forward by Warburton (1992) that the substance seems to improve cognitive functioning across a wide range of tasks and parameters.

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