

NOISE, CENTRAL NORADRENALINE AND SELECTIVITY IN MEMORY AND ATTENTION

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ABSTRACT

Background: Initial noise exposure can increase arousal and lead to increased selectivity in memory and attention. Less is known about the effects of prolonged noise exposure and noradrenergic drugs on selectivity in attention and memory. Clonidine, an antihypertensive α 2-adrenergic receptor agonist, reduces arousal, which leads to lower subjective alertness, impaired sustained attention, slower choice reaction time and saccadic eye movements. These Clonidine-induced impairments can be reversed by the selective antagonist, Idazoxan, and acute exposure to noise. The present analyses investigated the effects of Clonidine on selectivity in memory and attention and examined whether Idazoxan and noise blocked the effects of Clonidine. **Method:** A parallel-group double-blind design was used. Seventy-six healthy male volunteers were given either a placebo, 40mg Idazoxan, 200 μ g Clonidine, or a combination of 200 μ g Clonidine plus 40mg Idazoxan.

Half of each drug condition was exposed to 80dB white noise via headphones. At baseline and on three occasions post-drug administration, volunteers carried out a Stroop task, a category instances task, and a dual memory task. **Results:** Neither the noradrenergic drugs nor noise influenced selective attention and memory. The speed of reaction times in the category instances task was slower after Clonidine, and this effect was reduced by Idazoxan and noise. **Conclusion:** Neither noradrenergic drugs nor prolonged noise exposure changed selectivity in memory and attention. Clonidine led to psychomotor slowing, an effect which was reduced by Idazoxan and noise.

KEYWORDS: Central Noradrenaline; Noise; Clonidine; Idazoxan; Selective Attention; Task Priority; Category Instances; Stroop Task.

INTRODUCTION

There is a considerable literature on the effects of noise on cognitive performance. This has been reviewed many times,^[1-10] and the diversity of the research can be seen in my own studies.^[11-60] One explanation of the effects of noise has been in terms of changes in arousal.^[61,62] Initially, exposure to noise has an alerting effect, which increases selectivity in attention and memory. For example, noise has been shown to reduce the effect of a distracting colour-name in the Stroop Colour-Word test.^[23] In terms of increased selectivity in memory, research has shown that noise improves recall of high-priority information at the expense of information with a lower priority.^[16] Another task which has been used to demonstrate increased selectivity in memory when exposed to noise is the category instances task.^[17] In this task, the person is shown a category name (e.g. An animal) followed by either a good example of that category (e.g., Dog) or a weaker example (e.g., Mole). Participants take longer to respond to the weaker example, and this effect has been shown to be bigger when the person performs in noise. The present analyses examined whether these effects of noise would be observed when the noise exposure was over several hours and when the level of alertness of the volunteers was altered using noradrenergic drugs.

Central noradrenaline plays a key role in arousal. Clonidine, an antihypertensive α 2-adrenergic receptor agonist, reduces alertness^[63] and has been shown to impair sustained attention^[64] and slow choice reaction time^[65] and saccadic eye movements.^[66] The effects of Clonidine can be blocked by the selective antagonist Idazoxan.^[63-66] Initial exposure to noise also reduces the effects of Clonidine, but this was not observed for measures taken at a time of longer noise exposure. Research has also examined the effects of these noradrenergic drugs and noise on the biased probability effect in choice reaction time.^[65] Tasks were created where one stimulus was more probable than the others. Reaction times to the more probable stimulus were faster, but this effect was not modified by noise or the noradrenergic drugs. Based on this result, it was hypothesised that the noradrenergic drugs and prolonged noise exposure would not influence measures of selectivity in memory and attention. Rather, it was predicted that the drugs would influence psychomotor speed.

METHODS

Participants

Seventy-six males aged 18-35 years consented to participate. All the volunteers had their medical history checked, were given a physical examination, and had haematology and biochemistry tests. Exclusion criteria were taking medication, drinking more than 21 units of alcohol per week, and having clinically relevant current or past illnesses (e.g., hypertension or psychiatric disorders). Participants were told not to drink alcohol on the night before the test study. The research was approved by the medical ethics committee and conformed to the standards of the Declaration of Helsinki.

Design

A randomised, double-blind, between-participants group design was used, with volunteers being divided into two groups who performed the post-treatment test in either quiet or 80dB white noise played through headphones. These two groups were randomised into four drug conditions: placebo, 200µg Clonidine; 40mg Idazoxan, or the combination of 200µg Clonidine and 40mg Idazoxan. All the drugs were administered orally and given as two opaque capsules. There were, therefore, eight groups with 9-10 volunteers per group. The drug doses were selected based on effects observed in previous studies. All participants were familiarised with the task battery in a separate practice session prior to the test day. On the test day, the baseline session (conducted in quiet) started at 09.30, and the drugs were administered at 10.30. Post-drug sessions started at 11.00, 13.00 and 15.00. A light lunch was given at 12.30. The test battery lasted for approximately one hour.

Category instances task

In this task, a category name was shown on the computer screen (e.g., ANIMAL) followed by a dominant instance of that category (e.g. DOG), or a non-dominant instance (e.g., MOLE), or a non-instance (e.g., CHAIR). The participant had to respond "True" (by pressing a key with the left forefinger) if it was an instance and "False" (by pressing a key with the right fore-finger) if it was not an instance. Reaction times were measured to the nearest msec using a timer card. There were equal numbers of instances and non-instances and equal numbers of dominant and non-dominant instances.

Stroop task

This task had two conditions. In the first, a square appeared on the computer screen and was either red, blue, green or yellow. The participant pressed the appropriate key on a response

box. Reaction times were measured to the nearest msec using a timer card. There were equal numbers of the four colours.

In the interference condition, a word was presented in the wrong colour (e.g., RED). The participant had to respond to the colour of the ink and ignore the distracting word. The participant pressed the appropriate key on a response box. Reaction times were measured to the nearest msec using a timer card. There were equal numbers of the four colours.

Memory for high/low priority information

Two versions of this task were used. In the first, eight words were presented in the centre of the computer screen. Each word was on the screen for 2 seconds with a one-second inter-word interval. Half the words were presented in upper case and half in lower case. The high-priority task was to remember the case of the word, and the low-priority task was to remember the order of the words. After the presentation of the words, the participant was given a random list of the eight words and had to indicate which case the word was shown in and the order of presentation. The second task was similar, except that all words were presented in lower case and in one of the four corners of the screen. The high-priority task was to remember the order of presentation, and the low-priority task was to remember the location in which the word was presented.

Analysis strategy

Analyses of covariance (ANCOVAs) were performed to analyse the data. Separate analyses were carried out for each task. The scores from the post-drug sessions were used as the dependent variables, and the baseline score for each task was used as the covariates. The within-subject factor was the testing session, and the drug and noise conditions were the between-subject factors.

RESULTS

Category instances task

In this task, there was a highly significant effect of instance type ($F_{2, 131} = 49.0$ $p < 0.0001$). Dominant instances were responded to most quickly (mean = 1071 msec), then non-instances (mean = 1188 msec) and non-dominant instances were responded to most slowly (mean = 1242 msec). There were no interactions between instance type, noise and drug conditions, showing that these factors did not change the selective retrieval of category information. There was a significant effect of drug condition ($F_{3,65} = 2.34$ $p < 0.05$ 1-tail) and a drug x

noise interaction ($F_{3, 65} = 2.45$ $p < 0.05$ 1-tail) on overall reaction time. These results can be seen in Table 1. In quiet, Clonidine led to the slowest reaction time, and this effect was blocked by the Idazoxan + Clonidine combination. Noise reduced the effect of Clonidine but led to slower reaction times in the other conditions.

Table 1: Effects of Drug and Noise on mean reaction time (msec) in the category instances task (scores are the adjusted means from the Ancova).

	Placebo	Idazoxan + Clonidine	Idazoxan	Clonidine
Quiet	1092	1003	1109	1337
Noise	1236	1207	1120	1238
Overall	1164	1105	1114	1288

Stroop Colour-Word Interference task

The score analysed here was the difference between the interference condition and the colour naming condition. There were no significant effects of drug condition, noise or drug x noise interaction (all F 's < 1). Again, this shows no effect of these factors on resistance to distraction. The mean scores are shown in Table 2.

Table 2: Effects of drug and noise on Stroop interference (Msec; scores are the adjusted means from the Ancova).

	Placebo	Idazoxan + Clonidine	Idazoxan	Clonidine
Quiet	212	163	161	202
Noise	194	188	224	209
Overall	203	176	193	205

Memory for High and Low-priority information

In the Case/Order task, there was a significant effect of task priority ($F_{1,51} = 13.53$ $p < 0.0001$), with more correct words for the case task (mean = 5.92) than the order task (mean = 5.24). There were no significant effects of drug condition, noise, nor a noise x condition interaction (all F 's < 1). An identical profile was seen for the Order/Location task. More words were correct in the high-priority order task ($F_{1,51} = 46.1$ $p < 0.0001$; mean = 5.20) than in the low-priority location task (mean = 3.90). Again, there were no significant effects of drug condition, noise, nor a noise x condition interaction (all F 's < 1). These results show that neither the noise nor the drugs had significant effects on selective memory.

DISCUSSION

The present analyses show that neither noradrenergic drugs nor prolonged noise exposure have effects on selectivity in memory and attention. Previous analyses have shown that Clonidine reduces alertness, slows psychomotor performance and eye movements, and impairs sustained attention.^[1-3] These effects of Clonidine were blocked by Idazoxan and reduced by acute noise but not a longer exposure. The biased probability effect, faster reaction times to more probable signals, was not influenced by the drugs or noise. This lack of effects on selectivity in attention was confirmed here using the Stroop colour-word task. Selectivity in memory was examined by using tasks previously shown to be sensitive to acute noise, namely a category instance task and a memory task with high and low-priority components. Neither the category dominance effect nor the priority effect was influenced by the drugs or noise. Reaction times in the category instances task were slowed by Clonidine, and this effect was reduced by Idazoxan and noise. In summary, noradrenergic drugs influence psychomotor speed rather than selectivity in attention and memory.

Previous research has demonstrated the effects of noise on the tasks used here. However, the studies that demonstrated the effects of noise used a short noise exposure and a small number of repetitions of the tasks. This contrasts with the present experiment, which had a long noise exposure and involved performing the tasks in three test sessions. The effects of noise on the initial performance of tasks have been explained in terms of the selection of certain strategies. These strategies may change with longer exposure to the noise and longer performance of the task. This plausibly explains why the effects of noise were not observed in the tasks analysed here.

The present study had several limitations. First, single doses of the drugs were used, and it is possible that different results would have been observed with smaller or larger doses. Secondly, continuous white noise was played, and different effects are often found with other types of noise.

CONCLUSION

In conclusion, previous research has shown Clonidine reduces alertness, impairs sustained attention, and leads to slower psychomotor performance and eye movements. Acute exposure to noise and the selective antagonist Idazoxan reduce the Clonidine-induced impairments. Prolonged exposure to noise does not have an alerting effect and does not change the effects of Clonidine. Neither drug condition nor noise changed the biased probability effect, which

suggests that the noradrenergic system may not influence selective attention. The present analyses confirmed that neither noradrenergic drugs nor noise effect selectivity in attention (measured using the Stroop task) or memory (measured using the dominance of category instances and low/high priority memory tasks). Clonidine led to slower reaction times in the category instances task, and this effect was reduced by Idazoxan and noise.

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