

THE EFFECTS OF NOISE AND NORDRENERGIC DRUGS ON CHOICE REACTION TIME

*Andrew P. Smith, PhD

Centre for Occupational and Health Psychology, School of Psychology, Cardiff University,
63 Park Place, Cardiff CF10 3AS, UK.

Article Received on
01 November 2023,

Revised on 22 Nov. 2023,
Accepted on 12 Dec. 2023

DOI: 10.20959/wjpr20241-30747



*Corresponding Author

Dr. Andrew P. Smith

Centre for Occupational and
Health Psychology, School
of Psychology, Cardiff
University, 63 Park Place,
Cardiff CF10 3AS, UK.

ABSTRACT

Background: Clonidine, an antihypertensive α_2 -adrenergic receptor agonist, induces a state similar to sleep deprivation. This leads to impaired sustained attention, slower saccadic eye movements and reduced alertness. The selective antagonist, Idazoxan, reverses the Clonidine-induced reduction in alertness and impairment of sustained attention. Acute exposure to noise, but not longer exposure, also reduces the effects of Clonidine on alertness and attention. The present analyses investigated the effects of Clonidine on choice reaction time and examined whether the effects of Clonidine were modified by noise and blocked by Idazoxan. **Method:** A double-blind, parallel-group design was used. Seventy-six healthy male participants were given either 200 μ g Clonidine, 40mg Idazoxan, a combination of 200 μ g Clonidine plus 40mg Idazoxan, or a placebo. Half of each drug treatment group was exposed to 80dB white noise via headphones. At

baseline and on three occasions post-drug administration, participants carried out two choice reaction time tasks, one near the start of the hour-long test session and the other near the end.

Results: Clonidine significantly slowed reaction time, and this effect was reversed by Idazoxan and initially noise. Prolonged exposure to noise did not have a significant effect in the clonidine condition. **Conclusion:** At the start of the test session, Clonidine led to slower reaction times in the quiet group, and this effect was reduced by Idazoxan and noise. At the end of the session, Clonidine led to slower responses and this effect was significantly reduced by Idazoxan but not by noise.

KEYWORDS: Central Noradrenaline; Noise; Clonidine; Idazoxan; Choice Reaction Time.

INTRODUCTION

Central noradrenaline plays a key role in brain activation. Clonidine, an antihypertensive α_2 -adrenergic receptor agonist, creates a state resembling sleep deprivation and has been shown to impair sustained attention,^[1] reduce alertness^[2] and slow saccadic eye movements.^[3] The effects of Clonidine on attention have been shown to be blocked by the selective antagonist Idazoxan^[1] and similar effects have been observed for subjective alertness^[2] and eye movements.^[3] The effects of these noradrenergic drugs on cardiovascular function, often considered as an index of arousal, have also been investigated.^[3] Blood pressure was stable in the placebo group, increasing after being given Idazoxan and decreasing after ingestion of Clonidine. The combination of Idazoxan and Clonidine led to different results for diastolic and systolic blood pressure. Systolic blood pressure was increased in the combined condition, although to a lesser extent than when Idazoxan was given alone. Diastolic pressure was constant during the first two post-treatment sessions but declined in the third session to 95% of baseline. Blood pressure was higher at all sessions for those who received Idazoxan and Clonidine compared to those who only received Clonidine.

There has been extensive research on the effects of noise on performance, with my own research leading to over 50 publications^[4-63] over a fifty-year period. The effects of noise on performance have been explained by changes in arousal.^[64-65] Loud noise initially increases arousal, which can lead to improvements in certain tasks.^[35,57,64,65] Longer noise exposure leads to over-arousal, which can then give rise to fatigue and impaired performance. The antagonistic effect of noise on low levels of arousal, such as those due to sleep deprivation,^[66,67] provides strong support for the arousal theory of noise. The studies of noise and Clonidine can be interpreted in a similar way. Tasks and subjective ratings carried out soon after the start of the noise showed a significant reduction of the effects of Clonidine by the noise. Prolonged exposure to noise did not reduce the effects of Clonidine because it no longer increased arousal.

The present analyses continued to examine the effects of noradrenergic drugs on performance. The tasks reported here were four-choice reaction time tasks carried out at the beginning and end of a one-hour noise exposure. It was predicted that Clonidine would lead to psychomotor slowing and that this effect would be blocked by Idazoxan. It was also predicted that the initial noise exposure would reduce the effect of Clonidine but that this effect would not be observed with prolonged exposure to the noise. The tasks also allowed

the investigation of the effects of noise and noradrenergic drugs on the selectivity of attention. Prior research has shown that noise biases attention towards the high probability or dominant feature of the tasks.^[62,63] One study used a choice reaction time task where one target was more probable than others.^[15] The reaction times to the more probable target were faster than those to the less probable, and this biased probability effect was greater in noise than quiet. The effects of the noradrenergic drugs and noise on the biased probability effect were also examined in the present analyses.

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, and one four-choice reaction time task was carried out near the start of the session and the other near the end.

Four choice reaction time tasks

Two four-choice reaction time tasks were used. The first, carried out near the start of each test session, involved pressing the appropriate key on a response box when one of the letters A, B,

C or D was presented in the centre of the computer screen. Three of the letters were presented 50 times, and the other 100 times. The second task was identical, except that the stimuli were presented in the four corners of the screen. Reaction times were measured to the nearest msec using a timer card in the computer.

Analysis strategy

Analyses of covariance (ANCOVAs) were used to analyse the data. The mean reaction time scores in the post-drug sessions were used as the dependent variables, and separate analyses were conducted for the central and different location tasks. Noise and drug conditions were the between-subject factors. The baseline score for each task was used as the covariate, and the within-subject factor was testing sessions.

RESULTS

Four-choice reaction time task central presentation of letters

The results from this task are shown in Table 1. There was a significant effect of drug conditions ($F_{3, 49} = 7.46$ $p < 0.005$). Reaction times were slowest in the Clonidine condition and fastest in the Idazoxan condition. The combination of Idazoxan and Clonidine reduced the slowing seen in the Clonidine condition. There was also a significant drug \times noise interaction ($F_{3, 49} = 3.03$ $p < 0.05$). In the quiet condition, Clonidine was associated with the slowest reaction time, an effect that was greatly reduced by noise.

Table 1: Effects of drug and noise on mean reaction time in msec (scores are the adjusted means from the ANCOVA).

| | Placebo | Idazoxan + Clonidine | Idazoxan | Clonidine |
|---------|---------|----------------------|----------|-----------|
| Quiet | 567 | 554 | 529 | 732 |
| Noise | 542 | 602 | 524 | 583 |
| Overall | 554 | 578 | 526 | 657 |

Four-choice reaction time task stimuli presented in the corners of the screen

There was a significant effect of drug condition ($F_{3, 49} = 4.59$ $p < 0.01$). The mean reaction time in the placebo condition was 538 msec. Reaction times were slowest in the Clonidine condition (mean = 607 msec) and fastest in the Idazoxan condition (mean = 501 msec). The combination of Idazoxan and Clonidine removed the slowing seen in the Clonidine condition (mean = 525 msec). The noise \times drug interaction was not significant.

Effect of the biased probability

There was a significant effect of the probability of occurrence of the different stimuli in both tasks (Central task: $F(3, 149) = 15.69$, $p < 0.0001$; Different location: $F(3, 149) = 8.81$, $p < 0.0001$). The mean reaction time for the high-probability letter in the central task was 536 msec, and the mean for the lower-probability letters was 585 msec. The size of the biased probability effect was not modified by the drugs or noise. In the different location tasks, the mean reaction time for the high-probability letter was 462 msec, and the mean for the lower-probability letters was 570 msec. Again, the size of the biased probability effect was not modified by the drugs or noise.

DISCUSSION

The results from the present analyses confirm the findings from a sustained attention task and subjective alertness ratings.^[1,2] These earlier analyses showed that Clonidine led to more lapses of attention and lower alertness and that these effects were removed by Idazoxan and by exposure to noise. The present analyses and the earlier analyses of alertness considered the effects of the drugs and noise at the start and end of the test session. The results from the central location four-choice task carried out at the start of the session agreed with the results on lapses of attention and subjective alertness at the start of the session. Initial exposure to noise increased alertness, and this effect was very clear in the Clonidine condition, which reduced alertness. In this respect, the present results confirm those from the noise-sleep deprivation literature, where noise reversed the low alertness seen in sleep-deprived individuals.^[64,65]

Longer exposure to noise reduces alertness, and impaired performance is often observed following prolonged exposure to noise.^[62,63] It was predicted, therefore, that, as in the alertness analyses, longer exposure to noise would not reverse the effect of Clonidine. This was obtained in the analysis of the different locations four-choice task carried out at the end of the session. Clonidine still reduced performance at this time, and this slowing of reaction times was blocked by Idazoxan. Idazoxan alone led to the fastest reaction times, possibly because it restored function when it was below the optimum.

The four-choice reaction time tasks had some stimuli that were more probable. These were responded to more quickly, but this biased probability effect was not modified by drug conditions or noise. This suggests that previous effects of noise on this task reflect strategy selection when first exposed to noise.^[11]

The present study had several limitations. First, continuous white noise was used, and the literature shows that different effects are found with other types of noise. Another limitation was that only single doses of the drugs were used, and it is possible that a different profile of results would be observed with larger or smaller doses.

CONCLUSION

In conclusion, previous research has shown Clonidine induces a state similar to sleep deprivation and impairs sustained attention and subjective alertness. Noise and the selective antagonist, Idazoxan, block the Clonidine-induced impairment of sustained attention and alertness at the start of the test session. These effects were found in the present analysis of the speed of reaction in a four-choice task carried out near the start of the test session. Prolonged exposure to noise did not have an alerting effect in the Clonidine condition and did not remove the slowing observed in a four-choice task. Idazoxan increased the speed of reaction when the person was given Clonidine and towards the end of a fatiguing test session. Neither drug condition nor noise changed the biased probability effect, which suggests that the noradrenergic system may not influence selective attention. Further research with different types of tasks is required to examine selectivity in memory and attention in more detail.

ACKNOWLEDGEMENTS

This study was supported by the UK Medical Research Council.

REFERENCES

1. Smith, A.P. & Nutt, D.J. 1996. Noradrenaline and attention lapses. *Nature*, 380: 291. doi: 10.1038/380291a0
2. Smith, A.P., Coupland, N., Bailey, J. & Nutt, D. 2021. Effects of noise, Clonidine and idazoxan on eye movements. *ICBEN* 2021. http://www.icben.org/2021/ICBEN%202021%20Papers//full_paper_33145.pdf
3. Smith, A.P. 2023. The effects of noise, Clonidine and Idazoxan on subjective alertness. *World Journal of Pharmacy and Pharmaceutical Sciences*, 12(12): 65-78. DOI: 10.20959/wjpps202312-26177
4. Jones, D. M., Smith, A. P. & Broadbent, D. E. 1979. Effects of moderate intensity noise on the Bakan vigilance task. *Journal of Applied Psychology*, 64: 627 - 634.
5. Smith, A. P. 1980. Low levels of noise and performance. In: J. V. Tobias, G. Jansen & W. Dixon Ward (eds), *Proceedings of the Third International Congress on Noise as a Public Health Problem*. American Speech-Language-Hearing Association.

6. Smith, A. P. & Broadbent, D. E. 1980. Effects of noise on performance of embedded figures tasks. *Journal of Applied Psychology*, 65: 246 - 248.
7. Smith, A. P. & Broadbent, D. E. 1981. Noise and levels of processing. *Acta Psychologica*, 47: 129 – 142
8. Smith, A. P., Jones, D. M. & Broadbent, D. E. 1981. The effects of noise on recall of categorised lists. *British Journal of Psychology*, 72: 299-316.
9. Smith, A. P. 1982. The effects of noise and task priority on recall of order and location. *Acta Psychologica*, 51: 245-255.
10. Smith, A. P. & Broadbent, D. E. 1982. The effects of noise on recall and recognition of instances of categories. *Acta Psychologica*, 51: 257 - 271.
11. Smith, A. P. 1983. The effects of noise on strategies of human performance. In: G. Rossi (ed.), *Proceedings of the Fourth International Congress on Noise as a Public Health Problem*. Centro Richerche e studi amplifon, Milan. Pp. 797-808.
12. Smith, A. P. 1983. The effects of noise and time on task on recall of order information. *British Journal of Psychology*, 74: 83 - 89.
13. Smith, A. P. 1983. The effects of noise and memory load on a running memory task. *British Journal of Psychology*, 74: 439 - 445.
14. Smith, A. P. & Miles, C. 1985. The combined effects of noise and nightwork on human function. In: D. Osborne (ed.), *Contemporary Ergonomics 1985*. London: Taylor & Francis, 33 - 41.
15. Smith, A. P. 1985. Noise, biased probability and serial reaction. *British Journal of Psychology*, 76: 89 - 95.
16. Smith, A. P. 1985. The effects of different types of noise on semantic processing and syntactic reasoning. *Acta Psychologica*, 58: 263 - 273.
17. Smith, A. P. & Broadbent, D. E. 1985. The effects of noise on the naming of colours and reading of colour names. *Acta Psychologica*, 58: 275 - 285.
18. Smith, A. P. 1985. The effects of noise on recall of lists of associated words. *Current Psychological Research & Reviews*, 4: 17 - 21.
19. Smith, A. P. 1985. The effects of noise on the processing of global shape and local detail. *Psychological Research*, 47: 103 - 108.
20. Smith, A. P. & Miles, C. 1986. The combined effects of nightwork and noise on human function. In: M. Haider, M. Koller & R. Cervinka (eds), *Studies in Industrial and Organizational Psychology 3: Night and Shiftwork: Long-term effects and their prevention*. Frankfurt: Peter Lang, 331 - 338.

21. Smith, A. P. 1986. Cognitive effects of noise, heat and other stressors. In: Proceedings of the Workshop on Cognitive Testing Methodology. Washington: National Academy of Sciences, 114 - 128.
22. Smith, A. P. & Stansfeld, S. 1986. Aircraft noise exposure, noise sensitivity, and everyday errors. *Environment and Behavior*, 18: 214 - 216.
23. Smith, A. P. & Miles, C. 1986. Acute effects of meals, noise and night work. *British Journal of Psychology*, 77: 377 - 389.
24. Smith, A. P. & Miles, C. 1987. The combined effects of occupational health hazards: An experimental investigation of the effects of noise, night work and meals. *International Archives of Occupational and Environmental Health*, 59: 83 - 89.
25. Smith, A. P. 1987. Activation states and semantic processing: A comparison of the effects of noise and time of day. *Acta Psychologica*, 64: 271 - 288.
26. Smith, A. P. & Miles, C. 1987. Sex differences in the effects of noise and night work on performance. *Work and Stress*, 1: 333 - 339.
27. Smith, A. P. & Ottmann, W. 1987. Einflub von Umgebungsfaktoren aufdie psychische Leistung. In: *Arbeitspsychologie (Bond 1 der serie Wirtschaft-, Organisations- und Arbeitspsychologie der Enzyelopadie der Psychologie)*, (eds) U. Kleinbeck & J. Rutenfranz. Gottingen: Hogrefe, 304 - 359.
28. Smith, A. P. & Miles, C. 1987. Individual differences in the effects of noise and nightwork: (1) Introversion-Extraversion, neuroticism and anxiety. In: *Contemporary Advances in Shiftwork Research*, (eds) A. Oginski, J. Pokorski & J. Rutenfranz. Krakow: Medical Academy.
29. Smith, A. P. & Miles, C. 1987. Individual differences in the effects of noise and nightwork: (2) Circadian types. In: *Contemporary Advances in Shiftwork Research*, (eds) A. Oginski, J. Pokorski & J. Rutenfranz. Krakow: Medical Academy.
30. Miles, C. & Smith, A. P. 1988. Combined effects of noise and nightwork on running memory. In: *Practical Aspects of Memory: Current Research and Issues, Vol.2*, (eds) M. Gruneberg, P. E. Morris & R. N. Sykes. Chichester: Wiley, 224 - 229.
31. Smith, A. P. 1988. Acute effects of noise exposure: an experimental investigation of the effects of noise and task parameters on cognitive vigilance tasks. *International Archives of Occupational and Environmental Health*, 60: 307 - 310.
32. Smith, A. P. 1988. Noise, S-R compatibility, and hand dominance. *Scandinavian Journal of Psychology*, 29: 180 - 185.

33. Smith, A. P. 1988. Individual differences in the combined effects of noise and nightwork on human performance. In: Recent Advances in Researches on the Combined Effects of Environmental Factors, (ed.) O. Manninen. Tampere, Finland, 365 - 380.
34. Smith, A. P. 1989. Noise, confidence ratings and recognition memory. In: Contemporary Ergonomics 1989, (ed.) E. D. Megaw. London: Taylor & Francis, 482 - 487.
35. Smith, A. P. 1989. A review of the effects of noise on human performance. Scandinavian Journal of Psychology, 30: 185 - 206.
36. Smith, A. P. 1989. Circadian variation in stress: the effects of noise at different times of day. In: Stress and Anxiety, Vol.12, (eds) C.Spielberger, I.G. Sarason & J. Strelau. New York: Hemisphere, 141 - 151.
37. Smith, A. P. 1990. An experimental investigation of the combined effects of noise and nightwork on human function. In: Noise as a Public Health Problem, Vol.5, New Advances in Noise Research, Part II, (eds) B. Berglund & T. Lindvall. Stockholm: Swedish Council for Building Research, 255 - 271.
38. Smith, A. P. 1990. Noise, task parameters and cognitive vigilance tasks. In: Contemporary Ergonomics 1990, (ed.) E. Lovesey. London: Taylor & Francis, 98 - 103.
39. Smith, A. P. 1990. Effects of noise and task parameters on dual cognitive vigilance tasks. In: Proceedings of the First International Conference on Visual Search, (ed.) D.Brogan. London: Taylor & Francis, 339 - 344.
40. Smith, A. P. 1990. Noise, performance efficiency and safety. International Archives of Occupational and Environmental Health, 62: 1 - 5.
41. Smith, A. P. 1990. Individual differences in the effects of noise and nightwork on mood. Archives of Complex Environmental Studies, 2: 9 - 15.
42. Smith, A. P. 1991. The combined effects of noise, nightwork and meals on mood. International Archives of Occupational and Environmental Health, 63: 105 - 108.
43. Smith, A. P. Noise and aspects of attention. 1991. Special edition of the British Journal of Psychology, 82: 313 - 325.
44. Smith, A.P. 1993. Noise and selective attention. Proceedings of 6th International Congress on noise as a public health problem. Actes Inrets, 34(2): 535-538.
45. Smith, A.P., Thomas, M., Brockman, P. 1993. Noise, respiratory virus infections and performance. Proceedings of 6th International Congress on noise as a public health problem. Actes Inrets, 34(2): 311-314.
46. Smith, A.P. 1993. Recent advances in the study of noise on human performance. 6th International Congress on Noise as a Public Health Problem. Actes Inrets, 3: 293-300.

47. Smith, A.P., Whitney, H., Thomas, M., Perry, K. & Brockman, P. 1997. Effects of caffeine and noise on mood, performance and cardiovascular functioning. *Human Psychopharmacology*, 12: 27-34.
48. Smith, A.P. 1997. Noise and performance. In: IEH Report on The Non-Auditory Effects of Noise, R10: 68-69.
49. Hygge, S., Jones, D.M. & Smith, A.P. 1998. Recent developments in noise and performance. 7th International Congress on Noise as a Public Health Problem. N.Carter & R.F.S. Job (eds). 321-328.
50. Smith, A.P., Whitney, H., Thomas, M., Perry, K., & Brockman, P. 1998. Noise, caffeine and performance. 7th International Congress on Noise as a Public Health Problem. N.Carter & R.F.S. Job (eds). 377-380.
51. Smith, A. 2005. Aircraft and road traffic noise and children's cognition. *The Lancet*, 366: 715-716.
52. Smith, A.P. & McNamara, R. 2002. Noise disturbed sleep aboard ships and on oil installations. *Internoise 2002*. N528. Institute of Noise Control Engineering, Washington, USA.
53. Smith, A.P. & Ellis, N. 2002. Objective measurement of the effects of noise aboard ships on sleep and mental performance. *Internoise 2002*. N530. Institute of Noise Control Engineering, Washington, USA.
54. Smith, A.P. 2003. Noise, accidents, minor injuries and cognitive failures. 8th International Congress on Noise as a Public Health Problem. Edited by R.G. de Jong, T.Houtgast, E.A.M. Franssen & W.F. Hofman. Schiedam: Foundation ICBEN, 2003; 140-144. ISBN 90-807990-1-7.
55. Smith, A.P. & Rich, N. 2004. A longitudinal study of noise exposure, noise sensitivity, noise disturbed sleep and reports of health. *Proceedings of the 33rd International Congress and Exposition on Noise Control Engineering*. 44. Prague.
56. Smith AP, Waters B, & Jones H. 2010. Effects of prior exposure to office noise and music on aspects of working memory. *Noise and Health*, 12: 49, 235-43. Doi: 10.4103/1463-1741.70502
57. Smith, A.P. 2012. An update on noise and performance. Comment on Szalma and Hancock (2011). *Psychological Bulletin*, 138(6): 1262-1268. doi;10.1037/a0028867
58. Smith, A.P. 2017. Effects of noise on errors, injuries and subjective health of nursing staff. ICBEN 2017.

- http://www.icben.org/2017/ICBEN%202017%20Papers/SubjectArea04_Smith_0405_2458.pdf
59. Smith, A.P. 2017. Perceptions of noise exposure, well-being and academic attainment of university students. ICBEN 2017. http://www.icben.org/2017/ICBEN%202017%20Papers/SubjectArea04_Smith_P30_2489.pdf
60. Wellens, B.T., McNamara, R., Ellis, N. & Smith, A.P. 2020. Combined effects of occupational noise exposure and shiftwork on performance tasks in a seafaring population. *International Journal of Humanities Social Sciences and Education (IJHSSE)*. ISSN: 2582-0745. 7(7): 150-156. <http://dx.doi.org/10.20431/2349-0381.0707017>
61. Smith, A.P. 2021. Perceptions of noise at work and road traffic accidents. ICBEN 2021. http://www.icben.org/2021/ICBEN%202021%20Papers//full_paper_28000.pdf
62. Broadbent, D.E. 1971. *Decision and stress*. London: Academic Press.
63. Smith, A. P. & Jones, D. M. 1992. Noise and performance. In Smith, A.P & Jones, D.M. (eds), *Handbook of human performance, Vol.1: The physical environment*. London: Academic Press, 1-28.
64. Corcoran, D.W.J. 1962. Noise and loss of sleep *Quarterly Journal of Experimental Psychology*, 14(3): 178-182. <https://doi.org/10.1080/17470216208416533>
65. Wilkinson, R.T. 1963. Interaction of noise with knowledge of results and sleep deprivation. *J Exp Psychol*, 66: 332-337. doi: 10.1037/h0044161. PMID: 14051850.