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Effects of environmental noise on cognitive (dys)functions in schizophrenia: A pilot within-subjects experimental study

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ABSTRACT

Cognitive impairment, particularly in attention, memory and executive function domains, is commonly present and associated with poor functional outcomes in schizophrenia. In healthy adults, environmental noise adversely affects many cognitive domains, including those known to be compromised in schizophrenia. This pilot study examined whether environmental noise causes further cognitive deterioration in a small sample of people with schizophrenia. Eighteen outpatients with schizophrenia on stable doses of antipsychotics and 18 age and sex-matched healthy participants were assessed on a comprehensive cognitive battery including measures of psychomotor speed, attention, executive functioning, working memory, and verbal learning and memory under three different conditions [quiet: ~30 dB(A); urban noise: building site noise, 68–78 dB(A); and social noise: background babble and footsteps from a crowded hall without any discernible words, 68–78 dB(A)], 7–14 days apart, with counter-balanced presentation of noise conditions across participants of both groups. The results showed widespread cognitive impairment in patients under all conditions, and noise-induced impairments of equal magnitude on specific cognitive functions in both groups. Both patient and healthy participant groups showed significant disruption of delayed verbal recall and recognition by urban and social noise, and of working memory by social noise, relative to the quiet condition. Performance under urban and social noise did not differ significantly from each other for any cognitive measure in either group. We conclude that noise has adverse effects on the verbal and working memory domains in schizophrenia patients and healthy participants. This may be particularly problematic for patients as it worsens their pre-existing cognitive deficits.

1. Introduction

Cognitive deficits are considered a central feature of schizophrenia (Reichenberg and Harvey, 2007) and predict poor vocational functioning and everyday activities (Reichenberg et al., 2014; Strassnig et al., 2015). While many studies have aimed at potential cognitive improvement, using pharmacological, psychological, or combination methods (Harvey and Bowie, 2012), the removal of influences that may exacerbate existing cognitive deficits in schizophrenia has received relatively less attention. It is possible that environmental factors, such as noise, cause further cognitive impairment in people with schizophrenia (Wright et al., 2014), especially those living in urban environments.

It has long been observed that schizophrenia patients report oversensitivity to sensory stimuli (Bowers and Freeman, 1966) and this has been linked to problems maintaining selective attention (Braff et al., 1977) and screening out irrelevant information (Saccuzzo and Braff, 1981). Previous research has shown that sensory overload, invoked using a combination of excessive auditory and visual stimuli in a controlled environment, causes an increase in manifestations of schizophrenia like behaviour (unusual thought content, social withdrawal, and general cognitive decline) in healthy participants (Gottschalk et al., 1972). A number of studies have already documented the adverse effects of noise, using 'real-life' noise stimuli (e.g. multiple conversations, traffic noise), on certain cognitive functions, namely, attention, working memory and episodic recall in healthy adults (Wright et al., 2014). To our knowledge, there is no previous study examining the impact of environmental noise on these cognitive functions in people with schizophrenia.

Therefore, the primary aim of this pilot study was a preliminary investigation into the profile and magnitude of noise effects on cognitive functioning of people with a diagnosis of schizophrenia. Based on the pattern of noise-induced cognitive disruption seen in healthy adults (Wright et al., 2014), we hypothesised that noise would impair the performance of both healthy participants and individuals with schizophrenia on tests of attention, working memory and episodic recall. It was further hypothesised that performance of those with schizophrenia may be more adversely affected than that of healthy participants,

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given recent observations of increased hemodynamic response (Tregellas et al., 2009) and self-reported sensitivity to noise (Landon et al., in press), in addition to long established sensory gating deficits (Braff, 2010; Patterson et al., 2008), in this clinical population. A secondary aim was to explore possible differential effects of urban (e.g. building site) and social (e.g. bustling shopping centre) noise in schizophrenia patients. Although previous studies have shown similar effects of urban and social noise in cognitive performance of healthy adults (review, Wright et al., 2014), social noise may be relatively more disruptive to cognitive performance of patients, given the association between positive symptoms and exposure to social situations in this population (Freeman et al., 2015).

2. Methods

2.1. Participants and design

The study involved 18 outpatients who met ICD-10 criteria (World Health Organization, 1992) for diagnosis of schizophrenia and 18 age and sex-matched healthy participants. All participants were assessed on a cognitive battery (*Cognitive assessments*) under three noise conditions (quiet, urban, and social; detailed under *Noise conditions*), with a 1–2 weeks interval between any two assessments. The order of noise conditions (quiet-social-urban, quiet-urban-social, urban-social-quiet, urban-quiet-social, social-quiet-urban, social-urban-quiet) was counter-balanced across participants of both groups (each order used three times per group).

Patients were recruited from the outpatient clinical services of the South London and Maudsley NHS Foundation Trust and local research registers. Healthy participants were recruited via King's College London circulars to staff and students and local advertisements, and screened to rule out a personal or family history of an Axis I or II disorder. The inclusion criteria required all participants to (i) be aged 18–64, (ii) have normal-to-corrected hearing and vision, (iii) be fluent in English, (iv) have no history of organic brain disorder or primary ICD-10 diagnosis of substance abuse disorder, and (v) have IQ ≥ 80, assessed using the two subtest version of the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999). An additional exclusion criterion for patients was a period of hospitalisation or a change in medication within 6 months prior to participation.

For sample characterisation purposes (Table 1), all participants were assessed on predicted IQ using the National Adult Reading Test (Nelson and Willison, 1991), handedness using the Edinburgh Handedness Inventory (Oldfield, 1971), subjective sensitivity to noise using the Noise Sensitivity Questionnaire (Schutte et al., 2007), sleep quality using the Pittsburgh Quality of Sleep Inventory (Buysse et al., 1989), and paranoia occurrence using the Paranoia Checklist (Freeman et al., 2005). In addition, symptoms were rated using the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987) and the age of onset of psychotic symptoms and current medication recorded for those in the patient group.

The study was approved by the NHS Camden and Islington Research Ethics Committee (12/LO/0626). All participants provided written informed consent after the study procedures had been explained to them.

2.2. Noise conditions

All sound generating equipment were kept hidden from participants' view in an adjunct sound-proof room, with the connecting door kept open throughout all testing sessions, and speakers (also hidden from participants' view) kept in the sound-proof testing room.

Quiet (No noise): this condition took place in a quiet [~30 dB(A)] sound-proof laboratory.

Social noise: the social noise stimulus consisted of background babble and footsteps from a crowded hall [68 dB(A)] with louder peaks of indistinguishable social stimuli superimposed on top [78 dB(A); loud enough to cause annoyance but not damage hearing; Berglund et al., 1999]. No specific words could be discerned from the babble but it mimicked a familiar social environment people encounter in cities.

Urban noise: This noise stimulus consisted of building site noise and did not include any social noise. The noise intensity, time profile, and the number and duration of louder peaks were matched to that presented during the social noise stimulus.

Table 1
Sample characteristics.

Demographic characteristics		Schizophrenia patients (N = 18)	Healthy participants (N = 18)	Test (df)	Statistic	p
Gender (N)	Male/female	10/8	7/11	χ^2 (1)	1.00	0.32
Age (years)	Mean (SD)	45.50 (7.93)	43.22 (7.97)	t (34)	0.86	0.40
Handedness (EHI) score	Mean (SD)	0.64 (0.59)	0.44 (0.57)[a]	t (30)	0.97	0.34
Pre-morbid IQ (NART)	Mean (SD)	107.82 (10.10)	115.28 (8.23)	t (34)	2.47	0.02
Current IQ (WASI)	Mean (SD)	98.94 (10.92)[b]	114.06 (14.26)	t (32)	3.44	0.002
Noise sensitivity (NoiSeQ)	Mean (SD)	43.61 (12.80)	43.94 (14.11)	t (34)	0.07	0.94
Sleep quality (PSQI total) ↑	Mean (SD)	9.11 (4.03)	4.94 (4.53)[c]	t (33)	2.88	0.007
Paranoia occurrence ↑	Mean (SD)	45.00 (28.68)[c]	2.89 (6.70)	t (33)	6.06	<0.001
Clinical characteristics (patients only)						
Diagnosis	Schizophrenia only		N (%)	16 (88.89%)		
	Schizophrenia with depression			1 (5.56 %)		
	Schizophrenia with depression and borderline personality disorder			1 (5.56 %)		
Age at first onset (years)			Mean (SD)	20.44 (11.21)		
Antipsychotic medication	Atypical antipsychotic		N (%)	16 (88.89%)		
	Typical antipsychotic		N (%)	2 (11.11%)		
	Years in current medications		Mean (SD)	6.63 (7.65)		
PANSS symptoms	Positive		Mean (SD)	19.56 (6.09)		
	Negative		Mean (SD)	11.39 (3.45)		
	General psychopathology		Mean (SD)	31.61 (11.39)		

EHI = Edinburgh's Handedness Inventory; NART = Nelson Adult Reading Test; WASI: Wechsler Abbreviated Scale of Intelligence; NoiSeQ = Noise Sensitivity Questionnaire; PSQI = Pittsburgh Sleep Quality Index; PANSS = Positive and Negative Syndrome scale.
↑ Higher scores indicate poorer overall sleep quality or greater paranoia levels.
[a] Reduced N, 3 missing.
[b] 2 missing.
[c] 1 missing.

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