

## **Prior and current perceptions of noise exposure: effects on university students' wellbeing and attainment**

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### **ABSTRACT**

Extensive research shows that noise influences the cognitive performance of school children. This is especially true for aircraft noise exposure. In contrast, effects of noise on children's wellbeing appear to be less robust. There is also extensive research that a child's exposure to negative events can influence their later wellbeing and attainment. The present study is part of a programme of research examining factors which influence university students' wellbeing and attainment. In the present study 327 undergraduate students completed a survey measuring noise exposure when they were at primary and secondary school and also their current exposure to different types of noise. Wellbeing was assessed using the Student Wellbeing Process Questionnaire (SWPQ). Academic attainment was measured using results from coursework and exams to provide a grade point average (GPA) score. Analyses showed that perceived current noise was not associated with wellbeing or attainment. Perceptions of exposure to aircraft noise as a child were associated with lower GPA scores. This last result was interpreted in terms of an effect of prior noise exposure on motivation to learn.

### **INTRODUCTION □**

This paper is part of a research programme investigating factors which influence well-being and performance. Much of this research has been conducted with working populations [1-13] and a key feature of the research has been the use of short measuring instruments covering multiple concepts [14]. This allows sophisticated models to be tested [15; 16] and a variety of possible confounding factors to be co-varied. The research has also moved away from using only negative outcomes (e.g. stress, negative affect and anxiety/depression) to consider positive ones as well (e.g. life satisfaction, positive affect and happiness). This is important because research has shown that positive and negative states are not just the end points of a single continuum but have different underlying neural mechanisms. This view is consistent with early conceptualisations of well-being [17] but it has subsequently been argued that the early conceptualisations of well-being neglected important aspects of psychological health [18]. Although there is not yet a concrete definition of well-being, it has been loosely defined

as the combination of multiple associated variables, with negative, positive and subjective features, which are each considered independent parts of a whole [19].

A number of predictors of well-being have been identified. One of the most significant predictors of well-being is thought to be personality [20], with different aspects of personality being associated with various features of wellbeing. For example, extraversion and agreeableness tend to be associated with positive affect, neuroticism is a strong predictor of negative affect and conscientiousness is positively correlated with life satisfaction [21]. Our recent research has established robust predictors of well-being [14] and, in university students, these are stressors, negative coping (e.g. wishful thinking), social support and positive personality (self-efficacy, self-esteem and optimism). When assessing the impact of a specific factor on well-being, it is important to include these established factors in the analysis. The significance of the established factors gives one confidence that there is nothing unusual about the sample. It also means that one does not attribute effects to the additional factor being considered that actually reflects correlations with the established factors. When one considers predictors of academic performance one also needs to adjust for established predictors. Prior academic achievement (e.g. 'A' level grades) is an important predictor but so are psychological variables. One specific aspect of personality that has emerged to be central to aspects of academic motivation is conscientiousness [22]. This suggests that those who are organised and disciplined are most likely to be motivated and achieve higher grades. 'A' level grades and conscientiousness scores were recorded in the present study.

The current research used the Student Well-Being Process Questionnaire (SWPQ; [14]) to assess levels of subjective well-being in a student population. The SWPQ is a set of measures that can be combined together to provide a multidimensional measure of well-being and the factors that contribute to well-being outcomes. The SWPQ uses single-item measures to assess levels of subjective wellbeing. The practical benefits of a single-item measure relate to where more variables can be measured in less space. Although this can sometimes be at the expense of detail, shorter measures have benefits for research in terms of reduced cost and ease of interpretation [14]. Short-item measures have achieved a high status in research with their high degree of accuracy, from being developed carefully from the most influential aspects of the multi-item measures [23]. Indeed, the WPQ has proved its reliability in previous survey research and it has been shown to yield similar results to those obtained with longer scales [14].

There has been increasing interest in well-being in all groups in society. This is often driven by greater awareness of the level of common mental health problems. This has been the case with university students with research from the UK and the USA showing that high levels of depression, anxiety and stress are reported by undergraduate students [24]. This plausibly reflects the fact that the lives of students have become increasingly difficult in recent years, with changes to student grants and increasing academic pressures. In addition, with more, and more, young people attending universities in the UK, the pressure to achieve a respectable degree is far greater with increasing competition for future jobs [25]. Moreover, comparisons between students and the general population have reported that the psychological well-being of students is worse than those of a similar age who do not have these university pressures [26]. With the increasing academic and financial pressure upon students, it is not surprising that one elevated aspect of well-being is anxiety. At the beginning of the first year at university, anxiety is one of the most prominent well-being aspects, scoring higher than all other domains [25]. Further research has suggested that between one- and two-thirds of students report anxiety about their studies, which subsequently limits their capacity to study [27]. These anxiety conditions can have an impact on the attainment of students in their first year of university, reducing the potential likelihood of achieving a first-class degree [28]. Therefore, reduced well-being in students has the potential to negatively

affect academic attainment. Sleep is believed to be closely linked to the regulation of physical and emotional well-being. Early research indicates that poor sleep quality in students is associated with increased irritability, depression and lower life satisfaction [29]. Researchers have long noted an association between sleep disruptions and anxiety symptoms [30]. A recent study found that of the 129 children and adolescents with anxiety disorders, over half had three or more sleep disturbances, and 88% had at least one sleep problem [31]. Further, sleep disturbance symptoms in early childhood are associated with the occurrence of anxiety disorders over 20 years later [32]. Therefore, university students are likely to be at risk of increased anxiety experiences as a result of sleep disturbances throughout childhood. Other research has shown that depression is also likely to be a risk factor for university students [33]. Lack of sleep in students has been significantly associated with depression outcomes. Individuals who have poor sleep quality, sleep less than 7 hours at night and experience increased sleepiness during the day and manifest irritability as well as depressive symptoms [34]. This suggests that poor sleep can result in depressive as well as anxiety outcomes, with depression also causing sleep problems. According to when adolescents and students fail to achieve specific developmental tasks, such as peer relationships, gender roles, achieving emotional independence, preparing for a career, and achieving socially responsible behaviour, this leads to unhappiness, disapproval by society and difficulty with subsequent tasks [35]. These difficulties can also lead to depressive outcomes for students.

While there has been extensive research on the effects of environmental noise on the cognitive abilities of school children [36 – 40], it is not known whether these effects are observed in university students. Studies on the effects of noise on well-being of children have demonstrated reduced well-being in very young (3 year old) children [41]. Research has also shown that noise at school reduces the well-being of teachers [42] and sometimes the children [43]. However, little is known about the effects of noise on the well-being and attainment of university students. The first aim of the present study was to investigate associations between perceived current noise exposure from a number of sources (e.g. traffic noise, noise from neighbours) and well-being and academic attainment. Established predictors of well-being and attainment were also measured and included in the analyses. The above section suggests that it is plausible that noise may influence well-being, either directly, or by increasing stress which in turn leads to an increase in negative affect. Noise may also have other indirect effects (e.g. by interfering with sleep) which could reduce well-being and impair performance. Research has also shown that exposure to noise reduces motivation [44] and this may be an important mechanism through which noise could impair performance.

As well as investigating current noise exposure, the present study examined the association between prior perceived noise exposure (while the students were at primary and secondary schools) and outcomes at university. The above section showed that experiences during childhood can have effects in later life. This has usually involved investigation of traumatic experiences but it is plausible that similar mechanisms may be applicable to exposure to environmental stressors. Research has also shown [45] that noise sensitivity may be a risk factor for the development of health problems in the elderly. Noise sensitivity was included here in order to examine whether it has specific effects on well-being and attainment, or whether it reflects other psychosocial characteristics [46]. In addition, interactions between perceived noise exposure and noise sensitivity were examined in the analyses of well-being and attainment.

## **METHOD**

Ethical approval for this study was given by the Cardiff University, School of Psychology Ethics Committee, and the survey completed with the informed consent of the participant. The

Student Wellbeing Process Questionnaire (SWPQ) and the additional noise questions were presented as an online survey which was completed by first and second year undergraduate students. They received course credits for their participation. The participants consented to allowing access to their academic attainment results which were merged with the online survey which was then anonymised.

**Participants**

Three hundred and twenty seven students (290 female, 37 male; mean age: 19.4 years, range 18-41 years) completed the study.

**The Survey**

The questions relating to perceived noise exposure and noise sensitivity are shown in Table 1.

**Table 1:** Questions asking about noise exposure and noise sensitivity (unless shown, questions were answered on a 10-point scale ranging from ‘Not at All’ to ‘Very Frequently’)

When you were a child how frequently were you exposed to the following types of noise:
1. Traffic Noise
2. Aircraft Noise
3. Railway Noise
4. Machinery Noise
5. Noise from Neighbours
6. How frequently were you exposed to noise at primary school?
7. How frequently were you exposed to noise at secondary school?
In your current university accommodation how often are you exposed to the following types of noise:
8. Traffic noise
9. Aircraft noise
10. Railway noise
11. Machinery noise
12. Noise from Neighbours
Would you describe yourself as being sensitive to noise? (1=‘Not at all’ to 10 = ‘Very much so’.

The SWPQ consisted of two main sections. The first included student stressors, social support, negative coping, positive personality and conscientiousness. These questions are shown in Table 2. The next section included the well-being outcome measures. These included both negative (e.g. anxiety) and positive outcomes (e.g. happiness) and appraisals (negative appraisal: stress; positive appraisal (life satisfaction) and the questions are shown in Table 3.

**Table 2:** Questions measuring established predictors of well-being and attainment

<i>Student Stressors: (Responses on a 10-point scale: 1='Not at All' to '10=Very Much')</i>
Please consider the following elements of student life and indicate overall to what extent they have been a part of your life over the past six months. Remember to use the examples as guidance rather than trying to consider each of them specifically:
1. Challenges to your development (e.g. important decisions about your education and future career, dissatisfaction with your written or mathematical ability, struggling to meet your own or others' academic standards).
2. Time pressures (e.g. too many things to do at once, interruptions of your school work, a lot of responsibilities).
3. Academic Dissatisfaction (e.g. disliking your studies, finding courses uninteresting, dissatisfaction with school).
4. Romantic Problems (e.g. decisions about intimate relationships, conflicts with boyfriends'/girlfriends' family, conflicts with boyfriend/girlfriend).
5. Societal Annoyances (e.g. getting ripped off or cheated in the purchase of services, social conflicts over smoking, disliking fellow students).
6. Social Mistreatment (e.g. social rejection, loneliness, being taken advantage of).
7. Friendship problems (e.g. conflicts with friends, being let down or disappointed by friends, having your trust betrayed by friends)
<i>Social Support</i>
<i>Please state how much you agree or disagree with the following statements (1='strongly disagree; 10='strongly agree')</i>
1. There is a person or people in my life who would provide tangible support for me when I need it (e.g. money for tuition or books, use of their car, furniture for a new apartment).
2. There is a person or people in my life who would provide me with a sense of belonging (for example: I could find someone to go to a movie with me, I often get invited to do things with other people, I regularly hang out with friends).
3. There is a person or people in my life with whom I would feel perfectly comfortable discussing any problems I might have (for example: difficulties with my social life, getting along with my parents, sexual problems).
<i>Negative coping</i>
<i>Please state how much you agree or disagree with the following statements (1='strongly disagree; 10='strongly agree')</i>
1. When I find myself in stressful situations, I blame myself (e.g. I criticize or lecture myself, I realise I brought the problem on myself).
2. When I find myself in stressful situations, I wish for things to improve (e.g. I hope a miracle will happen, I wish I could change things about myself or circumstances, I daydream about a better situation).
3. When I find myself in stressful situations, I try to avoid the problem (e.g. I keep things to myself, I go on as if nothing has happened, I try to make myself feel better by eating/drinking/smoking).
<i>Positive Personality</i>
1. Overall, I feel that I have positive self-esteem (for example: On the whole I am satisfied with myself, I am able to do things as well as most other people, I feel that I am a person of worth)
2. I am confident in my ability to solve problems that I might face in life (for example: I can usually handle whatever comes my way, If I try hard enough I can overcome difficult problems, I can stick to my aims and accomplish my goals)
3. In general, I feel optimistic about the future (for example: I usually expect the best, I expect more good things to happen to me than bad, It's easy for me to relax)
<i>Conscientiousness</i>
I feel that I am a conscientious person (for example: I am always prepared, I make plans and stick to them, I pay attention to details)

**Table 3:** Questions measuring well-being outcomes (all questions have a 10 point response scale, e.g. 1='Not at all' to 10='Very much so')

1. On a scale of one to ten, how depressed would you say you are in general? (E.g. feeling 'down', no longer looking forward to things or enjoying things that you used to)
2. Overall, how stressful is your life?
3. Generally, how happy are you?
4. Overall, I feel that I am satisfied with my life (for example: In most ways my life is close to my ideal, so far I have gotten the important things I want in life).
5. On a scale of one to ten, how anxious would you say you are in general? (E.g. feeling tense or 'wound up', unable to relax, feelings of worry or panic).
6. Overall, how often do you feel physically fatigued?
7. Overall, how often do you feel mentally fatigued?

The SWPQ also collected demographic information (e.g. age and gender), studying information (year; course; 'A level scores'; how efficiently they perceived they studied), information on health-related behaviours (e.g. smoking), general health and body mass index.

## RESULTS

### Current noise exposure

Frequency of perceived noise exposure was generally on the low side, with noise from neighbours being the most frequent (mean rating = 6.42 s.d. = 2.6) and aircraft noise being the least frequent (mean rating = 1.7 s.d. = 1.3). Noise sensitivity was normally distributed with a mean rating of 4.73 (s.d. = 2.52). Initial analyses examined total perceived noise exposure (the sum of the frequencies of the different types of noise). A median split was carried out on the noise and noise sensitivity variables and these were the independent variables in a MANOVA. GPA, 'A level' scores (scored using the UCAS calculator), efficiency of studying (1= not at efficient to 10 = very efficient) and the total negative well-being score (the negative items minus the positive ones) were the dependent variables. This analysis was carried out using the 306 sets of complete data. The MANOVA showed a significant effect of noise sensitivity (Wilks Lambda = 0.94  $F_{4,299} = 5.2$   $p < 0.001$ ). Univariate analyses showed that this was due to high noise sensitivity going with more negative well-being ( $F_{1, 302} = 13.5$   $p < 0.001$ ; Low noise sensitivity: mean = 16.5 s.d. = 11.5; High noise sensitivity: mean = 21.5 s.d. = 11.8). Analyses of the individual noise sources were carried out and there were no significant effects of perceived current noise exposure. This was found when median splits were used to define low/high noise groups and also when high noise was defined as the top 10-15% only.

### Perceived noise exposure in school

Similar analyses were carried out using the perceived frequency of noise in school ratings (mean rating for primary school = 5.74 s.d. = 2.46; mean rating for secondary school = 6.03 s.d. = 2.45). The initial analysis combined the primary and secondary ratings to give a total school noise score. This analysis showed that high perceived noise in school was associated with lower 'A level' scores but no effects on the other variables. Further analyses showed that this was due to secondary school noise ( $F_{1,316} = 7.20$   $p < 0.01$ ; low noise mean = 149.6 s.d. = 22.1; high noise mean = 143.6 s.d. = 17.2). This effect remained significant when

conscientiousness was covaried which suggests that it did not reflect an effect of noise on motivation.

### **Perceived noise exposure as a child**

Again, ratings of perceived noise exposure were generally low (highest rating: Traffic noise mean = 4.92 s.d. = 2.45; lowest = aircraft noise mean = 2.49 s.d. = 1.82). The MANOVA revealed a significant effect of noise (Wilks Lambda = 0.965  $F_{4, 306} = 2.79$   $p < 0.05$ ) and noise sensitivity (but no significant interaction between them). The noise sensitivity effect was due to more negative wellbeing in the high noise sensitivity group. Univariate analyses showed significant effects of noise for both well-being ( $F_{1,309} = 4.43$   $p < 0.05$ ) and GPA scores ( $F_{1,309} = 4.56$   $p < 0.05$ ).

Subsequent analyses examined the individual noise sources and also covaried the established predictors. The two noise sources that were significant were noise from neighbours ( $F_{1,311} = 4.73$   $p < 0.05$ ) and aircraft noise ( $F_{1, 311} = 5.42$   $p < 0.05$ ). The effect of aircraft noise remained significant when both noise from neighbours and aircraft noise were included in the same analyses. However, when the established predictors of well-being (stressors, social support, positive personality and negative coping were included as covariates the effect of aircraft noise was no longer significant. However, the association between noise sensitivity and well-being remained significant when the established predictors were covaried which suggests that it cannot be accounted for by these other psychosocial factors.

Perceived exposure to aircraft noise as a child was associated with lower GPA scores (low aircraft noise: mean = 63.3 s.d. = 7.2 ; high aircraft noise mean = 59.9 s.d = 8.5). However, this effect was no longer significant when conscientiousness was covaried, which suggests that it may reflect lower motivation and engagement in the high aircraft noise group.

## **DISCUSSION**

The first aim of the present study was to investigate the association between perceptions of the frequency of current noise exposure from different sources, noise sensitivity, well-being and academic attainment of university students. The results showed little impact of noise exposure and there was no evidence of an interaction between noise sensitivity and reported noise. However, noise sensitivity was related to well-being, with high noise sensitivity being associated with more negative well-being. This effect remained significant when the established predictors of well-being (stressors, negative coping, positive personality and social support) were co-varied. Earlier accounts of noise sensitivity [46] suggested that it may just reflect negative affectivity. However, the present results show that it has associations with well-being that are largely independent of other psychosocial predictors. This provides a plausible mechanism underlying possible associations between noise sensitivity and health [45]. Further research is required to determine possible underlying mechanisms for such effects.

A second aim of the study was to examine associations with reported noise exposure in school. These results showed that noise in secondary schools is associated with lower 'A' level scores. This effect remained significant when conscientiousness was covaried which suggests that the lower 'A' level scores did not reflect reduced engagement or motivation. Two types of mechanism could underlie this effect. First, the result may not reflect an effect of noise but may be due to some correlated attribute that was not controlled here. Such effects could be produced by socio-economic variables or by other features of the schools. Secondly,

the noise effect could reflect an influence on learning. This is unlikely to be a basic skill such as reading but could relate to other important component skills (e.g. verbal reasoning or retrieval from semantic memory) which are known to be impaired by noise [47]. Future research could investigate this topic in more detail and try and identify key noise parameters and those functions which show an impairment.

The final aim of the study was to examine associations between childhood noise exposure and well-being and academic attainment. The initial analyses suggested that perceptions of higher noise exposure in childhood were associated with more negative well-being. However, these effects were no longer significant when established predictors of well-being were co-varied. Academic attainment, in this case GPA scores, were associated with perceptions of more frequent noise exposure in childhood. Noise from neighbours and aircraft were the two sources associated with the association with GPA scores. Combining the two noise sources in a single analysis revealed that it was aircraft noise that remained a significant predictor. However, the effect of aircraft noise was no longer significant when an established predictor of attainment, conscientiousness, was controlled. This suggests that at least part of the effects of childhood aircraft noise exposure on subsequent attainment is due to lack of engagement or reduced motivation to learn.

The present study had a number of limitations. Ideally, one should obtain a much more detailed profile of noise exposure. This can be done even with subjective perceptions of exposure. For example, one could ask about the intensity of noise as well as the frequency. Objective indicators of noise exposure could also be used and location of the schools and accommodation could be linked to noise maps. Parts of this study considered longitudinal associations (e.g. the prior noise and the subsequent outcomes) and this approach could be used to study effects of noise exposure while at university by taking the noise measurements over time and examining how prior noise exposure influenced coursework and examination performance. Despite the above shortcomings, the present study did have some important features that should be incorporated into future research. Use of a clear model of well-being allowed a more holistic approach to the topic. This multi-variate approach was made possible using the single item methodology validated in earlier research. The study demonstrated the usual effects of established predictors which suggests that a representative sample was selected. Finally, the methodology has allowed a large number of issues to be addressed in a very short period of time.

In summary, the study reported in this article showed that there was little evidence of associations between current perceived frequency of exposure to noise from different sources and the well-being and academic attainment of university students. In contrast, noise sensitivity was associated with well-being and this effect remained significant when established predictors were controlled. Noise exposure in secondary schools was associated with 'A' level performance but not outcomes while at university. Exposure to aircraft noise during childhood was associated with lower GPA scores at university and this effect possibly reflected reduced engagement and motivation to learn. Future research is required to replicate and extend these findings. In addition, it is important to identify underlying mechanisms and address the practical implications of the results.



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