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The Effect of Background Music and Noise on the Cognitive Test Performance of Introverts and Extraverts

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Summary: Previous research has found that the performance of introverts on complex cognitive tasks is more negatively affected by distracters, e.g. music and background noise, than the performance of extraverts. The present study extends previous research by examining whether or not background noise would prove to be as distracting as music. In the presence of silence, background UK garage music and background noise, 118 female secondary school students carried out three cognitive tests. It was predicted that introverts would do less well on all of the tasks than extraverts in the presence of music and noise but in silence performance would be the same. A significant interaction was found on all three of the tasks. It was also predicted that there would be a main effect of background sound: Performance would be worse in the presence of music and noise than silence. Results confirmed this prediction with one exception. This study also found a positive correlation between extraversion and intelligence, the implications of which are also discussed. The findings support the Eysenckian hypothesis of the difference in optimum cortical arousal in introverts and extraverts. Copyright © 2010 John Wiley & Sons, Ltd.

INTRODUCTION

Music is more pervasive now that at any other point in history, and as a result there has been a growing volume of research concerning the effects of background sound (music and noise) on cognitive performance (Cassidy & MacDonald, 2007; Furnham & Strabc, 2002). There is an important applied cognitive psychology literature on the effects of noise on learning and recall (Beaman, 2005; Kjeleberg, Ljung, & Hallman, 2008; Oakes & North, 2006). There have also been studies demonstrating the beneficial effects of music listening on pain (Mitchell, MacDonald, Knussen, & Serpell, 2007; Pothoulaki, MacDonald, Flowers, Stamataki, Filiopoulos, Stamatiadis, & Stathakis, 2008).

There is no doubt that answering the questions of how, when and why background sound can affect productivity, and well being as well as learning are clearly important (Evans & Johnson, 2000; Lesiuk, 2005) The literature has tended to look at three factors: The nature of the *distraction* (i.e. sound *vs*. music), on particular *tasks* (complex *vs*. simple) by particular *individuals* (extravert *vs*. introverts) (Banbury & Berry, 1998). For instance Lesiuk (2005) in a study of the work performance of 56 people over 5 weeks found that music significantly influenced mood (state positive effect) and time on the task. The more people listened to the music the more positive their mood, though it had little effect on work quality. She also noted that some personality types maybe more susceptible to the mood enhancing effects than others.

Early studies showed music is more likely to have an effect on performance when the task is complex (Smith, 1961). Kirkpatrick (1943) demonstrated the negative impact of background music on cognitive performance during tasks that required mental concentration, but McGhee and Gardner (1949) found that music had no significant impact on job performance in an industrial setting. They also concluded that music had no effect on tasks involving mental concentration. Oldham, Cummings, Mischel, Schmidtke, and Zhou (1995) showed that employees who listened to music *via* a personal stereo for 4 weeks had improved performance, turnover intentions, organisation satisfaction and mood states.

Other research has attempted to establish whether different types of music produce different effects on task performance (Furnham, Gunter, & Peterson, 1994). Findings have been inconsistent: Rauscher, Shaw, and Ky (1993) found that spatial IQ scores improved in the presence of some of Mozart's music, whereas Williams (1961) found that classical music had no effect on a reading comprehension task. Furnham and Strabc (2002) noted that the type of music and tasks administered to participants has a notable impact on results; vocal music was found to be significantly more distracting than purely instrumental pieces on similar tasks. Furnham, Trew, and Sneade (1999) examined whether performance would differ on a reading comprehension task, a logical problem-solving task and a coding task in the presence of background vocal music, instrumental music or silence. Results showed that only on the logic task did instrumental music improve performance.

In an important review Beaman (2005) noted that the 'nature of the noise' has an important impact of distractibility. Studies show that irrelevant noise that has abrupt changes in frequency and pitch is particularly disruptive, but that sound intensity has less effect. He also reviewed task-specific effects such as the difference between verbal and numerical processing showing how distracting noise has different effects of different tasks. Further he noted a very few studies on individual differences (intelligence, noise sensitivity) that seem to interact with the noise and task to effect performance.

Work in this area has been informed by Eysenck's (1967a) theory of arousal. Under-stimulated extraverts are predisposed to pursue high stimulation through arousal inducing behaviours; while over-stimulated introverts are inclined to avoid strong stimulation and arousal. Campbell and Hawley

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(1982) tested the theory and found that, when studying in a library, extraverts were more likely to choose to work in areas with bustle and activity while introverts were more likely to opt for a quiet area, away from the noise.

Eysenck's (1981) theory of personality predicts that on tasks of reasonable difficulty, introverts will perform better in non-stimulating conditions, as well in moderately stimulating situations and less well when under more intense stimulation and stress. Background music or noise, with its potential to increase levels of arousal, should have a more negative affect on introverts as it will cause them to exceed their optimum functioning level. A series of studies have demonstrated that introverts who are 'over-aroused' as a result of background disturbance show a greater detriment in performance than extraverts. Daoussis and McKelvie (1986) found introverts performed more poorly on a memory task in the presence of music compared to silence. Earlier research by Binaschi and Pelfini (1966) demonstrated how introverts and extraverts differed in their levels of performance on a visual and auditory reaction task in the presence of noise, with extraverts having shorter reaction times. Furnham and Bradley (1997) found that introverts were detrimentally affected by music in a reading comprehension task and a delayed memory recall task. There was no significant difference between the introverts and extraverts scores when the tests were conducted in silence. Furnham and Strabc (2002) provided evidence to suggest that introverts are more negatively affected by background noise than extraverts, whilst noting a trend for a lower level of performance in both introverts and extraverts in the presence of music. Ylias and Heaven (2003) also found extraverts performed better than introverts on a reading task when distracted but that this was the only 'Big Five' trait that had any main or interaction effect on the task performance.

Belojevic, Slepcevic, and Jokovljevic (2001) looked at concentration problems, fatigue and noise annoyance under quite and noisy conditions. They found, as predicted, introverts were slower than extraverts in the noisy condition and reported more concentration problems and fatigue during mental processing.

More recently Cassidy and MacDonald (2007) got 40 participants to complete five cognitive tasks in four different sound conditions (high and low arousing/affective music, noise, silence). Music, particularly high arousal music produced distraction and reduced performance most, followed by noise, then low arousal music and finally silence. They also found a personality (introversion/extraversion) effect for immediate and delayed recall and a sound $\times$ personality effect for the stroop task: Introverts were significantly poorer than extraverts in the presence of high arousing music. They also noted that extraverts reported working in more social and arousing environments and argued that extraverts may need to seek 'more extreme emotional meaning to achieve the level of arousal met by introverts while in the presence of preferred relaxing music' (p. 533).

The current study investigates the effects personality (level of extraversion) and auditory distraction (background music and noise) on performance in three cognitive tasks. The degree of extraversion of the participants was ascertained using the Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1968) rather than the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975). A number of re-analyses of the relationship between extraversion and arousal have been conducted, and several previously reported relationships between extraversion and arousal were found to hold for the EPI-extraversion scale but not for the EPQ-extraversion scale (see Cox-Fuenzalida, Gilliland, & Swickert, 2001) because it contains more impulsivity and fewer sociability items.

This study makes use of vocal (rather than purely instrumental) music. Iwanga and Ito (2002) examined the disturbance effect of vocal music, instrumental music and natural sound on memory performance, and found that perceived disturbance was highest under the vocal conditions (although disturbance was also evident in the instrumental condition). Similarly, Furnham and Bradley (1997) found that complex vocal music was more likely to have an impact on task performance than less complex, instrumental music.

The current study extended this research area in four ways: First using a purer measure of extraversion; examining the distracting effects of noise as well as music; measuring the intelligence of the participants and using IQ tests as the task-related dependent variable.

Two predictions were made: First, that there would be a main effect of background sound, so that for all three tasks performance would be best in silence, followed by background music and worst in the presence of background noise. Second, that for each of the three cognitive tasks, there would be an interaction between degree of extraversion and the distracting effect of background music and noise. A positive relationship between level of extraversion and performance was anticipated in the presence of both background music and noise, but not in the silence condition.

METHOD

Participants

One hundred and eighteen female school children aged 11–18 took part in the study. Each child completed the EPI (Eysenck & Eysenck, 1968) in order to measure her degree of extraversion.

Materials

Sounds

The 'noise' was produced from the Avid Records Special FX CD. The particular extract of noise was created on an Apple Mac new generation laptop using the programme Cool Edit Pro to mix the selected sounds together. The samples used were children playing, general sounds of people, an office atmosphere and laughs. The length of the finished piece was 12 minutes and 12 seconds. The noise was selected so as to be as representative as possible of the everyday working environment of a school classroom. The music selected was UK garage-style music taken from the Ministry of Sound: Clubbers Guide to Ibiza 2007 (Various Artists, 2007). This was chosen as garage music is frequently heard in the charts and on the radio and thus the musical style would be familiar to the participants. All the pieces selected had a high tempo, were vocal and had considerable instrumental layering. The songs chosen were; We Can Rise by Copyright featuring Tasita D'Mour (Club Mix), Da Bump by Mr V featuring Miss Patty (Warren Clarke Remix) and Last Night a DJ Saved My Life by Seamus Haji featuring KayJay (Haji and Emanuel Club Mix). The total length of the music was 13 minutes and 44 seconds. The sounds were presented *via* a cassette player placed at the front of the room. Decibel levels were not measured but all music was played at the same level in all conditions. Previous studies showed spatial dispersion of source and sound intensity (50–70 db) had no effect on cognitive processing (Jones, Miles, & Page, 1990) though it may well have been best to measure the loudness of both distractions.

Tests

The tests were at an appropriate level of difficulty for the sample: (1) Raven's Progressive Matrices (Raven, Court, & Raven, 1992) is a graded test of abstract (perceptual) reasoning. It consists of 60 items arranged in five sets, each of 12 items. An item contains a figure with a missing piece, below which are either six (first two sets) or eight (the remaining three sets) alternative pieces (one of which is correct) to complete the figure. (2) The Wonderlic Personnel Test is a test of general cognitive ability, which had a high correlation with the Weschler Adult Intelligence Scale (Wonderlic Personnel Test Inc., 1992). It consists of 50-items graded in difficulty, and is administered in 12 minutes. The items include word and number comparisons, disarranged sentences, serial analysis of geometric figures and story problems that require mathematical and logical solutions. (3) The verbal reasoning test was compiled from test items presented in Bryon (2006). The task consisted of a mixture of question types: Antonym identification (identifying the antonym of the target word amongst alternatives), sentence-completion (choosing an appropriate completion of a sentence amongst alternatives) and grammar (choosing the grammatically correct sentence amongst alternatives).

IQ scores

Scores from the Middle Years Information System (MidYIS n. d., 2008) were available for all participants. Developed at the Curriculum, Evaluation and Management Centre (CEM), University of Durham, the system provides scores relating to vocabulary and word fluency, mathematical speed and knowledge, non-verbal ability, skills (e.g. proof reading) and perceptual speed and accuracy. MidYIS scores are used by schools to predict pupil's future potential and academic performance; in this study, the overall score for each participant was used as a proxy for IQ.

Procedure

Subjects were randomly allocated to one of three groups and seated so that they could not see any other individual's responses. Participants were given the EPI at the start of the experiment. All participants then completed the three tasks; one task in the noise condition, one in the music condition and one in silence. The background sound was played *via* a CD player at the front of the room at a constant level. The random allocation of participants to task/background sound condition combinations was achieved using a Latin square design, and within a combination the order of the tasks was also randomised.

RESULTS

The correlation matrix presented in Table 1 shows that there was a positive correlation between performance on the three tests—and between the tests and the MidYIS scores—our proxy for IQ. However, there was also an unexpected positive correlation between extraversion, performance on the three tests and MidYIS. It was thus clear that we needed to control for IQ (i.e. use the MidYIS scores as a covariate) when assessing the influence of extraversion on task performance under the three noise conditions. In addition, because of the loss of statistical power and other problems associated with the dichotomisation of quantitative variables (see MacCallum, Zhang, Preacher, & Rucker, 2002), we decided to use hierarchical multiple regression (rather than ANCOVA) as the method of analysis. For each of the three tests, a model was constructed with MidYIS as a covariate, background sound (dummy coded) as one predictor and extraversion as a (continuous) second predictor. An interaction term between background sound and extraversion was also included. Prior to the analysis of performance on each test, the extraversion variable was centred, so that the main effect of background sound could be examined at the mean level of extraversion (i.e. a comparison of the adjusted means). These means are presented in Table 2.

Table 1. Table of correlations between the measures of cognitive ability and extraversion[a]

	Extraversion	Ravens	Wonderlic	Verbal reasoning
Raven's	.59			
Wonderlic	.68	.54		
Verbal reasoning	.47	.36	.50	
MidYIS (IQ)	.42	.57	.56	.62

[a]All correlations $p < .001$.

Table 2. Table of adjusted mean scores and standard deviations for the Ravens, Wonderlic and verbal reasoning tests under conditions of silence, music and noise

	Condition		
Test	Silence	Music	Noise
Ravens			
M	25.35	23.91	22.70
SD	3.19	4.19	3.22
Wonderlic			
M	24.98	25.15	21.39
SD	3.09	4.70	4.29
Verbal reasoning			
M	24.21	23.18	21.73
SD	4.51	4.42	4.20

Raven's test of abstract reasoning

Casewise diagnostics identified two outliers (values with standardised residuals $>|3.0|$) and these participants were removed before continuing with the analysis. The model revealed a significant main effect of extraversion, $F(1, 109) = 26.69$, $p < .001$, which accounted for 9.3% of the variability in the test scores. There was also main effect of background sound, $F(2, 109) = 11.47$, $p < .001$ ($R^2 = 8.0\%$), and a significant interaction between personality and background sound, $F(2, 110) = 6.08$, $p < .01$ ($R^2 = 4.2\%$). Planned comparisons revealed that, as predicted, performance in silence was significantly better than in the presence of music ($p < .05$) and performance in the presence of music was significantly better than in the presence of noise ($p < .05$). Simple effects analysis showed that in silence, there was no effect of extraversion on performance, $F < 1$ ($\beta = 0.09$). In both the music and noise conditions, extraversion was a significant predictor of performance, $F(1, 36) = 20.00$, $p < .001$ ($\beta = 0.59$, $R^2 = 25.3\%$) and $F(1, 42) = 79.45$, $p < .001$ ($\beta = 0.74$, $R^2 = 52.2\%$), respectively. The fitted regression lines under the three conditions are presented in Figure 1.

The Wonderlic Personnel test

One outlier (standardised residual >3.0) was removed prior to analysis. A significant main effect of extraversion was found, $F(1, 110) = 62.37$, $p < .001$ ($R^2 = 14.8\%$), and there was also a main effect of background sound, $F(2, 110) = 33.28$, $p < .001$ ($R^2 = 15.8\%$). There was again a significant interaction between personality and background sound, $F\ (2,110) = 5.07$, $p < .01$ ($R^2 = 2.4\%$). Planned comparisons revealed that performance in both silence and music was significantly better than in the presence of noise ($p < .001$) but performance in the presence of silence was not significantly different from performance in the presence of music ($p = .76$). Simple effects analysis showed that extraversion was a significant predictor of performance in all three background sound conditions: Silence, $F(1, 42) = 7.07$, $p < .05$ ($\beta = 0.28$, $R^2 = 7.1\%$); music, $F(1, 29) = 16.60$, $p < .001$ ($\beta = 0.50$, $R^2 = 19.0\%$) and noise, $F(1, 37) = 128.89$, $p < .001$ ($\beta = 0.90$, $R^2 = 58.7\%$). The fitted regression lines for the three conditions are presented in Figure 2.

Test of verbal reasoning

The analysis revealed a main effect of extraversion, $F(1, 111) = 5.04$, $p < .05$ ($R^2 = 2.2\%$), and background sound, $F(2, 111) = 5.13$, $p < .01$ ($R^2 = 4.4\%$). There was also a significant interaction between personality and background sound, $F(2, 111) = 5.38$, $p < .001$ ($R^2 = 4.6\%$). Planned comparisons revealed that performance in silence was significantly better than with music ($p < .01$) and just failed to be significantly better than with noise ($p = .06$). There was no significant difference between performance under the music and noise conditions ($p = .15$). Simple effects analysis showed that extraversion was a weak but significant predictor of performance in silence, $F(1, 37) = 4.10$, $p < .05$ ($\beta = 0.29$, $R^2 = 5.9\%$) and a strong predictor in noise, $F(1, 29) = 79.23$, $p < .001$ ($\beta = 0.77$, $R^2 = 44.3\%$). There was no effect of extraversion in the music condition, $F < 1$ ($\beta = -0.02$). The fitted regression lines for the three conditions are presented in Figure 3.

DISCUSSION

The results for the Raven's matrices test were precisely as predicted; performance in silence was better than with music, which in turn was better than performance in conditions of simulated office noise. On the Wonderlic test, performance in

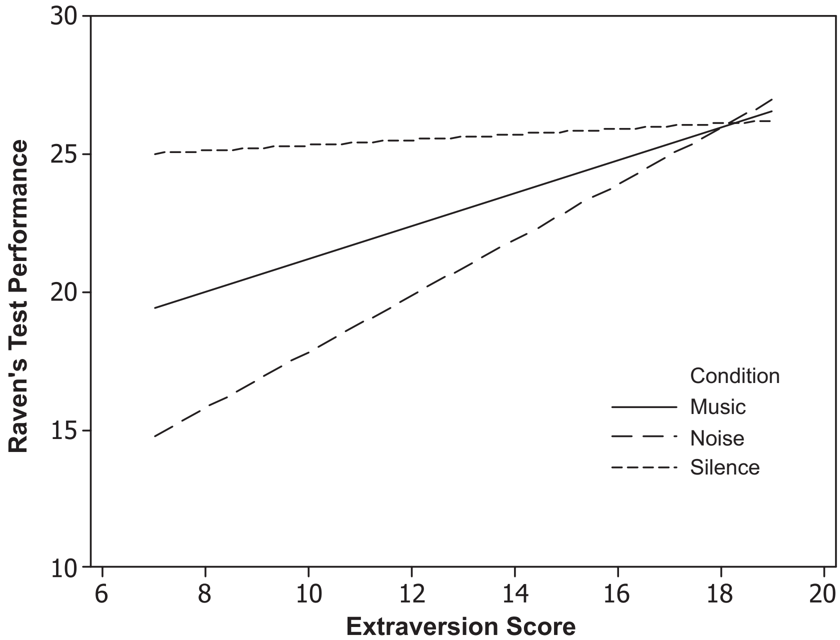

Figure 1. Fitted regression lines (controlling for IQ) for Raven's test performance as a function of extraversion under the three background sound conditions

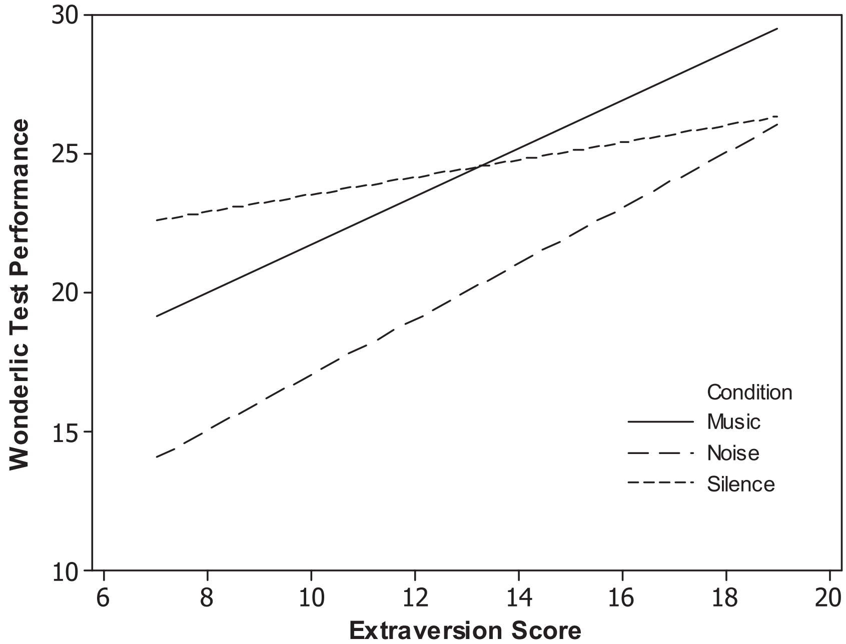

Figure 2. Fitted regression lines (controlling for IQ) for Wonderlic test performance as a function of extraversion under the three background sound conditions

silence and music was better than in noise, but performance in silence and music did not differ. On the verbal reasoning test, performance in silence was better than in noise, and with music performance was marginally better than in noise; but performance in silence was no better than with music. Thus performance in silence was superior to performance in simulated office noise; relative to silence, performance with background music was test-dependent.

Turning to the second hypothesis, there was either no relationship (Ravens) or a very weak relationship (Wonderlic and verbal reasoning) between test performance and extraversion when the tests were taken in silence. However, when the same tests were taken in the presence of noise, there was a strong positive relationship between performance and extraversion. Under noisy conditions, the performance of extreme extraverts was essentially unaffected, but increase in introversion was associated with a systematic decrease in test performance—with extreme introverts being markedly affected. The results under conditions of music were slightly less clear cut; whilst performance on Ravens and Wonderlic was positively related to extraversion (although the relationship was considerably weaker than in conditions of office noise) there was no relationship between extraversion and performance on the verbal reasoning test.

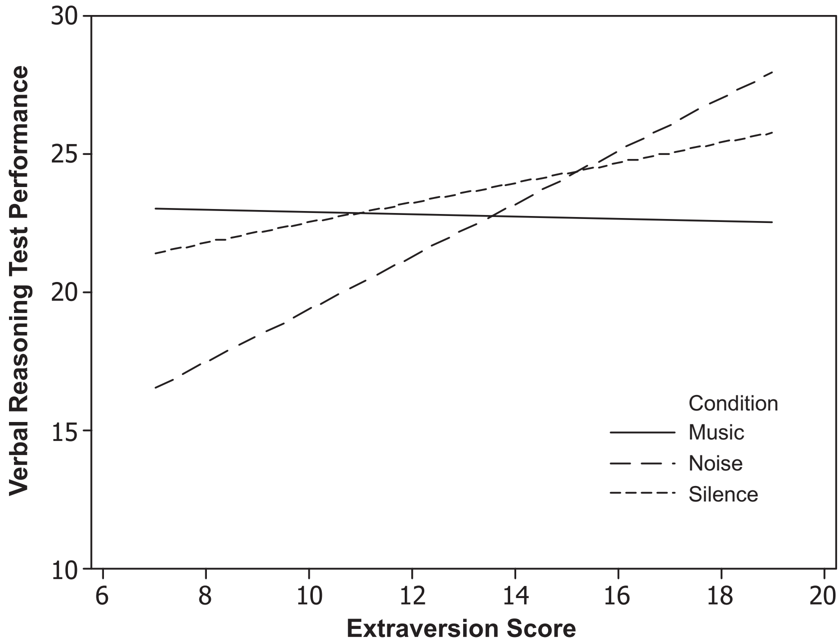

Figure 3. Fitted regression lines (controlling for IQ) for verbal reasoning test performance as a function of extraversion under the three background sound conditions

These results support previous findings that have found a significant difference between introvert's and extravert's performance in the presence of background music (Cassidy & MacDonald, 2007; Furnham & Allass, 1999; Furnham & Bradley, 1997; Furnham and Strabc, 2002).

The results indicate that for the Wonderlic and ravens task this was indeed the case, overall performance was best in silence compared to background sound. Analysis of both these tasks indicated that background music and noise significantly worsened performance when compared to silence, as predicted; music and noise were also significantly different from one another, working in the presence of noise being most detrimental to performance. This was not the case with the third task; in the verbal reasoning test, music and noise were not significantly different from each other and participants performed best in the music condition when compared to silence, those performance was still at its worst in the presence of noise.

What are the possible explanations why the verbal reasoning task did not obtain significant results in the predicted direction? It could be argued that the Wonderlic Personnel task and Ravens test of arithmetic were more cognitively complex than the verbal task. Research has indicated that there may only be a negative effect of background music and noise on complex cognitive tasks (Beaman, 2005; Smith, 1961, Evans & Johnson, 2000). Thus, if the task was not complex enough then this may not have had enough effect to exceed introverts beyond their optimum functioning level and thus produce a differential distraction of background music and noise on the cognitive test performance of introverts and extraverts.

Previous research has consistently indicated the detrimental effect of noise on individual's performance on complex cognitive tasks (Banbury & Berry, 1998; Beaman, 2005). There has been less unequivocal research on the negative effects of music on complex task performance. For example, Furnham and Bradley (1997) indicated a main effect for background sound on an immediate recall task but not on a reading comprehension task. Smith (1961) found no beneficial or detrimental effect of background music on tasks requiring complex cognitive activity. The discrepancy in the results of different experiments may be because of differences in the complexity of the music. However, Furnham and Allass (1999) found no effect on the cognitive performance when using silence, simple and complex music.

Background music and noise are both examples of background sound, what are the possible explanations for why performance was worse in the presence of noise when compared to silence? Noise and music my have equally distracting effects but cause quite different affective reactions. It also depends inevitably on the very nature of the music and the sound itself. Music that is most distracting is fast, familiar, vocal music that is most often known by, chosen and liked by the user (Furnham et al., 1999; Hargreaves and North, 1997). Indeed it is often chosen to be distracting (to take away from the repetitive nature of the task at hand) or to have a beneficial effect on mood.

That is, self-selected, familiar and personally liked music may be sought by people as a distraction to cope with pain (Mitchell et al., 2007; Pothoulaki et al., 2008) or to increase arousal in fast computer games. It has even been described as a 'audioanalgesic' (Mitchell et al., 2007).

Noise that is distracting is nearly always annoying because it is unpredictable and uncontrollable and interferes with an important task. Presumably no one chooses to work in the presence of noise, although they do so in the presence of music. Music plays a meaningful social and emotional role, so may be assigned an 'emotional' as well as a 'musical' meaning. It may be suggested that students are highly attuned to emotional arousal and meaningful messaging, and so may be less distracted by music than other potential population or, conversely, more distracted due to increased personal interest and affiliation with social messaging of popular music. Indeed recent studies on uses of music has shown that extraverts use music for stimulation whilst neurotics use it for emotional regulation (Chamorro-Premuzic et al., 2009).

This study found a positive correlation between extraversion and IQ, suggesting the relationship between intelligence and extraversion may be a bit more complex than it appears at first sight. Subsequent results showed that having controlled for IQ the hypothesis that performance for all participants should be similar in silence prevails. When controlling for intelligence, degree of extraversion is no longer a main effect of performance for Ravens progressive matrices, but continues to be in the presence of background sound (music and noise). The same pattern of results was found for the Wonderlic and the Verbal tests though non-significant. It would seem that performance on these tests is greatest with greater intellectual ability and degree of extraversion, both of which may not be independent theoretically as Eysenck (1971) suggested.

A review of the literature bearing on the relationship between extraversion and intelligence yields unequivocal results. Robinson (1985) provided data indicating that extraversion and introversion are intimately associated with different intellectual styles and intelligence profiles, but not with absolute levels of performance on intelligence tests. Accordingly, introverts and extraverts were found not to differ in overall IQ, only on profile: Introverts were found to perform relatively better on verbal tests, and extraverts on performance tests.

The study has yielded robust findings, not only to students and those who wish to maximise their learning potential, study environments and services, but also those interested in investigating the effects of everyday music listening on our behavioural state. The study has highlighted the detrimental effect of sound (music and noise) on task performance, in comparison to silence. A wide range of factors should be taken into account when investigating the effects of music on behavioural states. These include musical environment, psychological and social factors and other personality correlates, which may be inextricably linked. The replicability of these findings depends on the nature of the task and the nature of the distracter as well as the personality of the participants.

Future studies may help understand these issues better if they used a wider age population group, and used different kinds of music. Moreover, it would have been better to have different types of noise (i.e. just irrelevant speech *vs.* machine sounds) and the loudness was measured and perhaps varied to examine its effects on performance. What is most desirable in this research area is to supplement experimental research with studies done in naturalistic settings noting how, when and why people use distractions in their everyday life.

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