I can still hear you! Noise and noise prevention in offices.

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Abstract

The most important distraction in open plan offices is noise. Noise distraction decreases performances, causes stress and lowers job-specific wellbeing. Personality may play a role, as extraverts and introverts have been reported to react differently to noisy environments that cause higher levels of arousal. However, it is unclear whether these effects of noise affect age groups in a different way. Therefore, this study has investigated the effect of noise on affective employee wellbeing, namely anxiety-comfort, taking into account personal characteristics (age, gender, level of extraversion).

In a case study organisation a pilot was set up to measure noise levels in an open plan office; noise levels were measured for five consecutive days, and employees were asked to report on personal characteristics (gender, age, extraversion) as well as anxiety and comfort, at the start of the day, at noon, and at the end of the day. Regression analysis showed that noise levels influenced anxiety, and comfort (in the morning only); results were controlled for age group, gender and extraversion.

These results confirm the negative effect of noise on employees' wellbeing. As employees are reluctant to use headphones to reduce noise distraction, a pilot with noise reduction panels will be started to reduce noise and increase job-specific wellbeing.

Keywords: Noise level, distraction, employee wellbeing, anxiety-comfort

Introduction

Workforce demographics are currently enduring a period of change. The emergence of a highly diverse multi-generational workforce has posed a new set of questions for Corporate Real Estate professionals, HR managers, and organizations (Hughes and Simoneaux, 2008; Vicker, 2005).

The field of facility management is expanding from an operational into a tactical and strategical activity, depending on the geographical location, facility managers are confronted with a broad spectrum of responsibilities. They are responsible for occupational health and safety and are also concerned with employee wellbeing. Employee satisfaction, productivity, and wellbeing are becoming even more crucial for organisations that want to achieve a

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competitive advantage in today's knowledge intense business environment and want to retain knowledge workers of all generations (Brill et. al., 2001; Chan et. al., 2007). One of the factors that facility managers are responsible for is supporting the optimal performance of knowledge workers in office environments, taking into consideration all factors that impact this performance, e.g. noise distraction.

Open plan offices

Office space is an expensive resource and is to be used effectively and efficiently (Wiggins, 2010). Since the late 20th century, open plan offices are widely used across many industries. This type of office offers numerous benefits that may be economically advantageous to companies as open plan offices often occupy less space compared with traditional offices, may save infrastructure costs, and increases human communication, hence increasing collaborations and organisational performance (Leaman, 1992; Veitch et al., 2002).

Noise in open plan offices

Open plan offices also have a number of disadvantages, including increased noise and distractions, (e.g. Hedge, 1982; DeCroon et al., 2005; Brennan et al., 2002; Veitch et al., 2002). Telephones and other peoples' conversations have been reported as being the most disturbing sources of noise (Kaarlela-Tuomaala et al., 2009; Pejtersen et al., 2011). Many authors have discussed the effect of noise on the performance of office workers (Banbury & Berry, 2005; Jahncke et al., 2011; Szalma & Hancock, 2011), especially the distracting effect of speech (Schlittmeier & Liebl, 2015). A potential loss in productivity as high as eight per cent has been reported (Roelofsen, 2008). According to Hongisto (2006) speech is a major source of distraction, whether it is relevant or irrelevant, and at different sound levels.

Noise and wellbeing

Noise, being a distractor, has been suggested to be the most widespread stressor in the work environment of office workers (Oseland & Hodsman, 2015), negatively impacting employee wellbeing. Warr's circumplex model of job-related affective wellbeing (Warr, 1990) shows three dimensions of job-specific wellbeing, namely content-discontent; anxiety-comfort; depression-enthusiasm. These dimensions are affected by individual factors, socio-demographic factors such as age and gender, and features of the environment. Borod (2000) states that stress is an important factor influencing the relationship between anxiety and brain function. Furthermore, Borod, (2000) concludes that numerous neuropsychological and

cognitive studies have manifested that stressors may result in psychological stress, such as anxious arousal. Therefore, one's level of anxiety-comfort may be an indicator of affective wellbeing as well as stress level.

Influence of personal characteristics

Stress levels due to exposure to noise are also influenced by people's personality, e.g. level of extraversion. Introverts and extraverts have different preferred levels of arousal, which in turn affects how noise affects their performance. Noise can be considered to be a kind of stimulation, so extraverts should perform better than introverts in noisy environments (Oseland, 2009; Oseland and Hodsman, 2015).

To what extent does age play a role in the effect noise on anxiety-comfort and therefore job-specific wellbeing, and should it be part of the studies on generational differences in preferences regarding workplace in general? These preferences have been studies by several authors (e.g. Bennett et al., 2012; Brand, 2008; Joy & Haynes, 2011; Phillips & Addicks, 2010; Rothe et al., 2012; Rasila and Rothe, 2012; Groen and Lub, 2015), but empirical proof is limited. Brand (2008) argues that Generation Y workers are as distracted by noise as older workers. Also, Belojevic and Jalovjevic, (2001) could not find significant relations between noise sensitivity and age. Ehrlich and Bichard (2008) researched the Welcoming Workplace and described the effects of noise on older workers in open-plan offices. Joy and Haynes (2011) on the other hand state that noise is a distractor for concentration work, but do not report on differences between generations.

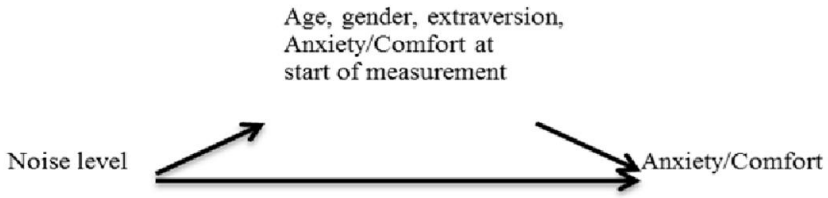

Fig. 1: Model for the effect of factors that affect Anxiety-Comfort used in this paper.

Therefore, the objective of this paper is to examine how office noise influences job-related wellbeing, and how a number of personal characteristics mediate this influence.

H_1: The influence of noise levels on of anxiety-comfort in open plan offices is mediated by gender, age group, level of extraversion, and level of anxiety at the start of the measured time interval.

H_2: The influence of noise levels on of anxiety-comfort in open plan offices is mediated by gender, age group, level of extraversion, and level of comfort at the start of the measured time interval.

Research methods

The research consisted of noise level measurements and a survey. Measurements were carried out in one of the open plan offices of the case study organisation, a multinational company in beverages. This open plan office has recently reduced its office space with 15% (due to low occupancy rates). As a result of this decrease the facility coordinator received an increasing number of complaints concerning noise interruption and loss of concentration. The total number of employees of the organisation is 240. The selected research area within the office contains 32 workplaces shared by 45 employees (see Figure 2).

During one week (Monday-Friday) noise levels in the office were measured. An iPad equipped with an external microphone (range 0-135 dB, 20-18000 Hz) was placed in the middle of the selected area; the decibel 10-th app was used to record the noise level. Noise levels were measured between 9.00 and 12.00 and 13.30 and 17.00, every 5 seconds. The iPad was calibrated with a sound level meter (SLM). A sound was played at a distance of 1, 5 and 10 m of iPad and SLM. The difference was marginal with 1 dB deviation at 1m and 5m, and 2 dB at 10m. Noise damping was not further considered, as the test area was small and has little sound damping features. Average occupancy of the open plan office was 80%, which is representative for occupancy of this open plan office.

The survey was paper-based. Respondents were asked to answer questions personal characteristics, namely gender, age category, hearing ability, use of headphones, department, and job-role. The level of extraversion was measured using the Big Five Inventory (John & Srivastava, 1999), on a 5-point scale. The level of anxiety and comfort was based on the Circumplex Model of Affect, a multi-dimensional framework that identifies two axes of psychological wellbeing, namely activation and pleasure (Russell, 1980; Warr, 1990, 2012). The axis anxiety-comfort represents high activation, unpleasant arousal (level of anxiousness) and low activation, peasant arousal (level of comfort). To stimulate respondents to fill in the questionnaire and take as little of their time as possible, both aspects of the anxiety-comfort axis were measured with one item, namely the level of anxiety, and level of comfort, on a 5-point Likert scale.

Respondents answered the questions on personal characteristics as soon as they started working in the morning; the measurement of anxiety and comfort took place at the beginning

of the day and repeated at 12.00 and 17.00. All data were collected and processed anonymously.

Fig. 2: location of workspaces and noise level measurement (spot) in open plan office.

Results

Sample characteristics

Table 1 summarizes the characteristics of the sample. It contained 95 completed responses, 40 men (42%) and 55 (58%) women. Respondents belong to three different generations, namely 41% Generation Y (born after 1980), 51% Generation X (1981 - 1965) and 8% Baby Boomers (born before 1965). The sample contains responses from interns (13), managers (25) and individual workers (57), working in mainly administration, marketing and logistics. Furthermore, as this research is about the perception of noise, people were asked about their hearing abilities; 14 responses indicated limited hearing abilities. Salient is that 25% of the responses from the age group 25-34 years indicated limited hearing abilities (Table 2). Roughly one-quarter of the responses indicated that they regularly use headphones in the office.

Extraversion

Extraversion of the responses was on average 3.23 (s.d. 0.34). This value is comparable to the Srivastava et al. (2003) but slightly lower than values reported by Denissen et al. (2008). As expected, extraversion showed no significant differences between age categories (Denissen et al., 2008) or gender (Costa, Terracciano, and McCrae, 2001; Schmitt et al., 2008).

Tab. 1: Overview of sample characteristics.

Sample characteristic		Frequency	Percent
Gender	Male	40	42
	Female	55	58
Generation	Y	39	41
	X	48	51
	Baby Boomers	8	8
Department	Administration	24	25
	Marketing	24	25
	Human Resources	10	11
	Sales	3	3
	Public relations	1	1
	Logistics	28	29
	Research and Development	5	5
Function	Intern	13	14
	Individual contributor	53	56
	Team leader	9	9
	Manager	10	11
	Senior Manager	6	6
	Other	4	4
Hearing ability	Good	81	85
	Limited	14	15
Use of headphones	Yes	27	28
	No	68	72

Tab. 2: Overview of age and hearing ability of sample.

Age and generation	Frequency	Percent	With limited hearing ability
Gen Y, 18-24	11	12	0
Gen Y, 25-34	28	30	7 (25%)
Gen X, 35-44	34	36	1 (3%)
Gen X, 45-50	14	15	3 (21%)
Baby Boomers, 51-60	8	8	3(38%)
Total	95	100	14 (15%)

Noise levels

Noise levels were measured during five consecutive days and showed similar patterns. Figure 3 shows the noise level on Wednesday. In the morning of the day, noise varied between 40 and approx. 60 dB with a mean level of approx. 55 dB outside breaks (bandwidth 50-60 dB) but rising to approx. 80 dB between 9.15 and 9.30, and between 10.00 and 10.30, and rather increases from 11.45 on, when people leave for their lunch break.

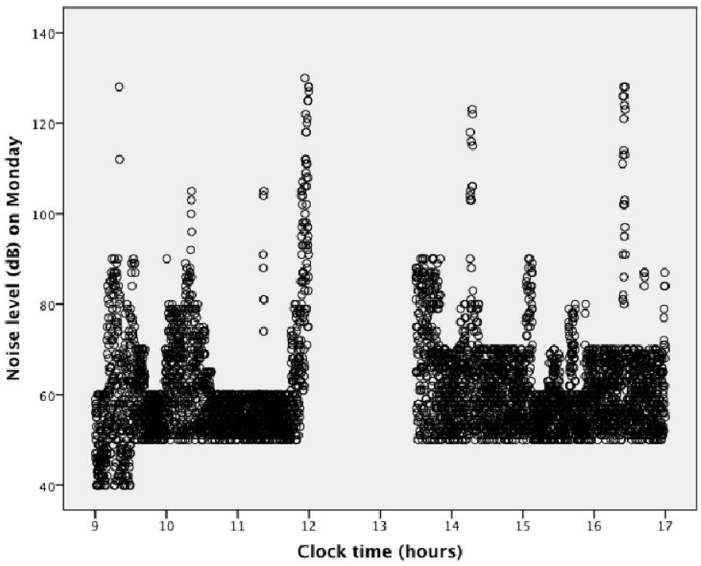

Fig. 3: Noise levels.

The afternoon likewise shows a pattern. Noteworthy is that the bandwidth of the noise is larger, namely 50-70 dB, with several peaks. From 15.00-16.00 the noise level is comparable to the morning level (50-60 dB). The recorded noise patterns show some distinctive extremes, which are a result of employee engagement (arriving at the office in the morning, assembling for presentations and meetings, moving for lunch, having conference calls, verbal communication, movement of objects, and opening and closing of doors and cabinets, going on breaks). Furthermore, morning and afternoon mail drop off as well as afternoon cleaning might impact the noise measurement.

Pattern in levels of Anxiety/Comfort during the day

At the beginning of the day (9.00), at the end of the morning (12.00) and the end of the day (17.00) respondents reported their level of Anxiety and Comfort. Anxiety levels at the beginning of the day showed no significant differences between the days of the week. Figures 4 and 5 show the levels of Anxiety and Comfort during the day, for the different age groups, averaged over five days. Anxiety levels during the day are correlated, and morning comfort levels are correlated with both the afternoon and the evening levels. Anxiety and Comfort inversely correlated with each other, as expected. For all but the oldest respondents Comfort was lowest at the end of the morning, and generally speaking Comfort correlates positively with age.

Regarding Anxiety, the youngest group showed the smallest effects on Anxiety during the day, the groups between 25 and 44 years showed a significant increase in Anxiety during the morning and a decrease in the afternoon, whereas the two oldest groups (>45 years) increased

during the day with the maximum Anxiety at the end of the day. Except for the youngest group (18-25) at any moment of the day, Anxiety was inversely correlated with age.

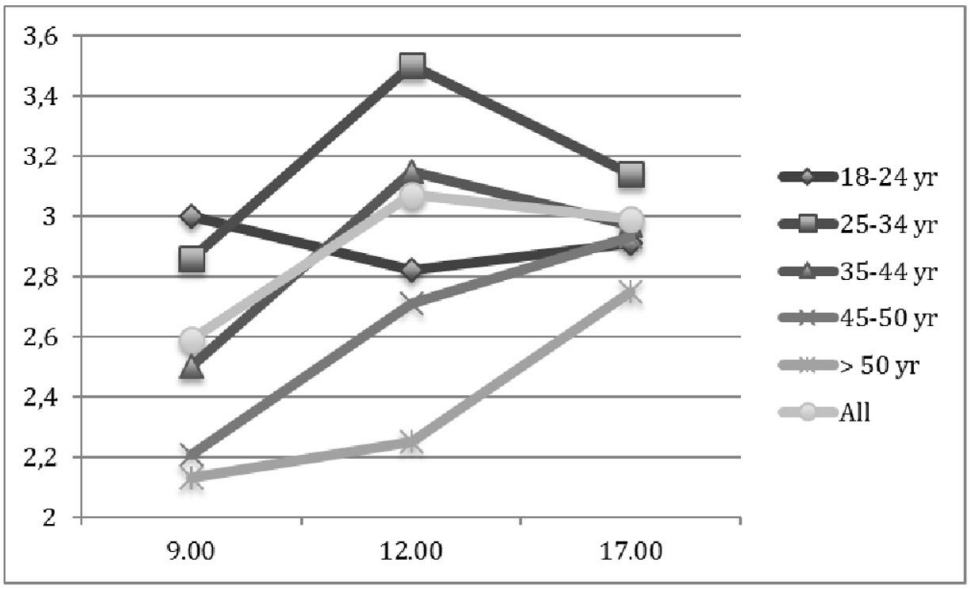

Fig. 4: Anxiety levels during the day (9.00, 12.00, 17.00) for different age groups.

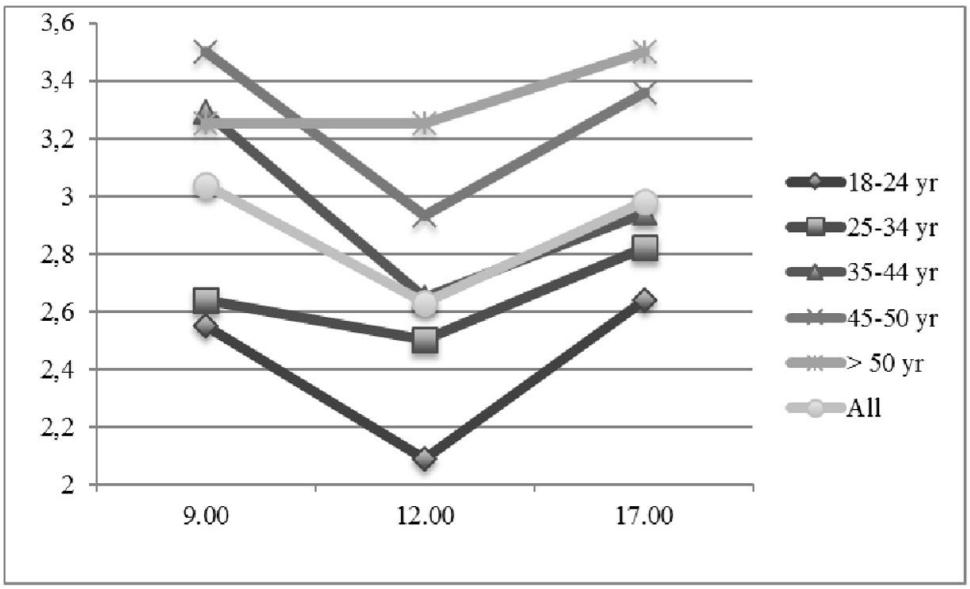

Fig. 5: Comfort levels during the day (9.00. 12.00 and 17.00) for different age groups.

Does noise level predict Anxiety/Comfort?

To determine what factors predict the levels of Anxiety/Comfort several models were tested with a hierarchical regression analysis (Tables 3 and 4). In Step 1 the effect of socio-demographic factors (gender, age group) and an individual factor (level of extraversion) was taken into account. In Step 2, the noise level was added, and in Step 3, another individual

factor was added, namely the level of anxiety-comfort measured at the start of the measured time interval.

Anxiety was predicted by noise levels, but this influence is clearly mediated by Anxiety levels at the start of the measurement, both in the morning and the afternoon. Gender, age, nor extraversion mediated this effect. Therefore, H_1 is supported.

Tab. 3. Hierarchical regression analysis predicting Anxiety

	Dependent variable: Anxiety (morning)			*Dependent variable: Anxiety (afternoon)*		
Control variables	Step1	Step 2	Step 3	Step 1	Step 2	Step 3
Gender	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Extraversion	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Age	.038	n.s.	n.s.	n.s.	n.s.	n.s.
Independent Variables						
Average noise level		.046	.049		.028	.041
Anxiety level start of measurement			.000			.000
Regression model						
F	3.15*	3.47*	7.02***	.299	1.48	8.16
ΔF	3.15*	4.09*	18.5***	.299	4.98*	32.8***
Adjusted R^2	.064	.095	.242	-.023	.02	.276
ΔR^2	.094	.039	.149	.010	.052	.253

Note. Age = mid-level of category. Standardized regression coefficients are reported *p<.05, **p<.01, ***p<.001. n.s. = not significant.

Tab. 4 Hierarchical regression analysis predicting Comfort

	Dependent variable: Comfort (morning)			*Dependent variable: Comfort (afternoon)*		
Control variables	Step1	Step 2	Step 3	Step 1	Step 2	Step 3
Gender	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Extraversion	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Age	.006	.020	n.s.	.041	.042	n.s.
Independent Variables						
Average noise level		.001	.000		n.s.	n.s.
Comfort level at start of measurement			.004			.000
Regression model						
F	2.798*	5.55***	6.63***	2.21	1.65	6.68***
ΔF	2.79*	12.8**	8.99**	2.21	.02325.1	
Adjusted R^2	.054	.162	.231	.037	.037	.232
ΔR^2	.084	.114	.074	.068	.068	.273

Note: Age = mid-level of category. Standardized regression coefficients are reported *p<.05, **p<.01, ***p<.001. n.s. = not significant.

Results for Comfort differed between morning and afternoon. Similar to the level of Anxiety, Comfort level in the morning was predicted by noise levels, but this effect is obviously mediated by Comfort levels at the start of the measurement. Comfort in the afternoon,

however, shows no significant influence of noise. Data were controlled for gender, age and extraversion. Therefore, H_2 is partially supported, only for the morning situation.

Discussion and conclusion

Noise is an often-reported distraction factor in open office. The level of distraction may depend on personal characteristics, e.g. level of extraversion and age, and the source, character and amount of noise. In this study, the effect of noise level was determined by two aspects of wellbeing, namely the level of Anxiety and Comfort, being inversely related aspects of the circumplex model of affect (Warr, 1990).

Regarding the personal characteristics, the respondents did not significantly differ in level of extraversion. Average levels of Anxiety and Comfort were not significantly different at the beginning of the days of the week.

The noise levels during the day, caused primarily by conversations and phone calls, varied between 40-70 dB, with higher levels in the afternoon than mornings, and peak values well over 80 dB. Employees in the open plan office of the case organisation have repeatedly complained/mentioned that this office is too noisy, and the data support this.

Levels of Anxiety and Comfort may be caused by noise levels, and mediated by personal characteristics such as gender, age, extraversion, and Anxiety/Comfort levels at the start of the measurement. The results support the assumption that employee wellbeing in this office is negatively impacted by noise; that this effect is not mediated by age or extraversion, and partially mediated by Anxiety/Comfort levels at the start of the measurement. Contrary to popular belief, our results do not show that noise affects generations differently, thereby supporting Brand (2008) Belojevic and Jalovjevic, (2001).

A limitation of this study is that noise was measured as averaged levels across all frequencies, not taking into account the nature of the noise. However, it does show that even acceptable noise levels do affect wellbeing. Differentiation into noise below, in and above the frequencies for speech might show more clearly what the effect of speech noise is on wellbeing.

Three measures may reduce noise levels. First of all, changes in behaviour; however, communication is an essential part of the job of the departments using this open office, turning this into an unlikely measure.

Secondly, the use of earplugs or headphones. From an internal office health and safety as well as human resource perspective, it is up to the employee to decide on the use of headphones. However, in this organisation, it is more accepted to use visually less noticeable

headphones (in-ears). Employees are in general reluctant to use headphones, as they perceive this as unappreciated by their co-workers. Some also reported that they do not want to be perceived as rude and ignorant towards their environment or are anxious to miss out on important information e.g. colleagues talking, acoustic (emergency) notifications. The data show no significant differences between employees that wore headphones and employees that did not wear headphones regarding their anxiety-comfort level. However, it should be mentioned that the results are based on only eight participants that were found to use headphones and therefore this result is of minor value.

As a result of the noise measurement, the decision was made to invest in sound damping solutions the increase employee wellbeing. As there are several solutions on the market e.g. noise cancelling desk & room dividers, noise cancelling furniture and artwork, or acoustic ceiling and wall panels different solution need to be reviewed. The acoustic products will be placed in a test area in the office, to review solutions that can be technically implemented, are practical regarding installation as well as maintenance, and are visually appealing. Evaluation of the product performance will include noise measurements before and during the test period and interviews with employees about their perception of the test area regarding noise reduction to evaluate the appreciation in relation to the investment.

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