

Małgorzata Heinrich

## What about noise? Perception of noise at the workplace – office study

Tutor: Svetlana Gudkova, PhD

**Małgorzata Heinrich** – is a student of Master in Management at Kozminski University (double degree program with KEDGE Business School in Bordeaux) and of Master in Musicology at Warsaw University, where she did her Bachelor Degree with honors. She was a student of ZPSM im. Fryderyka Chopina music school in Warsaw in the piano department. Now, she is a member of the editors' board in contemporary music magazine "Glissando" and an inspector in Excellence in Science Department, Polish Academy of Sciences.

### Abstract

Noise pollution is nowadays an environmental burning issue, as well as a social problem. It is reported to be a strong factor influencing people's health, well-being, as well as productivity, and mental capabilities. The effects noted occur mostly to be of adverse nature, however positive impacts have also been recorded in certain studies. The purpose of this paper is to investigate the subjective perception and declared influence of noise reported by a group of Polish office workers (taking into consideration their declared sensitivity to noise) and to assess its intrusiveness for white-collar work.

The methodology is based on the acoustic ecology approach proposed by R. Murray Schafer et al. (1977) that focuses on the subjective testimony given by the subjects. To assess the sensitivity to noise, Weinstein's Noise Sensitivity Scale is used. It is combined with a series of interviews conducted with a group of Polish office workers.

Results of the qualitative research show the subjective impressions of office workers related to noise and sound, their approach to the issue. They also identify the most intrusive noises, the levels of annoyance, and declared physical and mental detriments caused by the sounds.

Moreover, the approach toward silence and self-induced sounds is examined, as well as the preferences towards choosing the sonic environment while working.

**Keywords:** office, noise, health, productivity, sound

## Co z tym hałasem? Percepcja hałasu w miejscu pracy

### Abstrakt

Zanieczyszczenie hałasem jest współcześnie palącym problemem środowiskowym i społecznym. Sam hałas jest natomiast czynnikiem wpływającym znacznie na ludzkie zdrowie, samopoczucie, a także na produktywność i pracę umysłową. Zaobserwowane oddziaływania tej siły mają głównie naturę negatywną, jednak niektóre pozytywne efekty zostały zasygnalizowane w pewnych badaniach. Celem niniejszego artykułu jest zbadanie subiektywnej percepcji hałasu oraz jego zgłaszanych wpływów wśród grupy polskich pracowników biurowych (wziąwszy pod uwagę ich deklarowaną wrażliwość na dźwięk), a także ocena negatywnego wpływu hałasu w tym środowisku.

Przyjęta metodologia opiera się na podejściu ekologii akustycznej wypracowanym przez R. Murraya Schafera i in., które bazuje na subiektywnym świadectwie zainteresowanych podmiotów. W celu oceny indywidualnej wrażliwości na hałas poszczególnych uczestników badania zastosowano Weinsteina Skale Wrażliwości na Hałas. Ponadto przeprowadzono serię wywiadów z grupą pracowników biurowych.

Wyniki badań pokazują subiektywną percepcję hałasu i dźwięków przez pracowników biurowych, identyfikują najbardziej przeszkadzające dźwięki oraz poziomy rozdrażnienia, a także opinie dotyczące ciszy. Ponadto ukazują rodzaje dźwięków samodzielnie wybranych i stosowanych podczas pracy i preferencje wyboru środowiska akustycznego do działań związanych z zawodem.

Z powyższych rezultatów wyciągnięte zostają wnioski dotyczące dominujących sposobów postrzegania hałasu. Autorka prezentuje również pewne rekomendacje związane z poprawą środowisk akustycznych w biurach.

**Słowa kluczowe:** biuro, hałas, zdrowie, produktywność, dźwięk**Introduction**

Noise is nowadays one of the most burning environmental problems around the world, influencing public health and well-being. It is a force each developed country inhabitant has to face each day. According to WHO, solely in Western Europe, more than 1.6 million healthy years of life<sup>1</sup> are lost, due to the effects of traffic noise (WHO, 2018a). Furthermore, European Environment Agency claims that long-term noise exposure may cause 12 000 premature deaths (European Environment Agency, 2020), while European Union estimates that about 136 million citizens (of its 446 million total) are affected by the noise of different provenience of the level over 55 dB Lden (“Noise - Environment - European Commission,” 2020). Many of them are experiencing occupational noise in their workplaces, affecting their health in many ways (Schneider et al., 2005). And not only the industrial workers are influenced. According to the survey by Udemý and Toluna (2018) around 80% of white-collar workers in the U.S. are disturbed by office conversations and 70% by general office noise. It is visible therefore that the issue of workplace noise is not only reserved to industrial setting as it is often assumed and can influence workers’ productivity and efficiency.

Effects of noise have been studied profoundly for the past 50 years (Andrejiova, Balazikova, and Wysoczanska, 2019), however, the interest and research can be traced back as far as more than a century ago (Gatewood, 1921; Girdner, 1896; Laird, 1930, 1927; Pollock et al., 1932). Of particular interest have been the issues of noise in the workplace (Abbasi et al., 2019, Abbasi, Monnazzam, Zakerian, and Yousefzadeh, 2015; Nassiri et al., 2012; Thepaksorn, Koizumi, Harada, Siriwong, and Neitzel, 2019), aircraft and traffic noise (Baisch and Kamp, 2009; Basner, Griefahn, and Berg, 2010; Morrell, Taylor, and Lyle, 1997; Schmidt et al., 2013), noise effects on children (Klatt, Bergström, and Lachmann, 2013; Shield and Dockrell, 2008; Stansfeld and Clark, 2015), on sleep quality (Freedman, Gazendam, Levan, Pack, and Schwab, 2001; Frei, Mohler, and Rööslí, 2014; Nissenbaum, Aramini, and Hanning, 2012), on cognitive performance (Belojević, Öhrström, and Rylander, 1992; Jahneke, Hygge, Halin, Green, and Dimberg, 2011; Kristiansen et al., 2009; Perham, Banbury, and Jones, 2007), its correlation

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<sup>1</sup> Healthy life years is a number representing how many more years a person is expected to live healthily.

with cardiovascular diseases (Hahad, Kröller-Schön, Daiber, and Münzel, 2019; Kerns, Masterson, Themann, and Calvert, 2018; Lusk, Gillespie, Hagerty, and Ziemba, 2004, Lusk, Hagerty, Gillespie, and Caruso 2002; Tomei, Fantini, Tomao, Baccolo, and Rosati, 2000) and others. Most of the past research focuses on quantitative methods. To balance this, the present study will focus more on interpretative methods in order to put more light on the perception of the problem by those most affected by the phenomenon.

The identified scope of the influence of noise on humans is vast and can be divided into many sub-categories. Following some researchers (Basner et al., 2014; Stansfeld and Matheson, 2003) in the present paper, it was decided to categorize the most important effects of noise distinguishing auditory and non-auditory, the latter being further divided to physiological and others. One has to bear in mind, however, that such a cleavage is artificial, as very often the reactions are being interrelated, or structured in a causal relationship. Nevertheless, as the physiologic and psychologic symptoms are most often perceived as being distinct (see: Basner et al., 2014; Stansfeld and Matheson, 2003), they are discussed separately. Apart from that, there is a specific type of research specializing in the effects of office noise. Those focus on various aspects: noise's influence on bodily functions (Evans and Johnson, 2000), and on cognitive performance (Jahncke et al., 2011; Kristiansen et al., 2009), as well as on the different impacts considering the diverse types of noise (e. g. with or without speech) (Banbury and Berry, 1998). In the next section both the auditory and non-auditory effects of noise will be discussed, followed by office noise influence on workers. Such investigation of sound's impact on employees is of importance for work organization and management. As noise is not neutral, the managers have to take into account its effects not only on the health, well-being, and safety of the worker, but also its potential influence on their productivity and task performance.

### **Auditory effects of noise**

All the influences on the human's auditory system induced by noise are called the auditory effects of noise. They concern the processes in the ear, the cochlea, the nervous system, and the brain areas responsible for hearing. The detrimental effects of noise on hearing may be caused either by one sound event or by chronic exposure. As little as 75 dB prolonged exposure may cause hearing deficiencies (Centers for Disease Control and Prevention, 2019). It is estimated that about 1.1 billion young people worldwide are exposed to hazardous noise levels (Krug and World Health Organization, 2015), making the risk of noise-induced hearing loss (NIHL) a

global phenomenon. The main mechanism underlying the auditory effects of noise is the permanent damage and atrophy of auditory sensory cells in the cochlea (Basner et al., 2014), caused both by mechanical and metabolic damage (that is too intense metabolic processes in the cells) (Krug and World Health Organization, 2015). The destroyed cells do not regenerate, in their place, scar tissue appears (Clark and Bohne, 1999). Initially, the damage concerns cells responding to high frequencies (Krug and World Health Organization, 2015), in the next phases of prolonged exposure the loss covers also those related to lower pitches (Clark and Bohne, 1999).

Auditory effects of noise can be divided into **temporary** and **permanent**. Of them, most often encountered is a temporary threshold shift, due to the fatigue of sensory cells that results from exposure. Although persisting for a limited period of time, it may be a predictor of more radical damages. Regular and prolonged exposure may make the phenomenon become permanent (Ibidem). Another effect that can either be acute or chronic is tinnitus – a perception of ringing or hissing sounds, while no external tone is detected. It is claimed that it may affect severely the quality of life, including sleep disturbance, depression, or communication and concentration problems (Basner et al., 2014; Krug and World Health Organization, 2015).

Noise-induced hearing loss is a permanent, non-reversible condition, that is correlated with social effects, as well as affected cognitive performance and rising risk of accidents (Basner et al., 2014). According to WHO report, as of 2018, nearly 470 million people globally were experiencing disabling hearing loss. Those numbers are expected to grow rapidly, reaching over 900 million by 2050 (WHO, 2018b). It is proven that both social and occupational noise exposure has an influence on the presented condition (Basner et al., 2014). Research conducted in sawmills in Thailand showed that more than 22% of workers had shown symptoms of noise-induced hearing loss, while more than half of the workers had been exposed to a high level of sound. In the U.S. it is estimated that about 22 million workers are exposed to hazardous levels of noise (Centers for Disease Control and Prevention, 2020), while 11 million are reported to have NIHL (Nelson, Nelson, Concha-Barrientos, and Fingerhut, 2005). The study conducted in Europe, on the other hand, proved that 28% of workers were facing noise levels of over 85–90 dB, at least in a quarter of their working time (ibidem). It may be therefore observed that the scale of the phenomenon is extensive and affects people of all age groups and world regions.

### **Non-auditory effects of noise**

The effects of noise that do not influence the auditory system specifically are called the non-auditory effects. They may relate to any other area of human health and well-being, apart from the hearing, for example, mental health, cardiovascular and endocrinal responses, annoyance, impairment of concentration, and performance. They all will be described in the further part of the article. It may be therefore observed that noise has a vast diversity of influences on human physiology, as well as psychological and cognitive effects. They differ depending on the noise type (Baker and Holding, 1993; Banbury and Berry, 2005), its intensity and frequency (Jafari et al., 2019), as well as on the task performed (Kristiansen et al., 2009), and personal traits (Belojević et al., 1992; Moradi et al., 2019). For example – high noise levels, low frequencies, and increasing tone levels are found to be more irritating than low-level sounds (Jafari et al., 2019), while introversion has been proved to be adversely correlated with noise tolerance and adaptation levels (Moradi et al., 2019). As it is beyond the scope of this article to refer to all of possible noise exposure results, only the most important are shortly reported, focusing first on physiological and then on others, mainly psychological effects.

The first large group of consequences referred to in academic research are cardiovascular effects. Those include both acute and chronic effects such as an increase in heart rate, in systolic and diastolic blood pressure (Lusk et al., 2004, 2002; Tomei et al., 2000), which in turn may lead to hypertension, increased risk of coronary heart disease and stroke (Hahad et al., 2019), as well as peripheral vasoconstriction, resulting in growing peripheral vascular resistance (Stansfeld and Matheson, 2003). The research shows that among workers of different (mostly industrial) occupations exposed to noise in the US 24% suffer from hypertension, of which 14% may be attributed to the fact of exposure (Kerns et al., 2018). In another study conducted in Faisalabad, Pakistan, as much as 74% and 64% of respondents reported noise-induced hypertension and elevated blood pressure respectively (Farooqi et al., 2020). It was concluded that noise is an important factor in increasing cardiovascular risk (Tomei et al., 2000) and influencing both objective and subjective assessment of the repercussions.

Another group of physiological effects relates to endocrinal responses. High-intensity noise has been found to alleviate levels of noradrenaline and adrenaline (Evans and Johnson, 2000; Stansfeld and Matheson, 2003). There exist studies that suggest also a rise in cortisol as a response to noise (Nassiri et al., 2012), however, there is no consistency in reported effects (see:

Evans and Johnson, 2000). In general, noise functions in this context as a stressor, provoking chemical responses in a body (Stansfeld and Matheson, 2003).

Referring to psychological aftermaths, annoyance is yet a different and prevalent response to noise exposure, that has been widely referred to and reported. It may occur as a direct or indirect result of noise. It is also often correlated with other effects such as loss of job satisfaction, decreased well-being, communication problems (Abbasi et al., 2019), as well as it is claimed to stem from sound interference with daily activities, rest time, and is often present together with other psychological responses such as anger, stress or fatigue (Basner et al., 2014). It may also emerge as a response to perceived intrusion into one's acoustic privacy (Stansfeld and Matheson, 2003).

Furthermore, noise has been proven to have a detrimental effect on concentration and performance. This area has been well studied and much research provides valuable insights. It has been shown that noise has a generally adverse influence on cognitive performance (Jahncke et al., 2011) including impairment of memory and arithmetical mental processing (Banbury and Berry, 2005), deterioration of working memory, and restorative patterns (Jahncke et al., 2011), depleted free and serial recall, rehearsal (Perham et al., 2007), attention distraction (Basner et al., 2014), problems with long-term memory activation, reading comprehension, operation span and decrease of motivation (Jahncke et al., 2011). The effects may occur even in below damage-risk criteria levels, for example in an office environment (Jahncke et al., 2011; Maruthy, Gnanateja, Chengappa, Publius, and Athreya 2018). Most susceptible are especially the noise-sensitive (Weinstein, 1978) and introvert (Moradi et al., 2019) subjects. Interestingly, many similar effects have also been observed for listening to music during work. Research shows that people present poorer cognitive performance while listening to music, especially in the area of immediate recall (Furnham and Bradley, 1997), reading processes (Kämpfe, Sedlmeier, and Renkewitz, 2011), and serial rehearsal, most prominent for listening to liked music (Perham and Sykora, 2012). This may be applied to the occurrence of irrelevant sound effects, described by e.g. Jones and Macken (1993), which manifests itself by “poorer short-term memory performance in the presence of background sound compared to quiet control condition...” (Perham et al., 2007). That is due to a conflict emerging between two parallel seriation processes – one related to sound analysis, the second – to remembering the task sequence

(Ibidem). The results of music influence on human performance are not, however, consistent (see: Haake, 2011; Hallam, Price, and Katsarou, 2002; Kämpfe et al., 2011; Kumar et al., 2016).

There exist also different effects of noise that do not fit in any of the above-mentioned categories. They also, however, concern people's health and well-being, as well as work loyalty. In that diverse area, sleep disturbance emerges as one of the most prevalent aftermaths (Abbasi et al., 2015; Aydın Sayılan, Kulakaç, and Sayılan, 2020), including daytime sleepiness (Basner et al., 2014). Moreover, it has been shown that clamor negatively influences job satisfaction, stress (Abbasi et al., 2019; Jahncke et al., 2011), postural invariance (Evans and Johnson, 2000), the image of the company the subject is working in, as well as attachment to it (Raffaello and Maass, 2002). A strong correlation is reported between noise and impaired and non-effective communication (Balazikova, Tomaskova, and Dulebova, 2016; Truax, 2001). Some studies even link noise exposure and noise sensitivity to depressive symptoms (Tzivian et al., 2020) and depression itself (Beutel et al., 2016). It is, therefore, possible to observe that this vast diversity of the ways noise may adversely influence people is not to be ignored. Noise has been proven to have an impact on every area of life – health, job perception, cognitive performance, quality of sleep, and anxiety – causing major physical and mental risks.

### **Office noise**

Office noise for many people is a quotidian reality. Although often ignored and neglected, in research it is estimated that for from 30% to even 85% of office workers in Poland acoustic environment of their workplace is a reason for complaint (Domagała-Szymonek, 2019), and as many as 83% combines listening to music with different activities, including work (CBOS, 2018). Although not as intrusive as, for example, industrial noise, office hubbub is still proven to be detrimental in many areas, getting the attention of scholars and researchers. The areas studied include physiological stress responses and exertion (Kristiansen et al., 2009), postural adjustments (Evans and Johnson, 2000), cognitive performance (Banbury and Berry, 1998; Jahncke et al., 2011), and concentration (Banbury and Berry, 2005). The results of the research showed that even office noise, which levels lie far below the auditory risk threshold (Polish norms set the highest acceptable level at 65dB (Majer, 2011)), may result in dissatisfaction and decrease in such areas as work motivation (Evans and Johnson, 2000), in increased fatigue (Jahncke et al., 2011), elevated annoyance, and occurring distraction (Banbury and Berry, 2005). The study by Bunbury and Berry (Ibidem) revealed that 99% of subjects reported



impaired concentration caused by noises of differing sources, telephone ringing, followed by conversations and printers, being the most disliked sounds (Ibidem). Another study by a pair of researchers showed significant disruption of performance of office tasks caused by bureau noise and speech alike (Banbury and Berry, 1998). Other studies suggested increased exertion in the head (Kristiansen et al., 2009) and poorer memory performance (Jahncke et al., 2011) in the presence of office noise. Above-mentioned issues are most burning in the open-space offices, as they produce the loudest and intrusive sound environment and therefore cause more disruption, irritation and impairment of performance. This sheds light on the negative aspects of open-space office arrangement influence on productivity and on work conditions as a whole.

Interestingly increased risk of musculoskeletal disorder has been associated with open-office clamor, due to a higher invariance in postural settings and adjustments (Evans and Johnson, 2000). Therefore, it may be observed that such a type of noise, although seemingly safe, is not neutral for human health and well-being. The aim of this article is to investigate any further effects office noise may have on workers. As most of the research up-to-date was performed using quantitative methods, it was assumed that there exists a need for the qualitative, interpretative study to emerge. Following that premise, the presented research will focus on office workers' perception and assessment of noise and its influence on their work, performance, well-being, and health, putting them in the center of the perception process.

## **Methods**

The aim of this study is to describe the office soundscape and investigate the possible effects of noise on office workers. If any exist, the research is to find out whether they are of positive or adverse nature. Moreover, the subjective perception of sounds by the workers is to be observed and analyzed in order to find out which elements of the acoustical office setting are detrimental and how can they be improved to minimize negative effects on the employees. The research is also to pinpoint the least pleasant sounds experienced in the office. That is an issue of importance for work organization and management to be able to maximize performance and provide the best conditions for the employees to work safely and effectively.

For assessing the perception and impact of noise on white-collar workers qualitative, interview-based methods have been adapted, inspired by acoustic ecology methodology and its notion of ear-witness (Schafer 1994, 1977a, 1977b). Such an approach allowed the author to emphasize

the subjective and perceptual aspects of the analyzed issue. The form of the interview chosen is the semi-structured in-depth interview. The advantages of such methods reflect the main aim of the study, as it provides a wider view and context for the topic, as well as multidimensional information flow (Galetta, 2013). Moreover, it is useful for describing phenomena, behavior, and interdependencies, as well as people's perceptions (Gudkova, 2018), therefore it is well-suited for the case of the presented research

Interviews with 10 office workers were conducted in January 2021. The sample included 4 women and 6 men, age from 23 to 58 years old, with a mean age of 35.1 years old. All of them were working in office jobs, on different posts, and for different companies in offices in various places in Warsaw, all but one concentrated in or near the city center. The mean job seniority was 10.9 years, and the mean time spent in the office weekly was 39.7 hours. 5 of the respondents worked in open spaces, 3 in shared rooms, and 2 in individual rooms. In total, 26 questions were asked to each of the participants in a semi-structured interview. Each respondent was asked the same set of questions. The interviews were later analyzed individually and comparatively using the coding method and the conclusions were drawn.

Prior to the interview, each participant was given a Weinstein's Noise Sensitivity Scale questionnaire (Weinstein, 1978) for assessing their individual sensibility to noise, as it is claimed that the people's responses to noise may differ greatly (Worthington and Bodie, 2017). The questionnaire is composed of 21 questions, scored on a five-point scale, from strong disagreement to a strong agreement, with the higher score reflecting higher noise sensitivity. The scale was introduced in 1978 (ibidem), and is considered both a reliable and valid tool (Abbasi et al., 2019) and till this day is used widely (See: Aasvang, Moum, and Engdahl, 2008; Abbasi et al., 2019; Arezes, Barbosa and Miguel, 2010; Belojević et al., 1992; Moradi et al., 2019). Following some research (see: Abbasi et al., 2019) the interviewees were considered highly sensitive if their score was above 75 percentile, moderately sensitive if scored between 25 and 75 percentile, and not sensitive if the score was below 25 percentile.

## **Results**

From the research stemmed many findings, that may be insightful. First of all, the general acoustic environment of offices is described, followed by the identification of the most annoying sounds. Further on, the notion of silence is discussed. Moreover, behavior concerning

listening and choice of music accompanying work is described, as well as its functions. Finally, the area of interviewees' opinions related to noise and health, well-being, and productivity is investigated.

### *General Acoustic Environment*

In terms of the general acoustic environment of offices, although it differs slightly from office to office, some common elements may be found describing the general acoustic environment. According to the study, people's talking is one of the main sounds pointed out by workers in the acoustical sphere (and the one that is the most irritating) that accompany their everyday work. It is followed by printers, air conditioning or/and ventilation, telephone ringing, computer sounds, traffic noise, and a radio playing. Even such unusual sounds as table football, forklift trucks, combine harvester, and aircraft noise were mentioned. Together they create an office soundscape, where they may function either as a keynote sound<sup>2</sup> or as a sound signal<sup>3</sup>, as the research shows that many people actually pay attention to the surrounding noises in their offices. People talking is most prominent, but sounds as ventilation, printer, traffic noise, or phone ringing are mentioned.

### *Annoying sounds*

#### Speech

Many of the sounds reported are classified by the respondents as irritating and disturbing, people talking being adverted most frequently.

“My office is near Powązkowska Street [near the city center], it's very busy. I don't hear the noises from outside... Rather those coming from the office. If there is a lot of people there is a tremendous racket. I think the noise people make while talking on the phone, walking around the office talking to their devices... This noise I find most disturbing.” (MG)

The annoyance finds different sources. First and foremost, it stems from the fact that the sounds interrupt the process of work. The concentration is distracted from the task towards the content of discourse. As one of the interviewees claims:

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<sup>2</sup> Keynote sound – a term used in acoustic ecology to describe a sound “which are heard by a particular society continuously or frequently enough to form a background against which other sounds are perceived... Often keynote sounds are not consciously perceived, but they act as conditioning agents in the perception of other sound signals” (Schafer, 1994, p. 272).

<sup>3</sup> Sound signal – a term used in acoustic ecology to describe “any sound to which the attention is particularly directed” (Schafer, 1994, p. 275).

“I am more disturbed by people talking than, for example, a printer, that would be next to me and print something from time to time. It is a mechanical sound, it does not mean anything, does not bring any content. A conversation of two people, who are next to me, makes me think, analyze the topic.” (OO)

A conversation, therefore, also interrupts the work’s rhythm.

### Mechanical sounds

Although speech is the most frequently mentioned as a reason for irritation, some people pinpoint mechanical sounds as the main factor. Not only does the irritation stems from the fact of distraction, but also it emerges as a response to the sound quality itself. The examples of such noise mentioned were in. al. a plotter, fluorescent lamp blowing and winking, or ventilation.

People admit that:

“It is the worst situation when there is a relative silence, the basic noise level is quite low, and there appears a single continuous sound, it does not even have to be loud. It is very irritating, it makes it impossible to concentrate” (PP)

Or:

„- If there is a flickering fluorescent lamp, it can produce a very irritating noise, I hate it. In general, such monotonous, repetitive sounds disturb me so.

I believe so [that the cause is the repetitiveness of the sound], after some times it really drives me mad” (KK)

It is clear therefore that in such a case it is not the content, but the sound quality that is the source of annoyance.

### *Silence*

Interestingly enough, although most people face noise-related aggravation at work, some claim that they don’t like silence at work. The observed reasons include being distracted by silence, excessive relaxation, a sense of loneliness, tediousness, or losing the work’s rhythm. People with low scores on Weinstein’s scale were very decisive with their dislike. There is a group of people, however, that values silence for its helping in becoming concentrated, no distractors, and its calming qualities. All the respondents who scored high on Weinstein’s scale (over 75<sup>th</sup> percentile) claimed to like silence unconditionally. It is interesting to observe that exactly the same feature of quietness is sometimes assessed as negative (excessive relaxation, sleepiness, tediousness) and sometimes positive (calming qualities). Apart from that two extreme

approaches, there is a moderate one. There are respondents that admit that their need for silence is dependent on mood and on task:

“It depends. It depends on what I do and on my mood. Sometimes I need music for setting up a proper work rhythm, it sometimes may boost my productivity, but sometimes there is such task, like for example, reading a contract from a lawyer... Then I cannot have any stimuli that would distract me, I have to analyze every word. Even music would annoy and distract me then. It is a moment when I need a complete silence” (LL)

or claim to be able to focus regardless of the acoustic conditions. Nevertheless, when asked, most people would choose a quiet and calm place for work rather than busy and lively (a café for example) regardless of their noise sensitivity score.

### *Listening to music while working*

Listening to music while working is another vast topic uptaken in the presented research. It became visible that only the people with the highest Weinstein’s Noise Sensitivity Scale scores (over 75<sup>th</sup> percentile) claim not to listen to music or any other additional sounds while working, as it makes them unable to focus on the task. It may be concluded therefore that most people do listen to different sounds at work, music being the most frequently mentioned, followed by radio, podcasts, and relaxation sounds (water, birds, etc.). In terms of the choice of the type of music, no regularity was observed. Many were mentioned, creating a continuum from calm and relaxing music, and gentle to energetic, with a pronounced rhythmic pattern, and arousing. A similar situation appears regarding the choice of music genre. Among others rap, funk, classical rock, sung poetry, the music of the 60s, relaxation music, pop, drum&base, electronic, and heavy metal were mentioned. From all the genres, classical music seems to be most frequently pointed out. Music with Polish words was designated as the least preferable, as it was claimed that it possesses similar qualities and effects as listening to conversations. Apart from that, no pattern of choice was observed in most of the cases. As respondents claimed, it depends mostly on the mood and task performed, as well as personal taste: “[I have no clear preference], it’s rather the music that I simply like listening to.” In one case, however, an interesting regularity was observed. The respondent claimed that:

“...I am most productive to the music composed by Haydn. I focus best with it. Any other music, I don’t know Mozart or something, does not have such an effect on me... When it is about productivity it is definitely Haydn. If I have, however, to motivate myself for a task that does not require my full focus, then Metallica is really good.”(PP)

Unfortunately, the respondent was not able to identify the features of Haydn's music that make it so different from others in terms of the effect. Perhaps it would be an interesting topic for further studies.

#### Functions – making the work more pleasant

Even from that single case, it may be deduced that listening to music while at work serves many different functions. First and foremost, music makes work more pleasant and less tedious. It elevates general mood, which some claim has a positive effect on their productivity:

“It prevents boredom, that's for sure. It makes it more pleasant to work, I am simply in a better mood, and that in turn have an [positive] effect on productivity”. (MM)

It also makes the respondents feeling less lonely:

“...now, when I was working alone in the office, I was switching it [a radio] on, so that the room is not so empty... so that there is some activity going on around me...so that there is more noise than I am capable of making alone.” (CA)

#### Functions – stimulating or calming effects

Depending on the type of music chosen, it may either stimulate and prevent sleepiness or calm the worker in case of excessive stress:

“Sometimes I listen to more energetic music with very clear rhythm to stimulate myself, to boost, for example when it's the end of the day, I am already tired, but still I have to squeeze something out of me... Then dynamic music is perfect. On the other hand, when I am stressed... then I rather listen to calm music. Maybe not relaxation music, but definitely smooth” LL

#### Functions – blocking external stimuli

One of the most important functions of music identified and the one most frequently mentioned is blocking external stimuli. Through that, it improves concentration and focus. Interestingly, people working in communication-enhancing open-office settings claim, that most of the time they work with their headphones on – therefore isolating themselves from the excessive clamor of such arrangement, as the noises give too much distraction, making it impossible to focus on the tasks:

“Just because the office itself is well insulated and I can't hear noises from the street, I feel that people talking is even more enhanced. Nothing jams it, nothing muffles... I pay a lot of attention to that, and basically, if I am sitting at the desk, I spend like 70% of my time in the office with my headphones on. I don't even have to listen to anything, but the headphones dampen conversations, phone conversations for example” (LL)

“I definitely prefer peace and quiet. Then it is much easier for me to focus. However, when I have to work in a little bit more burbly place I save myself with the headphones and quiet music in the background. Then I am able to manage. But again – I really prefer a peaceful and quiet environment” (PP)

Functions - rhythmization

An interesting and actually ancient function of music was also mentioned, namely to rhythmize the performing of a task. Although initially being related to physical work (Prichard., Korczynski, and Elmes, 2007), it is clearly still relevant in a modern white-collar work environment:

“Energetic music for tedious tasks makes it more pleasant to work. And I have a feeling that it makes it easier for me to take up a good rhythm of work. You know, when you for example insert data into a program...Music helps me to take up a right rhythm.” (KB)

“When I choose a good music for the task I just find a right work rhythm. I have a nice background and things happening around don’t disturb me” (KK)

*Health, wellbeing, and productivity*

Another area that was being researched, is the themes of health, well-being, and work productivity concerning the acoustic environment of the office.

Productivity

All but one respondent claimed that the sounds surrounding them at work have a negative effect on their productivity and quality of their work. The most frequent causes of such a situation were losing concentration and work rhythm due to the noise. It was claimed that it makes it difficult to focus and makes the execution process of the task longer. As the interviewees state:

“If too much is happening around me [acoustically], I get distracted, I lose the work rhythm. I cannot Focus on what I am doing” (OO)

“When they [other people in the office] are talking, I definitely need to slow down with my work” (CA)

Again, ongoing conversations around were most frequently mentioned as the most intrusive sound in the environment, followed by other sounds of human provenience, mechanical sounds, and traffic noise from the outside.

Well-being and health

Most respondents claimed that office noise has a negative effect on their well-being. All but one of the respondents reported the occurrence of at least one of the symptoms from temporary hearing loss, annoyance, aggression, sleep disturbance, daytime sleepiness, impairment of the performance, work dissatisfaction, communication problems, increased stress levels, headaches, feeling of constant humming inside your head, or excessive fatigue. Concluding from the results, impairment of performance is the most common effect of workplace noise in offices. It is followed by excessive fatigue and annoyance. Increased stress levels, daytime sleepiness, communication problems may also be the results of office noise exposure. Furthermore, such symptoms as headaches, humming inside one's head, eye pain, and unpleasant arousal are other possible consequences. Interestingly enough, though reporting such symptoms, which directly or indirectly may affect human health, most people are not aware of noise's effects on it. Moreover, the majority describes their offices as not particularly noisy places.

To conclude, it may be observed that there exist many adverse effects of office noise on human beings. Although the sounds are not particularly loud, they do impair the performance, cause annoyance, fatigue, and other responses. As one of the respondents stated:

“There are sounds of very low frequency. The research shows, when you work for 20-30 years [in such conditions] it has an effect on human mental well-being. I can see it for myself, this example of ventilation... I am convinced that it can have an effect [on our health], even if we are not aware of it [the sound]. We don't have to hear the sound to feel its effects on our health and well-being.”

It is clear, therefore, that it's not only the loudness that matters, and even moderate office noise (in Poland the maximum level of it is set on 65 dB by the norm PN-N-01307:1994 (Majer, 2011)) affect the workers adversely.

## **Discussion**

The results show that in an in-office working environment the employees do pay attention to sounds and are aware of them. Many of them also find at least one source of noise irritating. That is in line with past research by Banburry and Berry (2005). The finding that speech is actually one of the most annoying and disruptive sounds also finds confirmation in other studies (Sundstrom et al., 1994; Haka et al., 2009; Haapakangas i in., 2014). It is also clear that it affects performance to a greater degree than office noise without speech (Banbury and Berry, 1998). It is argued that such regularity may be ascribed to irrelevant speech effect, a



phenomenon causing impairment of serial recall performance by the presence of speech that is not relevant for the task (Farley, Neath, Allbritton, and Surprenant, 2007) (or its wider form – irrelevant sound effect). It is due to the emerging conflict in processing information related to the task and this unrelated simultaneously (Perham et al., 2007). As we do observe that regularity in the presented research, it can be assumed that the above-mentioned theory may lay underneath the noticed phenomenon of regarding speech as the most disruptive noise in the office setting. This offers interesting and to some extent revolutionary consequences – open office environment, which has been presented as a communication-enhancing tool, in fact may supposed to be, through that exact notion of increased verbal communication, most detrimental in some areas.

Furthermore, the study revealed that the main effects of office noise on humans are impairment of the performance, annoyance, and excessive fatigue. Those results also find confirmation in the literature et al., 2009; Jahncke et al., 2011). It was also found that not many immediate results on health are identified by the respondents which align with the studies by Kristiansen et al. (2008), which found no significant reactions in EMG, HRV, and systolic blood pressure. The only bodily effect identified was increased perceived exertion in the head. Another study by Evans and Johnson (2000), however, found elevated epinephrine levels in the urine and greater postural invariance. It is therefore visible that not many immediate bodily reactions to office noise may be observed, however, those reported by the respondents may result in some negative health effects. It is impossible, however, in this study to assess objective physical and physiological responses to noise, as it is beyond the research borders. It may however be assumed that, following both presented and past research, bodily reactions to office noise might be limited. On the other hand, psychological and performance-related effects are relatively widely observed and may be assumed as prevalent.

Finally, interesting findings emerged concerning music listening while working. It is used either as a noise-coping strategy or as a booster for productivity, motivation, and inspiration. It is also told to alleviate the mood and to help to deal with monotonous and tedious work. Some respondents claim that listening to music actually increases their productivity and effectiveness. It is intriguing, especially in the light of past research, which is equivocal in terms of music effects on performance. It is acknowledged that music does have a beneficial effect on the mood (Kämpfe et al., 2011), as well as inspiration, stress-relieving, and managing personal space

(Haake, 2011). Some researchers also claim that music, especially soft and calm may, in fact, increase the performance (Hallam et al., 2002; Kumar et al., 2016), however, the studies were conducted among children and students, in case of the latter relying mostly on student's self-assessment, so may not be applicable to professional conditions. Another response to the inquiry of why people prefer to listen to music while at work and how it may increase their work performance may be provided by the stochastic resonance phenomenon. The effects are thought to rely mostly on the dopamine levels (Söderlund, Sikström, and Smart, 2007) and may be explained through the Moderate Brain Arousal model, stating that sub-optimal neural noise levels may be enhanced by external stimuli (Sikström and Söderlund, 2007). It shows that under certain conditions, moderate noise can actually improve task performance, with the noise level to performance relation having an inverted U-shape (Rufener et al., 2020). However, research results on that topic are inconsistent (Rufener et al., 2020).

On the other hand, there is a lot of evidence proving that music distracts attention and has a detrimental effect on performance, especially in the area of reading processes and memory (Furnham and Bradley, 1997; Kämpfe et al., 2011). Moreover, it is important to notice that most of the respondents claimed that they listened to music that is according to their preferences and liking. That seems natural, yet some research shows that, while both types of music have a detrimental effect on serial recall, the disliked one has an actually smaller negative effect than the liked one (Perham and Sykora, 2012).

This ambiguity in the research concerning the effects of listening to music, therefore, does not shed light on the analysis of my study results. As the research focused on subjective measures, it is not possible to objectively assess the exact influence the music has on the performance. However, based on subjective opinions and self-observation, certain conclusions may be proposed. First of all, I suggest that the effect the music has on the worker is depended on the individual noise sensitivity level, in the present study measured by the Weinstein's scale. Moreover, the positive effects of listening to music compared to listening to nothing may be correlated with the fact that the music functions as a blocker of external stimuli, therefore cutting the subject off the more intrusive noises, as for example – speech. Through that music may create a comfortable individual work-space designed acoustically by the subject, eliminating more irritable acoustic forces. As most open-office workers claimed to use music as an inhibitor of external stimuli, an interesting conclusion may be drawn from that. An open-

office environment originally thought of as communication-enhancing, in fact, may force workers to alienate themselves and create more work-friendly closed acoustic bubbles.

Apart from observing many interesting phenomena and relations, we must acknowledge that the presented study has its limitations. First and foremost, the confined size of the sample may influence the obtained results. Although quite typical for qualitative research, it may not be sufficient for generalizing the results. Moreover, as it was briefly mentioned before, it needs to be remembered that the research focused mostly on subjective perception and assessment of sounds and acoustic environment quality, not on objective measures. And as they should be considered insightful, especially by office space designers and employers, at the same time they need to be treated with some dose of caution in terms of generalizing. It is, however, believed that the study may contribute to an increased level of awareness and to the general improvement of acoustic conditions in workplaces, as well as catalyze the reconsidering of the typical arrangement of office space.

### **Recommendations**

As may be observed, the acoustic conditions in office workspaces are often the subject of complaints by its workers. As it adversely influences their health and wellbeing, it may be needed to implement some solutions that would improve the overall acoustic environment of offices. It is proven, that alleviating the level of acoustic quality has a positive effect on adverse noise impacts, especially in the area of subjective disturbance and cognitive performance (Haapakangas et al., 2014).

Of course, there exist many acoustic norms that are introduced by the law for building and designing different spaces. The main requirements concerning acoustics are presented in the Polish Norm PN-B 02151-3:2015-10, which describes acoustic insulation of partition walls in different buildings, including flats, detached houses, hospitals, hotels, and others. For the sake of the topic of the present article, the most important are the norms ascribed to administrative buildings and office rooms. There exist two main indexes measuring the insulation of the walls: R'A1 (mostly inner walls) and R'A2 (mostly outer walls), which usage is described in Polish Norm PN-EN ISO 717-1:2013. The indexes are measured for airborne sounds (walls) and impacts sounds (ceilings). As an example, a room for administrative work should have a R'A1 index on a minimum level of 35dB – which means that the wall should provide a 35dB

difference between the noise outside and inside the room. General noise levels acceptable in offices are regulated by Polish Norm PN-N-01307:1994 and are set on the levels of 55dB in administrative rooms, offices, and rooms for conceptual work and 65 dB in outer offices and customer service centers (Majer, 2011). However, sometimes the law is not a sufficient measure for good acoustic design.

As acoustic ecologists encourage, listening and critical evaluation should be the first step before undertaking any further actions (Schafer, 1994; 1998; Truax, 2001). It is crucial, as it allows to assess the conditions in terms of functionality, aesthetics, and epistemology (Heinrich, 2020), as well as to identify the main issues and drawbacks. It provides the base for any further design (Ibidem). Such a strategy is very easy and possible to introduce by every member of the office community, providing at the same time insights and opinions by the most interested parties.

Apart from that, education is another important step in a path for improving the quality of acoustic conditions. As was mentioned above, most people do not correlate the adverse impact of noise with health effects. Although in the office environment the intensity of noise is moderate, it affects the well-being, and through that may have further consequences, of which the workers should be aware.

In terms of more technical and direct solutions, there are some identified, provided by researchers, as well as by the research conducted by the author. Those include taking up such measures as installing dividing panels between each desk, as well as putting plants in the office, placing thick doors and airtight windows, keeping distance between workstations, introducing certain specific rules of conduct, considering the most noise-sensitive people, creating smaller open-spaces, or even providing individual rooms for the workers. First and foremost, it is proven that inserting **divider panels between each desk** is a very effective method for improving the acoustic quality of a room, by preventing the sounds from spreading and by their isolation (Hongisto, Keränen, and Virjonen, 2004; Passero and Zannin, 2012). Furthermore, **increasing the room's sound absorption level** was found to have a significant effect on the amendment of the acoustic environment, and, therefore, on employees' performance (Haapakangas et al., 2014). To achieve that the use of absorbing materials is proven to be effective, especially when applied to the ceiling (Passero and Zannin, 2012). The present research respondents also suggested implementing it on floors' and walls' surfaces. Although

the quantitative research claim such action's limited impact (*ibidem*), the workers themselves state its favourability:

“... the space is quite big, the sounds that are not related to people, conversations, disappear in it. So it is only discussions because we have paneling, that dulls all the pattering, the rooms are muffled with special materials...”

To limit the reverberation further and improve the isolation of sounds other measures may be implemented, as proposed by the employees. Those include putting more plants in the office, placing thick doors and airtight windows.

Apart from that, another important factor for improving the acoustic conditions in the offices is **to keep a proper distance between workstations**, which is acknowledged both by researchers (Kaarlela-Tuomaala et al., 2009) and, according to the present research, the employees themselves. Speech masking is also recommended by some (Haapakangas et al., 2014; Kaarlela-Tuomaala et al., 2009), however, at the same time is being rejected by others due to its adverse effect on the communication and acoustic information flow (see: Truax, 2001).

Introductions of certain, commonly agreed **rules** may also be a beneficial measurement for improving the acoustic quality of the workplace (Kaarlela-Tuomaala et al., 2009), and through that alleviate employees' well-being and performance (Liebl et al., 2012). Such rules may include having phone calls and conversations in private rooms, using a lowered voice level, not leaving phones ringing (Kaarlela-Tuomaala et al., 2009), or, as proposed by the present study's respondents, having them muted, as well as eating outside the office room. In order to further limit the noise intensity, modern ventilation, and air-conditioning should be implemented. Finally, according to advice by acoustic acology researchers, a “noise thermometer” should be installed in a visible place for informative purposes (Truax, 1998).

Apart from that, especially most **noise-sensitive people should be taken into consideration** by the managers while planning their office space. As it could be observed, noise-sensitive people are the ones that are affected most by the noise and lose the most in terms of concentration and performance. Good acoustic conditions should be provided for them specifically to help them reach efficiency at work.

Creating **smaller open spaces** would be recommended to limit the number of distractors and to lower the noise level. Of course, the ideal, though the unrealistic solution would be to provide

**an individual office for each** worker. That would reassure the best possible acoustic conditions for improving health, well-being, productivity, and work quality (Kaarlela-Tuomaala et al., 2009).

Finally, to ensure that the measures are controlled and improved, I suggest that **regular acoustic audits** should be performed to assess the noise levels and the effectiveness of the actions uptaken.

## Conclusions

The aim of the study was to investigate the perception of sounds and self-reported noise effects on health and well-being by office employees. It was showed that workers pay attention to sounds, often finding them annoying and distracting. A negative influence on work performance was also found. The results were in line with much current research. It is believed that improving the acoustic environment in offices would positively influence work performance, well-being, and consequently overall health of white-collar workers. To provide for that, proposals of solutions were given, such as using the divider panels, absorbing materials on surfaces, or implementation of commonly agreed rules of behavior. However, it is important to notice that the most optimal working condition in terms of acoustic quality is an individual office. Although costly, that is the solution that would definitely increase individuals' productivity.

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