How Paramedics Perceive Internal Noise in Ambulance? Sensory Processing Sensitivity (SPS) and Subjective Noise Assessment

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Abstract

Introduction: This article discusses the correlation between sensory processing sensitivity (SPS) as a feature of personality and temperament and paramedics’ subjective perception of noise inside an ambulance. Description of the theoretical basis of SPS has been strongly depicted. Material and methods: Polish translation of SPS 12-item short scale and a survey concerning the subjective perception of noise inside an ambulance have been used in this research. Assessment of noise included its three sources: emergency vehicle siren, resistance of rolling tires and noise produced by diesel engines. 46 paramedics from mobile emergency care units working in Poznan and the Poznan’s district have taken part in the research. Paramedics with higher SPS results were selected, creating a highly sensitive people (HSP) group. Results: When non-HSP people were compared to paramedics from the HSP group, an emergency signal was considered more burdensome for HSP paramedics. The intensity of noise generated by the vehicle’s suspension elements and tires was significantly higher in cars more than 3 years old. Older paramedics (≥30 years old) evaluated the intensity as well as burdensomeness of noise generated by suspension’s elements and tires, higher than the younger (<30 years old) ones. Conclusions: Both paramedics and drivers as occupational groups are liable to noise, which seems to be particularly harmful and burdensome to the HSP group. Further studies should be provided in this area. This may lead to an increase not only in their productivity but also in their quality of life.

Keywords: Ambulance, highly sensitive people (HSP), infrasound, paramedic, noise, noise exposure, sensory processing sensitivity (SPS)

INTRODUCTION

Hearing as one of the senses enables the reception of sound waves and is remarkably essential when it comes to communication and a sense of direction. Average human’s ear receives sound frequencies between 16 and about 20 000 Hz, whereas the best reception of octaves happens in childhood and significantly increases with age (from 40,000 Hz at newborns to even 5000 Hz in the elderly).[1] Every day we are surrounded by sounds of varied intensity (measured in decibels, dB)—ranging from whisper (about 10dB), hairdryer (55 dB), busy street (95 dB) to ambulances’ signal (about 130–135 dB). Unfortunately, sounds do not only include a pleasant conversation or relaxing music but also stand for sounds possibly harming the human body. The higher the intensity and length of an acoustic stimulus, the greater the consequences for human health and functioning.[2]

(1)  
<35 dB—sounds mostly harmless, however, they may cause some irritation and difficulties concentrating.

(2)  
35–75 dB—may cause some straining of the nervous system resulting in problems in speech comprehension, resting and falling asleep.

(3)  
75–85 dB—conduces to decrease in work productivity and may have some health effects including problems with hearing.
On the basis of the research and observations, a new processing sensitivity (SPS) term has been created, which stands for genetically conditioned temperamental feature characterizing people of higher sensitivity to environmental stimulus. This feature is induced by more profound, cognitive processing of the stimulus and connected with higher emotional reactivity. [24] Highly sensitive people (HSP) are 20% of the population. They are marked by negative approach, fear, somatization, sleepiness, tendency towards worrying, confidence in having greater ontogenic sensitivity and tendency to physical and emotional exhaustion, a need to be alone, problems with concentration and easiness to be distracted. Additionally, these people have been thought to be more apprehensive and shy. [25,26] Although HSP are not willing to get into new surroundings, it is not necessarily an effect of their “sociability” (as in introversion), but it depends on deeper sensory processing, which determines the strategy of coping based on rethinking before making a decision. This strategy turns out to be rather questionable in some stimulating social situations, which often demand fast reactions. [27] The research also shows the decreased threshold of emotional sensitivity is related both negative (as in high emotional reactivity) and positive stimuli, which, in turn, affects good reception of psychological intervention by these people. [28] SPS is assessed on the basis of a standardized 27-item Highly Sensitive Person Scale tool for adults [29] and the 12-item Highly Sensitive Child Scale. [30] Highly sensitive people can be described using shortcut suggested by the authors “DOES” including the paradigm’s key elements. [31]

“D”—depth of processing, which is manifested not only by a more detailed analysis of streaming information but also by hyperresponsiveness of the immune system and a greater effect of pain, hunger and caffeine.

“O”—overstimulation, quicker stimulus overburden resulting in tiredness. As a consequence, it also leads to sensibility to stress and worse mental condition. It is essential to state that the sensibility affects the whole nervous system resulting mainly in a lowered threshold of stimulation.

“E”—emotional reactivity & empathy, emotional reactivity and high compassion, stronger reception of one’s own emotional states and a better understanding of other people’s moods.

“S”—sensing the subtle, noticing the details.

From an evolutionary point of view, this feature, is not only supported by a reaction to both positive and negative stimuli, involves deeper processing of stimuli in varied situations but also motivates learning and leads to more effective responses in the similar cases in the future. At the same time, this mechanism absorbing too much energy, cannot be beneficial enough. [32] Although the depth of processing is mainly a cognitive (not always conscious) activity, it can also be manifested by a decreased reaction of the immune

(4) 85–130 dB—may trigger some ailments and cause organ failure. Sounds of such frequency make speech comprehension impossible even at a distance of 50 cm.

(5) >130 dB—conduces to a permanent failure of the acoustic organ, also causes damage to internal organs because of inner vibrations.

There is an abundance of data indicating an adverse impact of noise at the workplace. According to this data, 40 years of full-time work (8 hours/5 days a week) in a noisy environment of 85 dB brings about a 10% risk of hearing loss. Also, too high intensity of sound may cause pain at 120–140 dB. [3] What is more, hearing deficit induced by noise (Noise-Induced Hearing Loss, NIHL) is one of the reasons for preventable hearing loss. [4] The influence of sound is not limited to our ears. Research has shown that it can also contribute to sleeping disorders, narrowing of coronary arteries, difficulties breathing and increased secretion of stress hormones. [5,6] Sleeping disorders include slight difficulties falling asleep, frequent wakening at night and early awakening. [7,8] In addition, the noise may also impair some cognitive functions such as attention, concentration, reading, counting and comprehension skills, thus influencing abilities that are in a broad sense defined as the ability to cope with variety of tasks and general performance or efficiency, leading to a decreased subjective assessment of own quality of life. [9-13] People liable to noise at work are burdened with a higher risk of coronary artery disease—the risk increases proportionally to the difficulty and stress of the work conditions. [14] Medical staff including paramedics and ambulance drivers are expected to work very efficiently, but at the same time, they are exposed to the adverse effects of noise. [15] The research shows that this occupational group is most often susceptible to hearing damage and its health consequences. [16-19]

Hearing damage resulting from noise is multi-causal, caused by factors such as age, genes, free radicals, tobacco, alcohol and extrapersonal factors, [20] including impulse sensitivity. In the 90s it was pointed out that some people differ strongly when it comes to reality reception with receptors. Observations showed there were individuals with lower impulse sensitivity, but there were personality differences related to a significantly lower threshold of responsiveness too. [21] Such environmental sensitivity has been defined as an extent to which an individual can receive, process and respond to external stimulus, [22] it has also been distinguished as an individual’s measurable characteristics. This group of people and their sensitivity to stimuli have been summarized as some metaphors of flowers: Orchids as people of higher vulnerability (better functioning in optimal conditions to difficult conditions), Dandelions as those characterized by low environmental sensitivity (resistant and eager to develop everywhere) and Tulips as people of average sensitivity (suppressing some of the difficulties but not extreme ones). [23]
system and a stronger reaction to pain and hunger. As SPS is connected with higher empathy and awareness of social, emotional and perceptual tasks, it engages brain areas responsible for processing information about the prize (positive stimulus), memory, physiological homeostasis. It may also become an adaptive strategy which can facilitate deeper integration and environmental or social information memory, well-being and cooperation.

Genetic markers (dopamine receptor D4 and serotonin transport gene 5—HTTLPR), which influence faster depletion serotonin have been indicated as mechanisms explaining high sensitivity. Serotonin mediates in information processing between neurons and takes part in the regulation of mood and stimulus reception. On the basis of the results of neuroimaging research, it has been stated that individuals characterized by high SPS integrate neurological components of visual processing more than low SPS individuals. A negative experience can influence these individuals more vigorously and can predispose them towards the development of chronic negative effect or neuroticism, probably because of more integrated information processing. Distinguishing particularly active areas of the brain of sensitive people, these connected with empathy, reflexive thinking, self-control, and hormonal balance have been mainly pointed out. The most important correlates of sensitivity following include periaqueductal gray, hypothalamus, inferior frontal gyrus, insular cortex, temporoparietal junction and prefrontal cortex. However, the research has not confirmed amygdala activity is responsible for emotional processing. It can suggest that an emotional analysis of SPS individuals does not involve the limbic system but also higher brain structures responsible for awareness, planning, and integration of sensory stimulus.

MATERIALS AND METHODS

The pilot research was carried out in the group of 46 paramedics (15 females, 31 males; mean age 30 yrs, median 28 yrs, SD 8.6 yrs) working in the city and district of Poznan, the so-called region of Provincial Ambulance Station in Poznan (Wojewódzka Stacja Pogotowia Ratunkowego w Poznaniu).

The respondents were asked to subjectively assess loudness and burdensomeness of internal sounds produced by ambulances in road traffic using a 1-10 scale, where 1 meant the lowest whilst 10 the highest level of intensity and burdensomeness. The analyzed parameters included: the noise generated by diesel engine, suspension and tires as a signal of an emergency vehicle.

The analysis was based on the results on the shortened 12-item SPS scale, participants’ age (<30 and 30≥) and vehicle’s age (max. 3 years old or more). In addition, the level of noise in special purpose road vehicles was determined. The research was carried in on Mercedes Sprinter 316 CDI vehicles. The acoustic noise levels in ambulance achieved 130-135 dB-A as measured from a distance of 1 meter from the car.

Acoustic noise levels are significantly lower due to efficient sound-proofing and do not go beyond 80 dB-A. Infrasound seemed to be a specific problem in the vehicles mentioned above. The level of exposure to infrasound inside the vehicle on the way to a patient reached about 101 to 114 dB-G. Ambulances’ drive, suspension, and tires are responsible for infrasound generation. Shortened SPS scale (12 items) depicts behavior and reactions on a 1–7 scale, where 1 is the lowest, 7 the highest intensity of expression and responses. The tool was translated from English by two translators, then properly translated back and forth, evaluated and approved by competent judges (a graduate of the English Department, a graduate of the Polish Department and a psychologist). The Beta version of the tool was used. Psychometric properties of the tool will be determined in the next part of the study. Two extra screening questions related to neuroticism were included as suggested by the author of the tool. Individuals who gave positive answers to both questions were excluded from the study group.

The results have been analyzed on the basis of respondents’ average results on the SPS scale (mean 42 pts). On this basis, respondents were divided into HSP (n = 25, 11 females, 14 males; mean age 31 yrs, median 30 yrs, SD 9,4 yrs) and non-HSP group (n = 21. 4 females, 17 males, mean age 29 yrs, median 25, SD 7.6 yrs) were created. What is more, the results for paramedics working in maximum three-year-old ambulances (n = 29, 8 females, 21 males, mean age 31 yrs, median 33 yrs, SD 8.4 yrs) and older (n = 17, 7 females, 10 males, mean age 29 yrs, median 23 yrs, SD 8.9 yrs), as well as <30 (n = 25, 9 females, 16 males, mean age 23 yrs, median 23 yrs, SD 2.4 yrs) and 30≥ years old (n = 22, 5 females, 17 males, mean age 38 yrs, median 37 yrs, SD 5.5 yrs) were compared.

RESULTS

Subjective sense of intensity and burdensomeness of noise produced by the engine, elements of suspension, rolling wheels or the ambulance signal and differences between HSP and non-HSP groups are presented in Table 1. The ambulance signal was considered as more burdensome by HSP paramedics. The differences reached statistical significance.

Table 2 presents differences in noise assessment among paramedics driving cars less than or more than 3-year-old, whereas Table 3 shows results obtained by different age groups (<30 and 30≥). The intensity of noise generated by elements of suspension and tires in cars >3-year-old was considered significantly higher than in <3-year-old vehicles. Older (30≥ years old) paramedics reported the intensity and burdensomeness of the noise of the suspension system and tires as higher than the younger (<30 years old) ones.
Table 1: Differences in subjective assessment of noise intensity and burdensomeness between HSP and non-HSP groups

| Group                                      | N  | Mean  | SD     | Student’s t test of equal means, significance (two-sided), P<0.05 |
|--------------------------------------------|----|-------|--------|-------------------------------------------------------------------|
| Noise intensity                            |    |       |        |                                                                   |
| Engine                                     | HSP| 25    | 4.0400 | 1.59374                                                          |
|                                           | non-HSP | 21  | 3.4286 | 1.36277                                                          |
| Emergency vehicle siren                    | HSP| 25    | 6.5200 | 1.75879                                                          |
|                                           | non-HSP | 21  | 5.4286 | 1.98926                                                          |
| Elements of suspension and resistance of tires’ rolling on the surface | HSP| 25    | 4.0400 | 2.05102                                                          |
|                                           | non-HSP | 21  | 3.7143 | 2.30527                                                          |
| Noise burdensomeness                       |    |       |        |                                                                   |
| Engine                                     | HSP| 25    | 3.6800 | 1.88680                                                          |
|                                           | non-HSP | 21  | 2.9048 | 1.60950                                                          |
| Emergency vehicle siren                    | HSP| 25    | 6.3600 | 1.99750                                                          |
|                                           | non-HSP | 21  | 4.2857 | 2.26148                                                          |

HSP – highly sensitive paramedics, non-HSP – paramedics beyond high sensitivity trait. Bold – means statistical significance.

Table 2: Differences in subjective assessment of noise intensity and burdensomeness for max. three-year-old and older cars

| Group                                      | N  | Mean  | SD     | Student’s t test of equal means, significance (two-sided), P<0.05 |
|--------------------------------------------|----|-------|--------|-------------------------------------------------------------------|
| Noise intensity                            |    |       |        |                                                                   |
| Engine                                     | Older | 17  | 3.7647 | 1.78639                                                          |
|                                           | Newer | 29  | 3.7586 | 1.35370                                                          |
| Emergency vehicle siren                    | Older | 17  | 6.2941 | 2.05441                                                          |
|                                           | Newer | 29  | 5.8621 | 1.86556                                                          |
| Elements of suspension and resistance of tires’ rolling on the surface | Older | 17  | 4.7059 | 2.68712                                                          |
|                                           | Newer | 29  | 3.4138 | 1.63701                                                          |
| Noise burdensomeness                       |    |       |        |                                                                   |
| Engine                                     | Older | 17  | 3.0000 | 1.80278                                                          |
|                                           | Newer | 29  | 3.5172 | 1.78527                                                          |
| Emergency vehicle siren                    | Older | 17  | 5.0588 | 2.48673                                                          |
|                                           | Newer | 29  | 5.6207 | 2.27429                                                          |
| Elements of suspension and resistance of tires’ rolling on the surface | Older | 17  | 4.0588 | 2.83881                                                          |

Newer – max. three-year-old ambulance, older – ambulance more than three-year-old car, bold – means statistical significance.

Table 3: Differences in subjective assessment of noise intensity and burdensomeness for variety of age groups (<30 and 30≥)

| Group                                      | N  | Mean  | SD     | Student’s t test of equal means, significance (two-sided), P<0.05 |
|--------------------------------------------|----|-------|--------|-------------------------------------------------------------------|
| Noise intensity                            |    |       |        |                                                                   |
| Engine                                     | <30 | 25    | 3.6800 | 1.37598                                                          |
|                                           | 30≥ | 21    | 3.7619 | 1.78619                                                          |
| Emergency vehicle siren                    | <30 | 25    | 6.0000 | 1.73205                                                          |
|                                           | 30≥ | 21    | 5.8095 | 2.22753                                                          |
| Elements of suspension and resistance of tires’ rolling on the surface | <30 | 25    | 3.1200 | 1.58955                                                          |
|                                           | 30≥ | 21    | 4.8095 | 2.40040                                                          |
| Noise burdensomeness                       |    |       |        |                                                                   |
| Engine                                     | <30 | 25    | 3.1200 | 1.92180                                                          |
|                                           | 30≥ | 21    | 3.5238 | 1.69172                                                          |
| Emergency vehicle siren                    | <30 | 25    | 4.7600 | 2.47117                                                          |
|                                           | 30≥ | 21    | 5.9048 | 2.11907                                                          |
| Elements of suspension and resistance of tires’ rolling on the surface | <30 | 25    | 2.8800 | 2.00666                                                          |

<30 – paramedics under 30 years old, 30≥ – paramedics 30 years and older, bold – means statistical significance.
DISCUSSION

There is a shortage of scientific evidence on the phenomenon of sensory processing sensitivity (SPS) in the context of noise sensitivity, so it requires in-depth empirical exploration. Studies on SPS/HSP suggest sensory processing may be associated with mental disorders. Psychological investigations indicated SPS may be related to the concept of temperament and personality. 

Subjective assessment of noise burdensomeness has been already examined in a controlled environment. Results show that people of greater temper are more sensitive to infrasound and lower frequency sounds. Highly reactive individuals complained about sleepiness, tiredness, and problems with concentration. Literature also demonstrates the negative influence of noise in the audible zone and infrasound on human’s psychomotor ability. According to the authors, the criterion for infrasound burdensomeness for jobs demanding concentration, noise levels should not go beyond 86 dB-G. The numbers were 20+ dB-G higher in case of working ambulances with an audio signal on. The results obtained are consistent with other scientific reports. The authors also indicated a high correlation between above-average work dissatisfaction and a need to take a rest after work. Specific work conditions in mobile medical teams can definitely increase these tendencies.

In modern ambulances, the staff is exposed to high noise levels when they are in direct proximity of vehicle with the audio signal on. Up to 10-meter distance, exposure to noise is very unpleasant. Additionally, this range of frequency is supposed to warn the surroundings, which actually escalates this negative psychological effect. High level of noise may be hazardous to the children’s health (especially if they have coexisting diseases). On the other hand, due to modern technology, the exposure to audible noise levels inside such a vehicle has been limited and fits acoustic comfort zone (high noise sound-proofing can achieve a sound reduction of up to several dozen decibels). Modern technology has not been fully able to limit patients’ exposure to general vibrations and coexisting infrasound and the sound of low frequency. These are levels which can influence the psychosomatic status of both patients and paramedics.

CONCLUSIONS

Pilot research indicates statistically significant differences in subjective assessment of internal noise in ambulances among HSP and non-HSP groups. In addition, differences in the reception of noise among two age groups have been found. For older (30+) paramedics noise of tires’ rolling and sounds of suspension seems to be more burdensome. This factor also plays a role in older cars. Despite the limitations of the study such as the size of the group), we may suggest implementing procedures, which raise awareness of aspiring medical rescue staff. Some additional diagnostic procedures helping to select health professionals who are able to work in unfavorable conditions should be applied before hiring paramedics. Additionally, replacement of units of suspension, even if their servicing indicates efficiency, should be considered. It can also become a reason for discussion about further use of diesel engines in medical vehicles booth in the context of noise-generating infrasound and vibrations.

Because of the high stimulus sensitivity of HSP people and mechanisms of their functioning, it is essential to analyze work conditions, specifically if they may lead to stimulus overload. It seems that these individuals are notably liable to stress at work, low job satisfaction and the need to take a rest. Paramedics and ambulance drivers are occupational groups who especially exposed to noise. The noise can be particularly intense and burdensome for HSP individuals. Identifying and eliminating the risk factors can help in to create a friendly occupational environment, which is adjusted to these people’s needs in order to increase productivity and their quality of life.

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Conflicts of interest
There are no conflicts of interest.

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