The specific demands of people on the acoustic environment in working status with complex cognitive tasks

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ABSTRACT

Noise has been proved to be a psychophysical stressor which impairs the cognitive process. Creating a healthy acoustic environment is particularly important for people's health and well-being. According to the former study, a healthy acoustic environment was defined as a demands-focused concept and the specific demands were proved to be closely associated with status. Based on the finding, the aim of this study is to further explore people's subjective demands on the acoustic environment in working status with complex cognitive tasks. Through focus group interviews, 81 specific demands under working status with complex cognitive tasks were obtained. Afterwards, a big-sample questionnaire survey was conducted to screen out the demands needed by most people, such as "no rapid heartbeat", "do not make it difficult to obtain information from the working materials" and "do not evoke feelings of disgust". This paper lay a foundation of basic database for a future laboratory experiment to propose a standardized questionnaire of the healthy acoustic environment in working status with complex cognitive tasks.

INTRODUCTION

Noise has been proved to be a psychophysical stressor which impairs the cognitive process [1]. Creating a healthy acoustic environment in working status is particularly important for people's health and well-being. According to the former study, the healthy acoustic environment was defined as a demands-focused concept [2]. In order to establish a healthy acoustic environment in working status, it is necessary to explore people's subjective demands on the acoustic environment.

Previous studies mainly focused on whether an acoustic environment would cause negative effects on certain indicators related to people's demands. The indicators frequently used by researchers were work performance [3, 4], attention and short-term memory [5, 6], subjective distraction [3, 7], annoyance [7, 8], fatigue [9, 10], comfort [3, 11] and some neurophysiological indicators [12, 13]. It is meaningful for us to understand the influence mechanism of an acoustic environment on these indicators, but with people's increasing requirements for health [14] and a healthy acoustic environment [2], whether "no negative effects" can cover people's all-round demands in working status is worthy of further discussion.

In addition, most studies on whether an acoustic environment has effects on certain indicators on the basis of specific spaces, such as open-plan offices [6, 7, 15], closed offices [5], control rooms [17, 18] and industrial workplaces [5]. It is significant to identify the differences in different spaces, but some general conclusions may be missed because people need to work in a variety of settings or places. Therefore, systematically exploring people's demands for the acoustic environment in a general "working status" seems more important.

It is necessary to mention that this study takes "complex cognitive tasks" as an example to investigate people's specific demands for the acoustic environment in working status. It's also worth noting that "complex cognitive tasks" in this paper refers to tasks for concentration, such as comprehensive reading, complex calculations, creative thinking and so on.

In order to explore people's all-round demands on the acoustic environment in working status with complex cognitive tasks, two studies were carried out. Firstly, through focus group interviews, people's all-round demands on the acoustic environment were explored. Afterwards, in order to eliminate individualized demands, a big-sample questionnaire survey was carried out to screen demands needed by most people.

METHOD

Focus group interviews

In order to explore people's all-round demands, focus group interviews were selected because it was effective for collecting and integrating various opinions from multi-participants.

Participants with complex cognitive tasks in routine work were selected by purposive sampling method according to the International Standard Classification of Occupations (ISCO-08) [19]. Finally, researchers in universities, civil servants, architects, planners, auditors, accountants, financial workers, financial directors, lawyers, human resource managers, etc., were recruited and interviewed. When there were no new demands emerging after three consecutive groups, the data were saturated. In total, 35 interviewees participated in 11 groups of interviews. Each group was composed of 3-5 interviewees. Interviews were conducted face to face at the researchers' office or the meeting rooms in participants' companies. Among the 35 participants, there were 18 males and 17 females aged from 23 to 56 years old (20-29 years old, 10; 30-39 years old, 11; 40-49 years old, 9; 50-60 years old, 5).

To start the interview, an interview outline was created and it mainly contained two aspects. Firstly, in order to make it easier for participants to start the investigation, several approachable questions were prepared, such as "have you ever experienced any acoustic environments that cause you to have negative or positive feelings when you are in working status with complex cognitive tasks?", "what negative or positive feelings does the acoustic environment bring to you?", "what are the characteristics of the acoustic environment?" Secondly, based on their experiences, the questions such as, "what demands do you have for the acoustic environment when you are in working status with complex cognitive tasks?" were asked. In order to excavate people's specific demands, some detailed questions were also prepared, for example, "what kind of psychological/psychological/behavioral demands do you have?" It should be noted that questions were given as guides only, and the participants were encouraged to express their opinions. Interviews lasted from 45 to 67 min. Participants voluntarily signed informed consent for their involvement in the interview and allowance of audio recording during interviews.

By searching for key phrases, people's specific demands on the acoustic environment in working status with complex cognitive tasks were obtained.

Questionnaires

After obtaining diversified demands, in order to screen demands needed by most people, a big-sample questionnaire survey was also carried out. All demands identified by focus group interviews were made in questionnaires for eliminating individualized demands. Considering the time taken to complete a questionnaire, demands were randomly and evenly divided into two questionnaires, and each questionnaire contained 45 questions (including 40 or 41 demands and 4 or 5 repeating questions, respectively). Questionnaires were sent out face to face or through social media, and people who were involved in complex cognitive tasks in their daily work according to ISCO-08 [19] were invited to fill in it. Finally, 275 questionnaires were sent out and the proportion of male and female participants is approximately 1:1. The age of the respondents ranged from 21 to 65 years old.

RESULTS

People's all-round demands

After coding the data of focus group interviews, eighty-one demands were identified and they contained fifty demands on physiology, psychology and behavior (Table 1) and thirty-one demands on characteristics of an acoustic environment (Table 2).

Specifically, as shown in Table 1, in working status with complex cognitive tasks, seven physiological demands related to the acoustic environment were mentioned by people, such as "no rapid heartbeat", "no dizziness or headache" and "no ears ringing". Twenty four psychological demands were referred, such as "do not make me annoyed", "do not make me evoke feelings of disgust", "make me feel comfortable" and "make me feel relaxed". Nineteen behavioral (cognitive) demands were mentioned, such as "do not make it difficult to obtain information from the working materials", "do not cause a decrease in productivity" and "do not cause me to have to wear earplugs, headphones or raise the volume of my headphones". In general, all physiological demands and behavioral demands mentioned by people were related to "no negative effects". It seemed that "no negative effects" was people's basic demands in working status with complex cognitive tasks. It is interesting that psychological demands not only included aspects of "no negative effects" (e.g., "do not make me annoyed"), but also involved demands of "positive effects" (e.g., "make me feel comfortable"). It seems that, compared with physiological and behavioral demands, people have higher requirements for psychological feelings in working status with complex cognitive tasks, which is significant for policy-makers and researchers to pay sufficient attention to people's psychological demands in future.

In addition to demands on physiology, psychology and behavior, thirty-one demands on characteristics of an acoustic environment were also mentioned by people, such as "quiet", "not noisy", "not sharp or not harsh", "stable", "friendly" and "harmonious". The complete characteristics were shown in Table 2.

It is worth mentioning that all dimensions mentioned above make up a database and they lay a foundation for screening demands needed by most people in the next step.

Table 1: Physiological, psychological and behavioral demands obtained by focus group interviews

Physiological demands	**Digital codes**
No rapid heartbeat	24
No chest tightness	37
No dizziness or headache	38
No ears ringing	40
No body or face fever	46
No elevated blood pressure	49
No goose bumps	50
Psychological demands	**Digital codes**
Do not make me annoyed.	3
Do not make me evoke feelings of disgust.	7
Do not make me impatient.	13
Do not need to waste time and energy fighting the acoustic environment when working.	15
Make me feel comfortable.	18
Make me feel relaxed.	19
Make me feel calm.	21
Do not make me fell irritable.	22
Make me feel pleased.	23
Accompany me and let me not be lonely.	25
Do not bring me psychological stress.	26
Make me feel moderately exciting.	27
Do not make me feel uneasy or agitated.	29
Do not make me feel depressed.	30
Enhance mood.	31
Do not make me feel alert (alert: be more aware of what is going on around than usual).	33
Make me full of motivation.	35
Do not make me feel tired.	36
Mobilize my enthusiasm to the work.	39
Relief my stress.	41
Do not frustrate or demoralize me.	42
Make me feel energized.	44
Do not make me generate ideas of self-denying (denying myself because I can't overcome negative influences).	45
Do not make me feel scared or unsafe.	48
Behavioral demands	**Digital codes**
Do not make it difficult to obtain information from the working materials (e.g., difficult to read or learn something new).	1
Do not cause a decrease in productivity.	2
Do not interrupt my thought.	4
Do not have to wear earplugs, headphones or raise the volume of my headphones.	5
Do not be hard to get to work.	6
Do not give rise to the act or thought to intervene in noise sources (e.g., stop or sent away the noise sources).	8
Do not give rise to the act or thought to blame others (e.g., blame makers of noises).	9
Do not cause errors (e.g., open the wrong document or misspell letters).	10
Do not increase the time to complete the tasks.	11
Do not have to change tasks at hand, and do something not requiring concentration.	12
Do not cause negative effects on memory (e.g., forget next tasks or the order of things) .	14
Do not make it difficult to communicate with others.	16
Do not give rise to the act or thought to leave the workplace or to change a workplace.	17
Do not cause a decline on judgment and decision-making.	20
Do not have to stop what I am doing to go to the bathroom or a public rest area.	28
Keep me focused.	32
Do not give rise to the act or thought to break things.	43
Do not give rise to the act or thought to treat others unfriendly.	34
Do not give rise to the act or thought of quitting.	47

Table 2: People's demands on characteristics of an acoustic environment obtained by focus group interviews

Quiet	Not noisy	Unfamiliar	Soothing
Not sharp and not harsh	Not sudden	Friendly	Soft
Stable	Natural sounds	Positive	Familiar
Not messy	Fast paced	Melodious	Harmonious
Slow paced	Orderly	With positive energy	Relaxing
Not hurried	Not completely silent	Peaceful	With small amplitude
No music	Controllable	Imperceptible	Uninformative
Zen voices	Light or classical music without lyrics		
Keyboard sounds, printing sounds and book flipping sounds			

Filtered demands with a large sample survey

In order to screen demands needed by most people, a big-sample questionnaire survey was carried out. A total of 275 questionnaires were sent out and 209 ones were effective, with an effective rate of 76%. Sixty-six questionnaires were excluded by checking occupations of the participants and the repeating questions.

Since most of the demands mentioned by people in focus group interviews were related to "no negative effects", the proportion of people who experienced the negative effects were investigated. As shown in Figure 1, effects related to physiological, psychological and behavioral demands were marked with blue, yellow and red colour, respectively. Each effect was assigned a digital code, and all the digital codes can be referred in the second column of Table 1.

As shown in Figure 1, most people had experienced effects in working status with complex cognitive tasks, and effects experienced most by people were "difficult to obtain information from the working materials" and "a drop in productivity", which ranked first and second. The effects related to behavioral (cognitive) demands seemed all ranking higher (marked with red) than others, which in a certain extent suggested negative behavioral (cognitive) effects were universal and more attention should be paid to it in working status with complex tasks. Furthermore, most of the effects related to psychological demands ranked in the middle (marked with yellow), and most of the negative psychological effects of the acoustic environment have been experienced by most people, such as "annoyed" (84% people have experienced, ranked 3th), "feelings of disgust" (76% people have experienced, ranked 7th) and "impatient" (74% people have experienced, ranked 13th). Nevertheless, most people haven't experienced physiological effects, such as "goose bumps caused by acoustic environments" (78% of people haven't experienced) and "body or face fever caused by acoustic environments" (65% of people haven't experienced). This may be because there are fewer excessive conditions in people's working places with complex cognitive tasks. Of course, it could also be because physiological effects could not easily be perceived by people, which need more empirical researches.

Figure 2 showed the proportion of people who care about or do not care about a demand. As shown in it, more than half of people (marked with dotted line in black) have demands for most dimensions. By analyzing the distribution of effects (Figure 1) and the corresponding demands

(Figure 2) in physiology, psychology and behavior, it can be found that there are a few people experiencing physiological effects (Figure 1, ones with green), but most people (eighty percent and above) have demands for physiological dimensions (Figure 2, ones with green). For example, 22% of people have experienced “goose bumps” caused by an acoustic environment, but there were 85% of people have demands on “no goose bumps”.

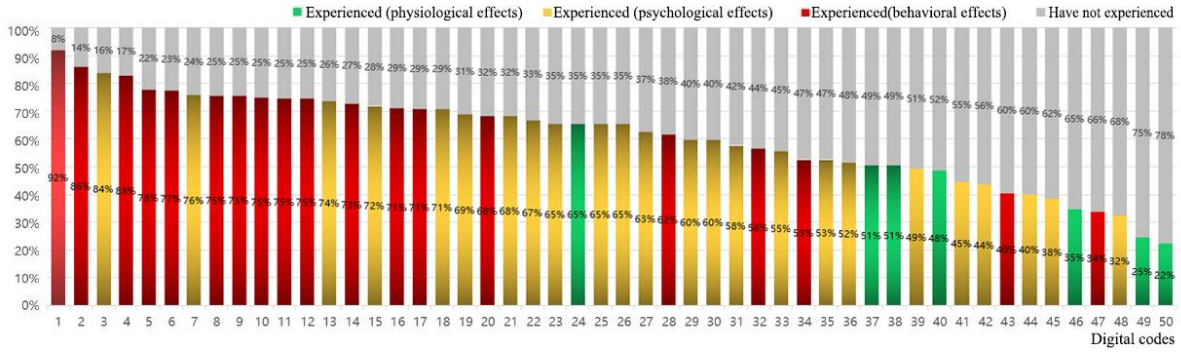

Figure 1: Hundred-percent bar-chart of people who have experienced or haven’t experienced an effect

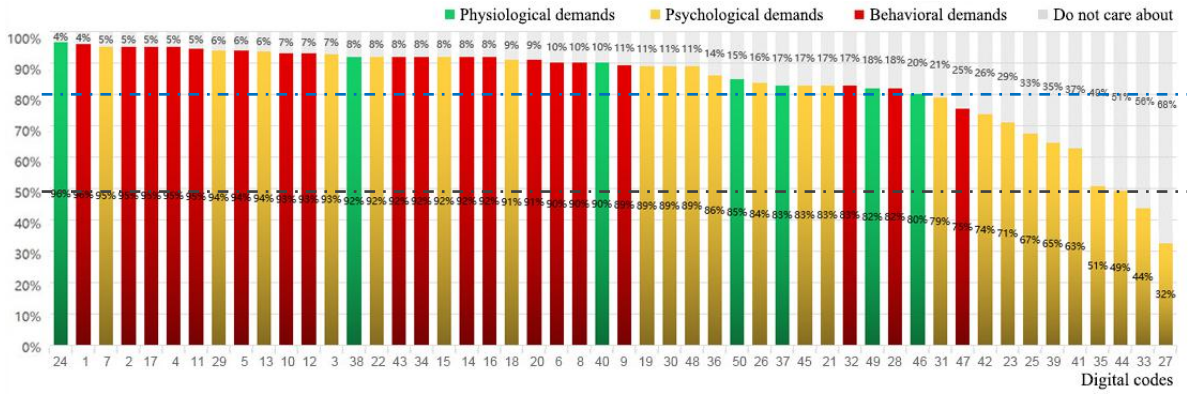

Figure 2: Hundred-percent bar-chart of people who care about or don’t care about a demand

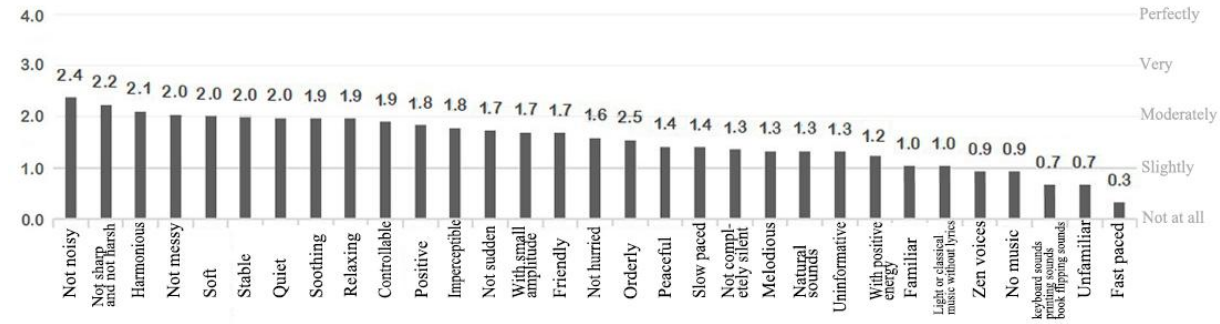

Figure 3: The extent of requirements on characteristics of an acoustic environment

In addition, the extent of people's requirements on various characteristics of an acoustic environment in working status with complex cognitive tasks was shown in Figure 3. As shown, the characteristics of the acoustic environment people required most were "not noisy", "not sharp or not harsh" and "harmonious". The characteristics people required between moderately and slightly were "not messy", "stable", "quiet", "soothing" etc. People have less requirements for "fast paced", "unfamiliar", "keyboard sounds, printing sounds and book flipping sounds", "no music", "Zen voice", "light or classical music without lyrics" and "familiar".

Combined with the extent of requirements, we screened all the above demands. According to hundred-percent bar-chart of people who care about and those don't care about a demand (Figure 3) and the extent of requirements on characteristics of an acoustic environment (Figure 4), 39 demands needed by more than eighty percent of people (marked with dotted line in blue in Figure 2) and 24 characteristics ranked higher than "slightly" were screened. Totally, 63 demands needed by most people were obtained and they were listed in Table 3. All these demands constituted the basic database for further proposing a standardized questionnaire.

Table 3: Filtered demands

Physiological demands	
1	Do not cause rapid heartbeat.
2	Do not cause chest tightness.
3	Do not cause dizziness or headache.
4	Do not cause ears ringing.
5	Do not cause body or face fever.
6	Do not cause elevated blood pressure.
7	Do not cause goose bumps.
Psychological demands	
8	Do not make me annoyed.
9	Do not make me evoke feelings of disgust.
10	Do not make me impatient.
11	Do not need to waste time and energy fighting the acoustic environment for working.
12	Make me feel comfortable.
13	Make me feel relaxed.
14	Make me feel calm.
15	Do not make me fell irritable.
16	Do not bring me psychological stress.
17	Do not make me feel uneasy or agitated.
18	Do not make me feel tired.
19	Do not make me feel depressed.
20	Do not make me generate ideas of self-denying. (Deny myself because I can't overcome negative influences).
21	Do not make me feel scared or unsafe.
Behavioral demands	
22	Do not make it difficult to obtain information from the working materials (e.g., difficult to read or learn something new).
23	Do not cause a decrease in productivity.
24	Do not interrupt my thought.
25	Do not have to wear earplugs, headphones or raise the volume of my headphones.
26	Do not be hard to get to work.
27	Do not give rise to the act or thought to intervene in noise sources (e.g., stop or sent away the noise sources).
28	Do not give rise to the act or thought to blame others (e.g., blame makers of noises).
29	Do not cause errors (e.g., open the wrong document or misspell letters).
30	Do not increase the time to complete the tasks.

31	Do not have to change tasks at hand, and do something not requiring concentration.
32	Do not cause negative effects on memory (e.g., forget next tasks or the order of things) .
33	Do not make it difficult to communicate with others.
34	Do not give rise to the act or thought to leave the workplace or to change a workplace.
35	Do not cause a decline on judgment and decision-making.
36	Do not have to stop what I am doing to go to the bathroom or a public rest area.
37	Keep me focused.
38	Do not give rise to the act or thought to break things.
39	Do not give rise to the act or thought to treat others unfriendly.
People's demands on characteristics of an acoustic environment	
40	Not noisy
41	Not sharp and not harsh
42	Harmonious
43	Not messy
44	Soft
45	Stable
46	Quiet
47	Soothing
48	Relaxing
49	Controllable
50	Positive
51	Imperceptible
52	Not sudden
53	With small amplitude
54	Friendly
55	Not hurried
56	Orderly
57	Peaceful
58	Slow paced
59	Not completely silent
60	Melodious
61	Natural sounds
62	Uninformative
63	With positive energy

CONCLUSIONS

This paper presented a study for exploring people's subjective demands on the acoustic environment in working status with complex cognitive tasks. Through focus group interviews, 81 specific demands were obtained, including 7 physiological demands, 24 psychological demands, 19 behavioral (cognitive) demands and 31 characteristics of an acoustic environment. Afterwards, a big-sample questionnaire survey was conducted to screen out demands needed by most people. Finally, 39 physiological, psychological and behavioral demands and 24 characteristics of an acoustic environment were screened out, such as "no rapid heartbeat", "do not make it difficult to obtain information from the working materials", "do not make me evoke feelings of disgust" and "not noisy". The 63 demands obtained in this study constituted a basic database for proposing a standardized questionnaire in future.

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