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The Impact of Noise on Employees' Performance, Satisfaction, Stress Level, and Concentration in Open-Plan Corporate Offices.

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Abstract— *Noise is defined as any sound that obstructs or interferes with a person's ability to accomplish their job duties, whether it be background noise or noise from a loud workplace. An open-plan office is a workspace that makes use of available space rather than isolating staff members in offices or cubicles. An essential factor that influences both well-being and focus with relation to functional performance is noise, especially in enclosed spaces. The purpose of this study was to examine the impact of noise on employees in an open-plan workplace regarding focus, task performance, concentration, and interpersonal communication, by conducting research using previous studies relating to the effect of noise on workers' performance and well-being in an open-plan working environment. Moreover, through conducting an experiment to measure the concentration of employees in Emaar Misr headquarters in open space and private offices, as well as a survey to conclude which of the two spaces is more convenient for employees. The results mainly showed that most of the employees working in an open-plan office dislike the concept as well as experience a high level of stress, lack of concentration, loss of performance, lack of comfort, and experience health issues. Furthermore, by applying concentration experiment it concluded that there is a direct relation between noise and lack of concentration in the workplace.*

Keywords— Noise; Open-plan working office; Performance; Physical health; Concentration; Stress level; Employees.

I. INTRODUCTION

“Noise is the most impertinent of all forms of interruption. It is not only an interruption but also a disruption of thought.” [1]. An undesirable sound is a common definition of noise. But in theory, noise is any sound that disturbs you. This frequently means that the degree to which the sound is perceived by the subject listener as noise, rather than the specific sound or its size, defines the sound as noise. Today, a growing number of people work in the services industry and spend most of their days indoors in an open-plan office. If individuals are to perform unhindered and at their best inside a company, a healthy and comfortable work environment is obviously not unimportant. Employees in open-plan workplaces claim that even at low noise levels, various sound sources, notably audible conversation, annoy them. This also relates to the specific work environment at the time. Noise is defined as any sound that obstructs or interferes with a person's ability to accomplish their job duties, whether it be background

noise or noise from a loud workplace [2]. Employee performance suffers due to noise, especially in situations that call for creativity and thought [3]. On occasion, noise may even lead to short-term memory loss. Performance and memory are negatively impacted by noise and frequently slowed down as a result. The background noise in a building has, at some point, annoyed or distracted most individuals [2]. Noise not only impacts employees' performance but also impacts their physical health as some employees suffer from symptoms such as headaches, stomach aches, irritation, and insomnia [2]. The irritation may have caused only a little annoyance, or it might have been severe enough to prevent them from working. This prompts the important question of whether noise irritates and impacts employees' performance and concentration as well as their physical health, as the answer to this question could save not only money but also time for the firms and companies working with the open-plan office layout, and most importantly could prevent any physical health issues for the employees.

II. LITERATURE REVIEW

A. Open-Plan Working Space

An open-plan working space is a space where the actual separation of departments and teams has been simulated by removing walls and partitions and replacing them with other elements like cubicles, furniture, and plants [4]. It is a space where people from various teams work together in an open-plan design in a large area. These workplaces not only have an open floor plan, but also numerous workspaces created for tasks. For instance, there are areas for social gatherings and activities, areas for larger meetings, and areas for jobs requiring a certain level of concentration. The main purpose of an open layout working space is that the users of the space will select the area of the workplace that satisfies their mood and fits their current work. Moreover, this layout encourages social interaction and increases communication between users [4].

a. History of Open-Plan Working Spaces

There is a lengthy history behind the idea of open-plan offices. Open-plan workspaces have been a concept since the early 1900s, it resembled a factory floor where workers performed their job in an open-layout space. Open offices were

created for workers in positions like clerks, secretaries, and typists till the 1960s [5]. Starting from the 1960s, this concept was developed in the United States of America, where firms started to split the open area by cubicles. As real estate expenses increased in large cities, cubicles were developed as a solution to reduce those expenses. While cubicles were widespread in the USA, L-shaped corner desks were frequently used in Europe, where four to six individuals could work together in a single space [4].

b. Advantages and Disadvantages of Open-Plan Working Spaces

TABLE I
ADVANTAGES AND DISADVANTAGES OF OPEN-PLAN WORKING SPACE.

Advantages	Disadvantages
Cost reduction	Loss of productivity
Increased communication	Increase of sickness
Teamwork	Increase in stress levels for employees

B. Noise in the Open-Plan Working Place

Noise is defined as the undesired sound and vibrations that cause discomfort and annoyance to the users present in space. The sound waves are measured in Decibels using a decibel meter [2], [6].

a. Impact of Noise on Health

Noise is considered one of the main reasons for stress in the working place, it was proven that noise is directly proportional to stress level. The degree of stress is one of the key determinants of general well-being [7]. Working in an open office environment increases stress, the mental workload, poor performance, conflict, high blood pressure, and reduced job satisfaction, which has a negative impact on internal motivation and leads to a high staff turnover. Moreover, stress caused by noise leads to heart, stomach, and nervous system problems. One of the most popular diseases caused by noise in open-plan working places is hearing loss, as temporary loss of hearing may be developed when exposed to loud noises for a short period, while permanent hearing loss may be developed over a longer period of exposure to loud noises. Furthermore, noise exposure is related to insomnia and overall exhaustion. [6], [7].

b. Impact of Noise on Employees' Performance Satisfaction

People frequently experience noise in their daily lives. A significant source of background noise in buildings is often the sound of heating, ventilation, and air-conditioning (HVAC) systems. HVAC noise in offices has the potential to irritate employees and interfere with their ability to concentrate. Many people in the acoustics field have been left wondering how much noise distraction leads to lost productivity as a result. Numerous studies have looked at the effects of too much low-frequency energy in background noise [8], [9]. These studies' findings include that background noise has an impact on productivity. In addition, according to ventilation noise with a low-frequency dominance may lengthen the time required to react to a verbal reasoning assignment when compared to the

noise of equivalent volume with significantly less low-frequency energy. On top of that, according to other researchers, those who expressed discomfort with low-frequency noise also experienced weariness, headaches, and irritability, which might all have an impact on how well they perform at work [10].

Even though office workers are exposed to noise that is below the harmful limit, listening to coworkers' conversations can reduce their productivity by 66%. In open-plan workplaces, the noise intensity typically ranges from 46 to 58 decibels (dB) In general, people will experience less acoustic pleasure if the background noise level is higher than 45 dB According to a report, noise decreases office workers' productivity [3]. According to Haapakangas, noise interferes with workers' capacity to concentrate on how to do their job [11]. Additionally, Seddigh claimed that workplace noise made workers more irritable and stressed [12]. According to a survey, 31% of workers are unhappy with the noise level at work, making it the second most bothersome physical component in the workplace in terms of comprehensibility [3]. According to Oseland, 92% of workers said that noise interfered with their ability to do their jobs effectively [13]. According to other research, conversations between people and their coworkers are the main source of noise that irritates other workers [3]. Moreover, according to Blasio, needless and pointless talks among individuals increased acoustical irritation and the prevalence of mental health symptoms, which affected employee wellness and work performance in open-plan offices [3]. These earlier investigations were crucial in proving that there is, in fact, a connection between noise and worker performance and satisfaction. Leading to the conclusion that noise directly affects employees' performance, health, and satisfaction.

C. Analytical Case Study

The Sidoarjo Regency Health Office in Indonesia's Sidoarjo region served as the site of this experiment. The Sidoarjo Regency Health Office, one of the businesses in the health industry, oversees handling health-related issues [14].

Time-based observational analytic research is the method used in this study. The population for this study consisted of 29 employees from the Sidoarjo Health Office, with 17 working in the department of health resources and 13 in the department of health services. There is a total of 30 people. The population's size and makeup are reflected in the sample. The sampling strategy utilized in this study is total sampling. Total sampling is a sampling technique in which the sample size is determined by the total number of samples drawn from the population. The sample for the study consisted of 30 people. The noise intensity evaluations are conducted in the health resource and health service rooms. Based on the results of the noise intensity measurement, the following tables allow seeing the size of the average noise intensity for 4 hours at 5 measurement locations [14].

TABLE II
AVERAGE NOISE INTENSITY IN (5) POINTS.

No	Point of Measurement	Average Noise Intensity (DBA)
1	1	70.28
2	2	70.18
3	3	69.01
4	4	72.18
5	5	73.40
Average		71.01

No	Point of Measurement	Average Noise Intensity (DBA)
1	1	63.26
2	2	65.74
3	3	61.90
4	4	65.90
5	5	63.62
Average		64.08

The following table illustrates the variance between the Minister of Health's Regulation No. 48 of 2016 and the average noise intensity for the Health Office Sidoarjo Regency [14].

TABLE III
THE VARIANCE BETWEEN THE MINISTER OF HEALTH'S REGULATION NO. 48 OF 2016 AND THE AVERAGE NOISE INTENSITY FOR THE HEALTH OFFICE SIDOARJO.

Location	Intensity Noise	NAB	Information	Number of Employees
Room Resource Health	71.01	65	Above NAB (High Noise)	17 (56.30%)
Room Service Health	64.08	65	Under NAV (Low Noise)	13 (43.30%)
Total				30 (100%)

Health Resources's average noise level is above the NAV at 71.01 dB (A), which is considered high, while Health Services's average noise level is below the NAV at 64.08 dB (A), which is considered low. There are 17 respondents present in the health resources environment of the room, compared to 13 respondents present in the health service environment. As a result, 56 % of respondents to this survey reported hearing loud noise, compared to 43.3% who reported hearing low noise [14] as shown in Table IV.

TABLE IV
THE PRODUCTIVITY OF EMPLOYEES IN BOTH ROOMS
NOISE

Productivity Performance	Low		High		Total	
	N	%	N	%	N	%
Enough	6	36.2	15	88.2	21	70
Good	7	53.8	2	11.8	9	30
Very Good	13	100	17	100	30	100

The findings and conclusion of this investigation are as follows:

A. The majority of the staff members at the Sidoarjo Health Office reported loud noises.

B. The majority of the Sidoarjo Health Office staff members works well and is productive.

C. Employees at the Sidoarjo Health Office may function less productively due to ambient noise.

III. METHODS

The research adopts a mixed-method approach using both quantitative and qualitative data, through three different stages (primary data collection, secondary data collection, and experimental data collection). First, the primary data collection was conducted through an online, close-ended survey that was distributed to 100 employees (12 juniors, 35 seniors, 47 managers, and 6 N/A) which represents a total sample size of (305) employees with a margin of error = (8%) in Emaar Misr headquarters in El Mokattam. While the experimental data collection was performed by measuring the sound decibels in the open-plan office and a private office using a decibel meter. Concentration is the main aspect that affects performance (Seddigh et al., 2014). To assess the performance of the workers, two focus groups (each group out of 5 members) are selected from the office, including (3) juniors, (3) seniors, and (4) managers in total taking into consideration that it is stated by Jonathan Lazer and Harry Hochheiser, 2017, that (2-3) focus groups from (4-5) members each is considered a representative sample. They were then given a test (concentration grid: Exercise to improve and measure concentration and visual scanning speed where they are asked to track numbers in the correct ascending order) once in the open plan office and once in the private office, while measuring the time taken to complete the task in both rooms as shown in Fig. 1. Then the results of the time in the two rooms were compared. Consequently, the higher concentration was determined according to these results. Then secondary data collection is conducted by analyzing previous papers, a case study, and available data regarding the impact of noise on employees' performance and well-being in an open-plan working office.

83	39	50	72	35	31	85	37	57	24
19	99	77	47	73	64	40	07	46	32
15	29	97	10	51	87	54	48	01	38
06	53	89	84	96	80	82	23	66	28
18	44	91	60	92	63	93	59	55	61
94	79	33	20	67	86	17	22	81	78
14	21	27	16	02	09	30	56	12	68
90	04	05	74	43	11	42	69	49	70
03	13	26	34	88	71	41	52	08	76
62	95	65	58	25	98	36	45	75	00

Fig. 1 Sample of concentration grid with numbers.

IV. RESULTS AND FINDINGS

After conducting the survey and analyzing the answers the results were as follows, 100 employees responded to the survey 94 (94.0%) employees are working in open-plan and 6 (6%) in a private office (did not complete the survey) (refer to Fig. 2), the 100 employees were 63 (63%) males and 37 (37%) females, their ages were 37 (37%) from 35 to 44, 13 (13%) from 45 to 54, 44 (44%) from 25 to 34, and 6 (6%) from 55 to 64 (refer to Fig. 3), 50 (50%) of the employees were managers/directors, 38 (38%) were seniors, and 12 (12%) were Juniors (refer to Fig. 4).

■ Workin in Open Office ■ Working in Closed Office

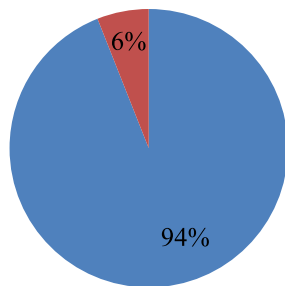


Fig. 2 Working in open or closed offices

■ 18-24 ■ 25-34 ■ 35-44
■ 45-54 ■ 55-64 ■ 65 and above

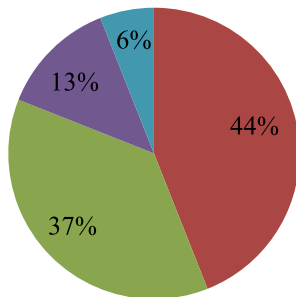


Fig. 3 Age groups

■ Manager\Director ■ Senior ■ Junior

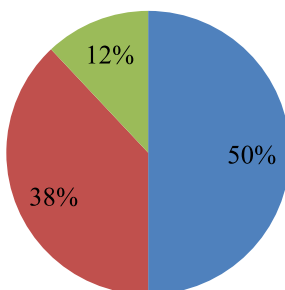


Fig. 4 Occupation

Employees were asked to scale their satisfaction with the open-plan working office in general from (0 – 5 where 0 was considered no answer, 1 poorly satisfied, and 5 highly satisfied). 6 (6.0%) employees answered 0, 25 (25%) employees answered 1, 19 (19%) employees answered 2, 25 (25%) employees answered 3, 19 (19%) employees answered 4, and only 6 (6.0%) employees answered 5. The result of this question shows that most of the employees who participated in the survey are unsatisfied with the open-plan office as the total answers mean is = (+/-2.44) as shown in Fig. 5.

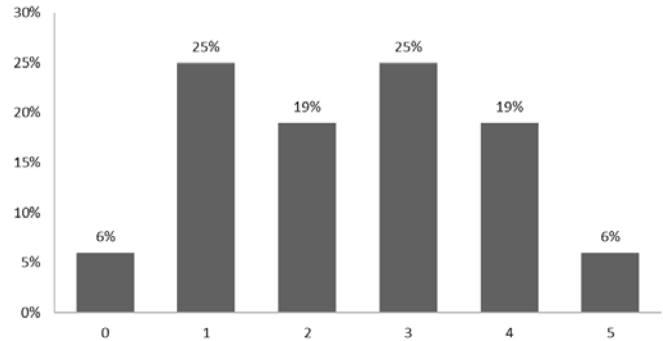


Fig. 5 Scale of employee general satisfaction with the open-plan office (Authors, 2022)

Then the employees were asked to scale how comfortable they are with the surrounding noise within the open-plan working office from (0 – 5 where 0 was considered no answer, 1 uncomfortable, and 5 comfortable). 13 (13%) employees answered 0, 31 (31%) employees answered 1, 19 (19%) employees answered 2, 19 (19%) employees answered 3, 12 (12%) employees answered 4, and only 6 (6%) employees answered 5. The result of this question shows that most of the employees who participated in the survey are uncomfortable with the surrounding noise within the open-plan office as the total answers mean is = (+/-2.06) as shown in Fig. 6.

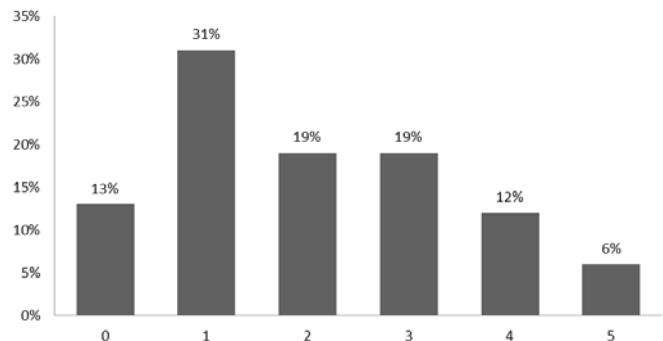


Fig. 6 Employees' comfortability with the noise in the open-plan office (Authors, 2022)

Then the employees were asked to scale how strongly the surrounding noise affects their concentration on the work tasks in the open-plan office from (0 – 5 where 0 was considered no answer, 1 was insignificant, and 5 was very strong). 0 (0%) employees answered 0, 13 (13%) employees answered 1, 12 (12%) employees answered 2, 19 (19%) employees answered 3, 37 (37%) employees answered 4, and 19 (19%) employees

answered 5. The result of this question shows that the concentration of most of the employees who participated in the survey is very affected by the surrounding noise within the open-plan office as the total answers mean is = (+/-3.38) as shown in Fig. 7.

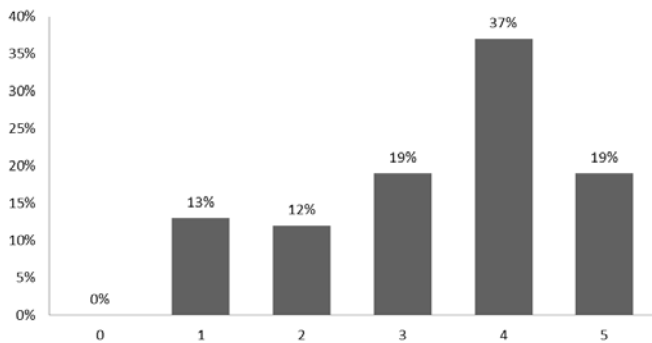


Fig. 7 Scale of how noise affects the concentration of the employees (Authors, 2022)

Then the employees were asked to scale how the surrounding noise in the open-plan office impacts their stress level from (0 – 5 where 0 was considered no answer, 1 was insignificant, and 5 was high-stress level). 13 (13%) employees answered 0, 6 (6.0%) employees answered 1, 25 (25%) employees answered 2, 12 (12%) employees answered 3, 19 (19%) employees answered 4, and 25 (25%) employees answered 5. The result of this question shows that most of the employees who participated in the survey experience high levels of stress due to the surrounding noise within the open-plan office as the total answers mean is = (+/-2.94) as shown in Fig. 8.

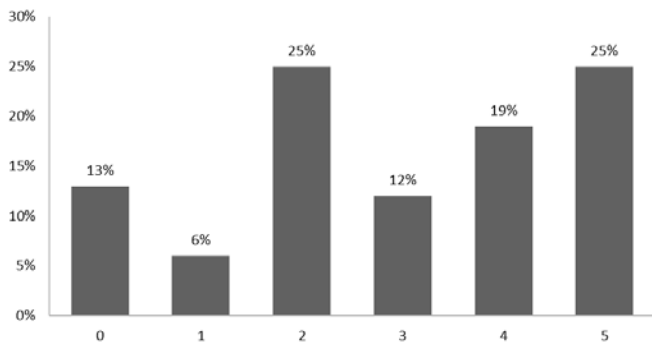


Fig. 8 Scale of how noise impacts the stress level of employees (Authors, 2022)

Then the employees were asked to scale how they think the surrounding noise in the open-plan office negatively affects their overall performance from (0 – 5 where 0 was considered no answer, 1 was an insignificant effect, and 5 was a strong effect). 19 (19%) employees answered 0, 6 (6.0%) employees answered 1, 19 (19%) employees answered 2, 0 (0%) employees answered 3, 25 (25%) employees answered 4, and 31 (31%) employees answered 5. The result of this question shows that most of the employees who participated in the survey are strongly affected by the surrounding noise within the open-plan office and has a negative impact on their overall

performance as the total answers mean is = (+/-3.00) as shown in Fig. 9.

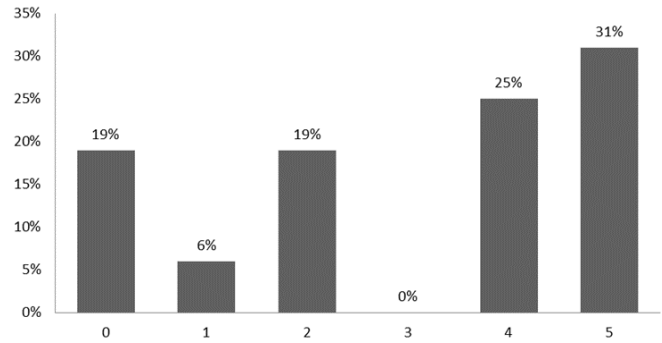


Fig. 9 Scale of how noise affects the overall performance of employees (Authors, 2022)

Then the employees were asked to choose from a checklist if they suffer from any of the included symptoms after working hours in an open-plan office (they can check multiple options). (50%) employees suffer from headaches, (13%) employees suffer from stomach aches, (6%) employee suffers from insomnia, (25%) employees suffer from irritation, (0%) employees suffer from a temporary auditory impairment, and (31%) employees do not suffer from any symptoms as shown in Fig. 10.

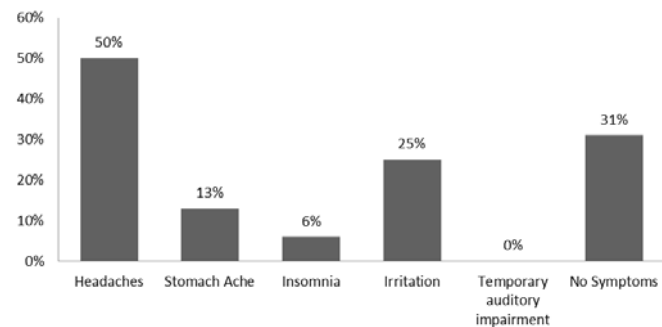
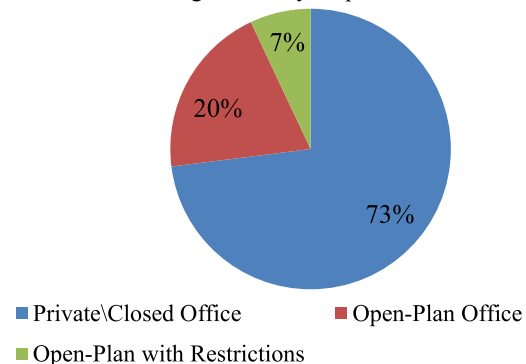


Fig. 10 Checklist of symptoms the employees suffer from after working hours (Authors, 2022)

Finally, they were asked whether they prefer an open-plan office or a private office with space to add a choice if they wanted. 73 (73.0%) employees preferred a private office, 20 (20%) employees and 7 (7%) employees added an option which is an open-plan office with strict rules. This shows that most of the employees prefer a private office instead of an open-plan office as shown in Fig. 11.

Fig. 11 Employees preferences



members) made up of 3 juniors, 3 seniors, and 4 managers are chosen from the office. Then, while measuring the time required to accomplish the activity in each space, they were given a test (a concentration grid) once in the open plan office and once in the private office. The outcomes from the time spent in the two rooms were then compared. The sound was measured in decibels using a decibel meter in the open-plan office and in a private office using a decibel meter in 3 different time intervals, and then the average was taken.

TABLE V
THE AVERAGE SOUND LEVELS IN DECIBELS IN THE OPEN AND PRIVATE OFFICES.

Open-Plan Office	
Time Interval	Sound in decibels
9 A.M.	58 dB
1 P.M.	74 dB
5 P.M.	54 dB
Average	62 dB

Private Office	
Time Interval	Sound in decibels
9 A.M.	37 dB
1 P.M.	40 dB
5 P.M.	38 dB
Average	38.3 dB

The results showed that the average sound level in decibels in the open plan was 62 dB which is high, while in the private office the average was 38.3 dB which is considered low [3], this shows that the private office is a calmer environment that helps in focusing and concentrating (refer to Table. VI).



Fig. 13 Concentration Grid.1 and 2.

TABLE VI
TIME TAKEN BY EMPLOYEES TO FINISH THE TEST AT THE TWO LOCATIONS.
(AUTHOR, 2022)

Participant number	1	2	3	4	5
occupation	Manager	Manager	Manager	Junior	Junior
Grid 1 (Open-space)	9:35	7:20	8:10	16:00	15:00
Grid 2 (Private-office)	6:18	6:30	7:12	12:15	8:40

Participant number	6	7	8	9	10
occupation	Manager	Senior	Senior	Junior	Senior
Grid 1 (Open-space)	10:17	12:55	9:15	15:42	8:52
Grid 2 (Private-office)	10:08	12:10	8:42	12:26	6:58

Average grid 1 time taken in mins.: 11:20
Average grid 2 time taken in mins.: 9:36

The result of the concentration grid experiment came as the following, it was noticed that the time taken by employees to finish the concentration grid in a relatively noisy open-plan office was more than the time taken by them to finish it in a calm private office, as the average time taken by the employees in the open-plan is 11 minutes 20 seconds, while in the private office the average was 9 minutes 36 seconds, showing a 1 minutes 45 seconds gap, this indicates that the concentration of employees in the private office is higher than ion open-plan office.

V. DISCUSSION

After conducting the survey and the experiment and analyzing the data and answers of both, the research findings are as follows:

- The survey that was conducted and given to the employees stated that the majority of the employees working in an open-plan office dislike the concept experience a high level of stress, lack of concentration, loss of performance, lack of comfort, experience health issues, and symptoms after working hours such as headaches, insomnia, stomach ache and irritation, and the majority would prefer to work in a private office, which must be taken into consideration by Emaar Misr in order to improve their worker's environment, to increase the performance, hence increase the firm productivity.

- The experiment that was conducted in Emaar Misr Headquarters, showed a high level of noise in the open-plan office, which will directly impact the employees. This was proven by the concentration test as the average time taken in the open-plan office was more than in the private office, which proves that there is a direct relation between noise and concentration in the workplace.

- Moreover, a pattern was noticed when it came to comparing the time taken by different occupations in the office, as the managers took less time than the seniors and took less time than the juniors. This pattern could be because of the difference in experience or due to the adaption with time to the open-plan office.

VI. CONCLUSION, RECOMMENDATIONS, AND FUTURE STUDIES

The aim of this research was to investigate the impact of sound on the employee's performance, concentration, satisfaction, comfortability, stress level, and physical health symptoms. After reviewing previous papers, multiple researches, and a case study concerning this topic, it was deduced that there is a direct relation between noise and the previously stated aspects. To look into it further, an investigational experiment was carried out, to either agree with the literature review outcome of this research or disagree with it. The result of the experiment stated that there is indeed a direct relation between noise and the stated aspects, confirming the outcome of the literature review.

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