Acoustic comfort and fit-out in open space offices: considerations based on a real case assessment

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Multiple activities in open offices lead to multiple sound sources that can negatively affect users. In response, an approach has been developed that considers objective parameters, subjective perception, and architectural solutions. However, common practice reveals interferences between these areas, causing poor acoustic design. This paper aims to identify these interferences by analyzing a real case. Objective parameters (STI, RT, and $L_{Aeq,T}$) were measured and evaluated according to EN ISO 3382-3 and BS ISO 22955. A synthesized GABO questionnaire was distributed to identify the most annoying sound sources. The results show that compliant STI and RT do not lead to low annoyance levels from understandable and unintelligible speech. Compliant noise levels are still perceived as annoying for all activities. Additionally, the position of functions can affect how sources are perceived differently. This highlights the need for multi-criteria analysis to analyze and overcome these interferences and ensure high acoustic comfort.
Keywords: acoustic comfort, open offices, fit-out, architectural acoustics

Il confort acustico e il fit-out degli uffici open space: considerazioni basate sull'analisi di un caso reale

La presenza di più attività negli open offices comporta più sorgenti sonore che possono avere effetti negativi sugli utenti. In risposta, è stato sviluppato un approccio che considera parametri oggettivi, percezione soggettiva e soluzioni architettoniche. Nella pratica comune, però, si riscontrano delle interferenze tra tali ambiti che, se non risolte, causano una progettazione acustica scadente. Tale paper intende identificare tali interferenze tramite l'analisi di un caso reale. I parametri oggettivi (STI, RT e $L_{Aeq,T}$) sono stati misurati e valutati rispetto alla EN ISO 3382-3 e alla BS ISO 22955. Una versione sintetizzata del questionario GABO è stata distribuita per identificare le attività più disturbate. I risultati mostrano come, STI e RT ottemperanti non comportino un basso livello di fastidio del parlato comprensibile e non comprensibile. Valori di rumorosità ottemperanti sono comunque percepiti fastidiosi per tutte le attività. Inoltre, la posizione tra le funzioni può avere effetti diversi sul modo in cui le sorgenti sono percepite. Ciò evidenzia la necessità di analisi multi-criteriali per analizzare e superare tali interferenze e garantire un elevato comfort acustico.
Parole chiave: confort acustico, open offices, fit-out, acustica architettonica

1 | Introduction

Open offices enhance exchanges between colleagues and facilitate all team-based organisational work.

Several activities conducted in the same space increase the number of disruptive sources – such as ringing telephones, conversations over the phone, face-to-face discussions, typing on computer keyboards, office equipment, and more – that negatively impact cognitive performance in tasks like mental arithmetic [1], learning associated words or text [1,2], mental workload and visual/auditory attention [3], and both text comprehension and memorisation [4,5]

These disturbances appear more significant based on the task being performed rather than solely on the source type. Jones and Macken (1995) demonstrate that the number of errors in a short memorisation task decreases with the presence of additional voices during the task [6]. The level of annoyance due to noise increases with the task's difficulty [7,8], and the distraction mainly arises from the intelligibility of speech [9,10].

Individual factors, such as general sensitivity to noise, can also account for the level of annoyance experienced in an open workspace [11]. Some studies indicate that individuals who are generally more sensitive to noise report feeling more exposed and thus more bothered by it [12,13]. For this reason, it is crucial to view the working environment holistically when assessing sound quality.

The first attempt to account for the relative loudness perceived by the human ear was defined by the A-weighted curves [14]. Still, the previous studies have demonstrated that dB(A) is insufficient to describe human perception.

For this reason, several methodologies have been developed for this aspect. The BS ISO 22955:2021 (hereinafter BS ISO 22955) proposes the GABO model (Gene Acoustique dans les Bureaux Ouvrés) [15] questionnaire to assist companies in complementing objective noise intensity measurements with employees' subjective evaluations of their physical working environment. The model comprises 67 questions grouped into four specific dimensions: general perception of the working environment, perception of the noise environment, general perception of noise, and health assessment. BS ISO 2955 defines a methodology for designing acoustic comfort in existing or new open spaces. It outlines five activities that could be undertaken in open spaces, specifies the objective metrics and targets for each, and presents architectural and technological solutions that aid in achieving those targets [16].

1.1 | Application in current practice: problem

Achieving optimal indoor acoustic comfort in open space offices involves balancing clients' budgets and requests alongside targets set by law or voluntary protocols (such as LEED, BREEAM, and Well). This balancing also requires integration with various technical disciplines, including MEP (Mechanical, Electrical, and Plumbing), architecture, and structural engineering, while considering installation factors at the building site. The most challenging aspect in current practice is to find a compromise among all those aspects, even if the literature does not present a consistent methodology for finding and solving those clashes. Acoustic comfort in open spaces is achievable by balancing several targets, which can challenge the acoustic designer to respond clearly to clients and architects. This paper seeks to identify these conflicts by evaluating the open space of an international engineering firm's headquarters and analysing the impact of noise on activities related to the space's architectural features.

2 | Methodology

The paper's aim requires to be developed on a case study since no references have been found in literature at the state of this paper.

The study requires a survey of the space to identify the main geometrical characteristics (volume, area, height) and the acoustic materials. The acoustic measurements were run according to UNI 3382:3 and BS ISO 22955. Lastly, a questionnaire has been performed to characterise the sample and understand the annoyance level caused by the noises of the activities.

2.1 | Case study architecture

The selected case study represents a typical open space of an engineering firm featuring several types of functional spaces.

The company's main organisational structure consists of discipline-based departments assembled in the workplace. The workplaces alternate between collaborative spaces, phone booths, meeting rooms, and informal meeting areas (Fig. 1). Those are organised in the main longitudinal zone separated by two corridors.

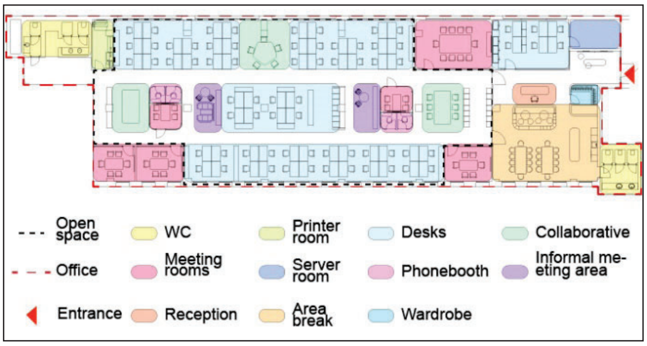

Fig. 1 – Functional zoning
Aree funzionali

Due to the existing countershaft and MEP distribution, there are no plasterboard partitions in the central area of the open office. Therefore, small meeting rooms and phone booths have lower ceilings than the net floor height.

According to BS ISO 22955, the activity categories identified in the open space are communication outside the room (via calls, etc.) (hereinafter Activity n° 3) and collaboration among individuals at nearby workstations (hereinafter Activity n° 4).

Additional activities are proposed based on observations of each employee's main tasks. These activities include:

1. Text understanding (Activity n° 1);
2. Writing (emails, reports, etc.) (Activity n° 2);
3. Digital modelling (including 3D BIM, 3D simulations, etc.) (Activity n° 5);
4. Design-related activities (Activity n° 6).

Activity n° 4 matches these activities, while tasks associated with design phases (Activity n° 6) fall under Category Two. The maximum targets equivalent weighted A sound pressure level during activity for these new activities are assigned according to the BS ISO 22955 standards (Tab. 1).

Tab. 1 – Targets of Weighted A sound pression level during activity per activity
Valori massimi di livello di pressione Sonora ponderati A $L_{Aeq,T}$ durante le ore di lavoro

Activity number	*Activity typology*	*Target $L_{Aeq,T}$ (dB(A))*
1	Text understanding	40
2	Text writing (email, report, etc.)	40
3	Communication outside the room (via calls, etc.	55
4	Collaboration among individuals at nearby workstations	52
5	Digital modelling (including 3D BIM, 3D simulations, etc.)	40
6	Design activities	48

The acoustic materials in the space are textile-based panels on the desks, moquette and wool fibre panels placed in some of the perforated panels of the chilled beams. Table 2 shows the α_w for each material.

Tab. 2 – Absorption coefficient of acoustic materials
Coefficienti di fonoassorbimento dei materiali acustici

Furniture/ position	*Material*	*Absorption coefficient* α_w
Chair	Textile	0.4
False ceiling	Perforated panels with mineral wool panel	0.8
Pavement	Moquette	0.3
Desk screen	Textile	0.7

2.2 | Measurements

The measurements aim to evaluate descriptors representing the open space's sound sources. Speech intelligibility and background noise are measured according to ISO 3382 part 3, which necessitates defining both a direct and an indirect path to establish measurement points.

The paths are determined based on the need to characterise the various spaces with distinct architectural features (Fig. 2). Path n° 1 goes through the area near the façade with a high window-to-wall ratio (WWR) and features a single collaborative desk (identified with id Col B) at the centre.

Path n° 2 is defined in the central area of the open space. It presents the lower number of workspaces bounded by shelves. Between the desks and the collaborative desk C, an informal meeting area, a cluster compounded by two phone-booths, and a meeting room are located.

Path n° 3 is defined along the third longitudinal area, with a lower WWR and no collaborative desks. Path n° 4 is determined to go from path n° 3 to path n° 1, passing through the second path. STI and equivalent weighted-A sound pressure level measurements have been performed with a specific STI speaker (NTI TalkBox) that simulates a human talker (60 dB(A) at 1 meter according to IEC 60268-16) with the STIPA test signal and spoken messages [17]. The background noise during the activity is measured with an SPL meter over an 8-hour session from 9 am to 5 pm [16]. The measurements are performed in three different positions of the open space chosen, one in each area. Since the attendance at the open space is not constant, they are run three times a week. The Reverberation time is measured by generating a sound sweep with an omnidirectional speaker and placing the microphone at the most representative points. The measurements are performed with calibrated microphones and processed by the Soundbook MK I (Fig. 2).

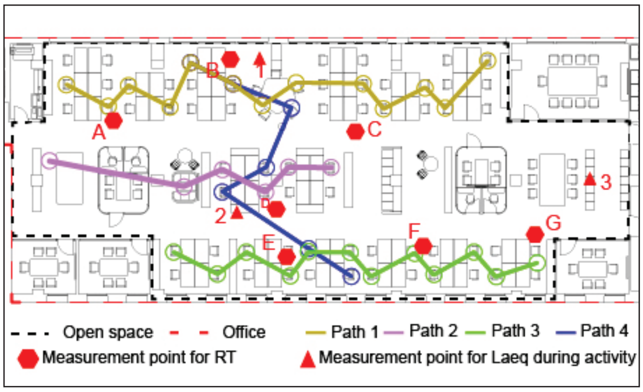

Fig. 2 – Measurement points and paths
Punti e percorsi di misura

2.3 | The questionnaire

The questionnaire aims to understand the general assessment of the open space and the relationship between the noise sources and the activities. The shared questionnaire is based on the GABO model but with some adjustments. The number of questions has been reduced to 32 to encourage employees to respond, which takes 5 minutes rather than 15 minutes.

The content addressed the participants' overall assessment of the surrounding environment in the workstation from which they answered and the evaluation of various sound sources according to the activities to be executed.

Three sections compound the survey:

- General information for a demographic characterisation of the user sample and using the frequency of the workstations;
- The perception of the space quality;
- The perception of the most disturbing noises per activities.

The first section concerns eight closed-ended questions. The second section concerns ten questions evaluated with a five-point Likert scale (from "less satisfied" to "very satisfied"), and the last section concerns five questions assessed with a seven-point scale (from "less disturbing" to "very disturbing"). Four more open-ended questions are presented in several sections (for asking about the motivations behind the answer or writing a general comment).

The first section concerns questions about the age and gender involved (Q1 – Q2), the workstation ID, and the time the questionnaire is answered.

For the habits of the open space, the questions consider the frequency per week of office work and the preferred workspace.

For the overall perception of the environment, the questionnaire asks for an evaluation (on a scale from "less satisfied" to "most satisfied") of noise (Q12), concentration (Q13), lighting comfort (Q14), position of the workstation (Q15), private conversation possibility (Q16), thermic comfort (Q17), furniture quality (Q18), and view of external areas (Q19). These five noise sources are presented in the literature as the main sources of noise annoyance in open offices [18,19], and they are also mentioned by the employees interviewed during the semi-structured interviews carried out before the questionnaire.

For the individual sound sources perception, the questionnaire involved evaluating the most disturbing sound sources and the most disturbed activity (scale from "less disturbing" to "most disturbing") for air terminal units (Q20), unintelligible speech (Q21), intelligible speech (Q22), colleagues' walk (Q23), and noise given by working facilities (such as clicking the mouse or tapping the text board).

In the end, two questions aim to evaluate the general noise level (Q30) and the level of noise disturbance (Q31). A final open question asks for a voluntary comment (Q32).

2.4 | Correlation analysis

The correlation between the acoustic environment and architecture is established by aggregating the results into spatial clusters. For the purpose of this paper, the open space is divided into nine clusters, each representing a specific number of desk seats and specific architectural characteristics and position (Fig. 3).

Initially, Pearson's correlation coefficient (r) between age, gender, use habits and overall perception of noises was estimated. The Pearson correlation measures the strength of the linear relationship between two variables. It has a value between –1 and 1, with a value of –1 meaning a total negative linear correlation, 0 being no correlation, and +1 meaning a total positive correlation. The results show that the overall perception is not affected by age (r = 0), gender (r = 0.13), and the number of working days at the office per week (r = 0.05).

The reliability coefficient (Cronbach's alpha) was estimated for evaluating noises, indicating acceptable data reliability [20] for the annoying perception of noises (0.7) and the overall quality of the open space (0.68). In the end, observations about achieving targets for objective metrics concerning the users' answers are presented.

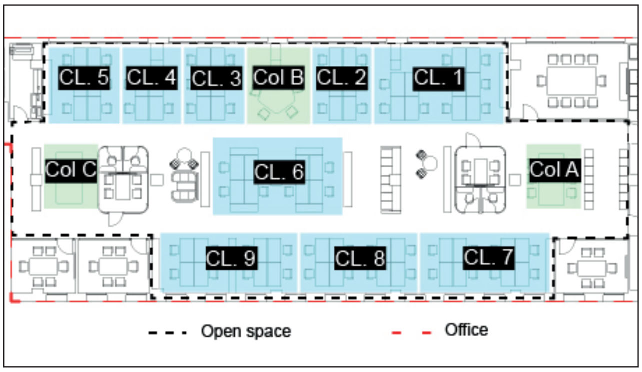

Fig. 3 – Clusters and Collaborative desks ID
Codice identificativo ID dei raggrappamenti di scrivanie e delle aree collaborative

3 | Results

3.1 | Measurement results

The following paragraphs present the results of the objective parameters and the evaluation according to the targets: reverberation time, background noise and sound transmission index.

3.1.1 | Reverberation time RT

The measured values do not comply with the regulation requirements. The BS ISO requires a maximum value of 0.5 s (as arithmetic means between 250 and 4000 Hz) and 0.8 s at 125 Hz for space activities 2, 3, and 4. These activities are mostly executed in the area where the measurements are performed. None of the values comply with the RT means, and only in clusters eight and nine is the RT at 125 Hz fulfilled (Fig. 4).

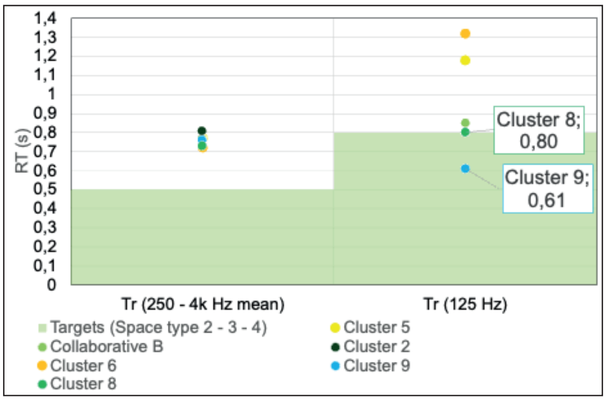

Fig. 4 – Reverberation time values
Valori di tempo di riverbero

3.1.2 | Background noise during activity $L_{Aeq,T}$

The measured values are 51 dB(A) in the Collaborative B (position 1), 49 dB(A) in the Cluster 6 (position 2), and 52 dB(A) in the Collaborative A (position 3). The BS ISO specifies a requirement for a value below this threshold. Among all the compliances, the background noise in Cluster 6 does not meet the request for activity, primarily due to a limited amount of collaborative work. The average background noise value during activity is compliant only for activities focusing on remote communication (by phone call) (Tab. 3).

Tab. 3 – Comparison between workstation noise level during activity and targets per activity type
Comparazione tra il livello di fondo durante le attività lavorative e i valori massimi secondo la BS ISO 22955

$L_{Aeq,T}$ (dB(A))	*Target per activity type (dB(A))*					
	1	2	3	4	5	6
50	≤40	≤40	≤55	≤52	≤40	≤48

3.1.3 | Distraction and privacy distance

The ISO 3382-3 defines distraction distance as the distance from the source where the STI is 0.5. The privacy distance is the distance from the source where the STI is 0.2.

Path 1's STI values are measured at eight workstations (Fig. 5). Six out of eight positions present STI higher than 0.5. Position 7 and position 8, a distance higher than the distraction distance (12.4 metres from the receiver), have a value lower than 0.5. With this linear regression, the privacy distance is 28.8 m from the source (Fig. 5).

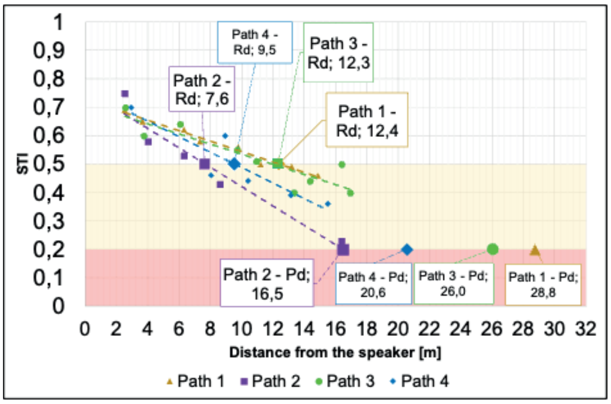

Fig. 5 – STI, distraction distance Rd and privacy distance Pd
Valori di STI, distanza di distrazione e distanza di privacy

In the second path, the presence of shelves with a height of 1.7 m, a meeting room, two phone booths and a sofa for informal meetings affect the STI values consistently the therefore the results (Fig. 5). Point 5 (measurement point at the collaboration desk C) shows a significant decrease in the STI value, almost achieving the privacy distance (16.5 m). Position 4 (corresponding to the area for informal meetings) is after the distraction distance (7.6 m) with an STI value lower than 0.5. The third path corresponds to clusters seven to nine. The distraction path is 12.3 m, and the privacy distance is 26.0 m, according to the linear regression of measured STI values. Four out of nine workstations have an STI higher than 0.5. (Fig. 5). The fourth path goes through the three previous lines. Most STI values are lower than 0.5 since they are more distant than the distraction distance (9.5 m).

3.2 | Questionnaire results

Eighty-six samples were collected during the survey, representing 79% of the total employees. The most frequently selected workplaces are in clusters 3 and 5, along with Collaboratives A and C. Most questionnaires were completed between 9:00 and 13:00 (52%), during which the LAeq is 50 dB(A).

3.2.1 | Sample's characterisation and office-using habits

The initial section of the questionnaire shows that most respondents identify as male (72%). In comparison, females comprise 28%, and non-binary individuals comprise 0% (Fig. 6a). A significant portion, 45%, of participants are aged between 25 and 34, and 27% fall into the 35 to 44 age range (Fig. 6b). Regarding office usage habits, 91% of respondents have previously worked in open spaces, while 9% do so for the first time (Fig. 6c). On average, 47% work in the office three days a week, 26% four days, and 13% five days per week (Fig. 6d).

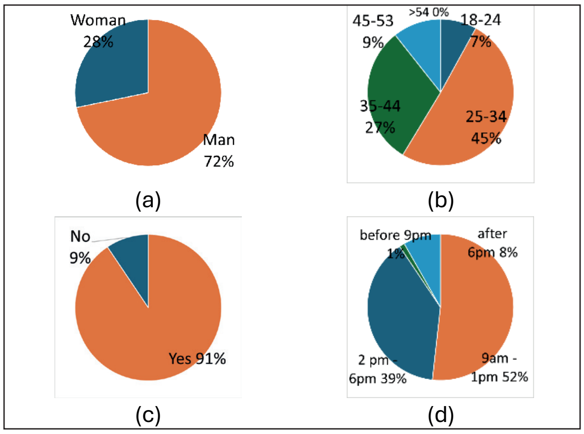

Fig. 6 – Answers of a) gender, b) age, c) first experience in open space working, and d) time slot of the answers
Risposte in percentuale circa a) genere, b) età c) prima esperienza lavorativa in un open space e d) orario in cui è stato compilato il questionario

3.2.2 | Evaluation of overall space quality

Fig. 7 illustrates the distribution of respondents' evaluations regarding overall space quality. The space is generally perceived as positive, particularly regarding the workstation area and furniture quality. The "workstation position" indicates the ability to access office facilities (meeting rooms, phone booths, and workstations). It received a satisfaction rating of 49%, indicating a 4 out of 5, and 33% reported being very satisfied. The category "furniture quality" refers to the quality of objects in the workstation (desk, chair, monitor, etc). The satisfaction rating is 42% for level 4 out of 5 and 41% for very satisfied. The categories rated negatively are the view of external areas and private conversation. The office is on the ground floor with a horizontal plan with windows in the most extended faces. One side faces a service street, the other a greenery. The most negative rates come from the cluster close to the first side. The category most rated negatively is the possibility of having a private conversation. 22% of the answers rate the space as less satisfying, and 28% rate the space as 2 out of 5.

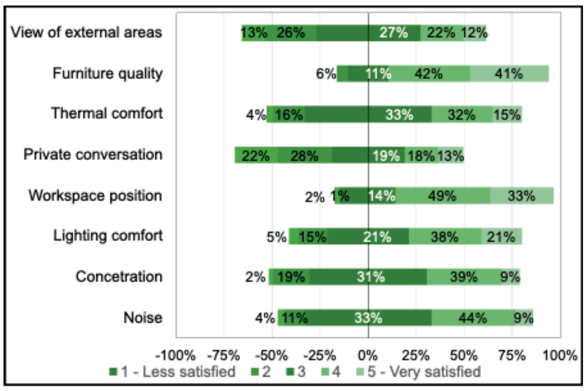

Fig. 7 – Space quality satisfaction
Percentuale di soddisfacimento della qualità dell'open space

3.2.3 | Perception of noise sources

The questions about the most annoying sound sources highlight that users passing by and working facilities are positively perceived. The working facilities are the sources tuned by physical tools that enable the works' activities (such as mouse clicking and board texting). The most annoying sound source is comprehensible speech. 24% of the respondents rated the category 5 out of 7, 17% 6 out of 7, and 19% very annoying (Fig. 8).

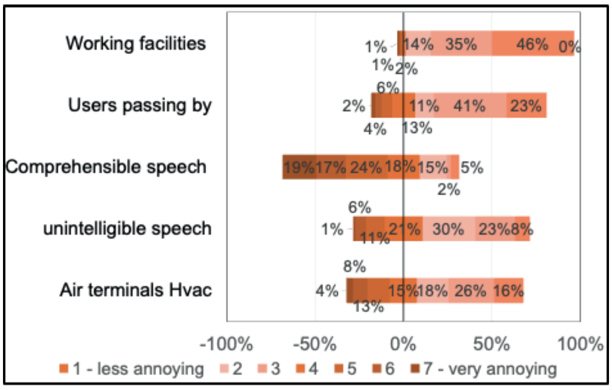

Fig. 8 – Annoyance and sound sources
Percentuale di disturbo causato da specifiche sorgenti

4 | Discussion

4.1 | Correlation between annoyed task, sound source, measured SPL by cluster, and architecture features

In cluster 1, the main sources of annoyance are unintelligible speech and colleagues' walking, with an average of 6.9 at the 90th percentile. They affect all activities, even if the measured SPL fulfils the target for calls with externals (Activity n° 3, green box) and activities with collaboration between people at the nearest workstation (Activity n° 4, dark green box) (Fig. 9).

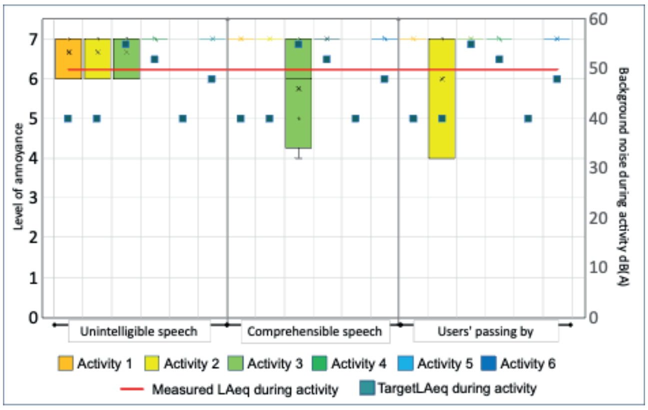

Fig. 9 – Level of annoyance per activity perceived due to unintelligible and comprehensible speech and users' passing by in cluster 1
Livello di disturbo percepito per attività dovuto al parlato comprensibile, non comprensibile e al passaggio nel cluster 1

Cluster 1 is the first cluster that most users have to pass by to get to the different areas of the open space. Moreover, it is close to the entrances of two meeting rooms. It is reasonable to think that the high level of annoyance caused by comprehensible conversations, unintelligible conversations, and colleagues walking are affected by this position. The 30% of reflective material characterises the cluster, and moquette has the higher equivalent area, but it has the lower absorption coefficient. Nevertheless, the Tr (125 HZ) complies with the BS ISO 22955 (Fig. 4).

In cluster 2, the most highly rated annoying sources, such as comprehensible conversation and users passing by, affect activities 1, 2, and 3. The other sources moderately affect the activities. Cluster 2 is in between collaborative desk B and cluster 1. The highly reflective material in the false ceiling (less than 20 %) defines a Tr(125 Hz) compliant but totally out of range for Tr(250-4000 Hz mean) (Fig. 4).

In cluster 3, the noise from the air terminal moderately annoyed activities 1 and 2, and in this case the SPL was higher than the targets expected for activity number 4. Unintelligible speech is, on average, perceived as annoying rather than comprehensible. The colleagues' walking is moderately annoying.

Cluster 4 has the most disturbing noise, attributed to the air terminal, with a rating of 4 out of 7. This observation applies to all activities. The other sources moderately affect various activities.

In Cluster 5, air terminal noise is evaluated as more annoying than unintelligible speech for calls with externals (Activity n° 3, green box). The terminals' noise is rated on average between 4 and 7 as a level of annoyance, bringing the 90th percentile to 6. Nevertheless, the measured background noise (50 db (A)) meeting the target (55 db (A)). Among the sources, comprehensible conversations are perceived as the least annoying for all activities compared to other sources. On average, the most annoying activity is the text understanding (Activity n° 1, orange box) (Fig. 10).

The effect of the close collaborative desk C can justify the high annoyance given by comprehensible speech at cluster 5. In this cluster, the percentage of absorption materials is less than 20% as the mineral wool panels are not present in all the perforated panels in the false ceiling.

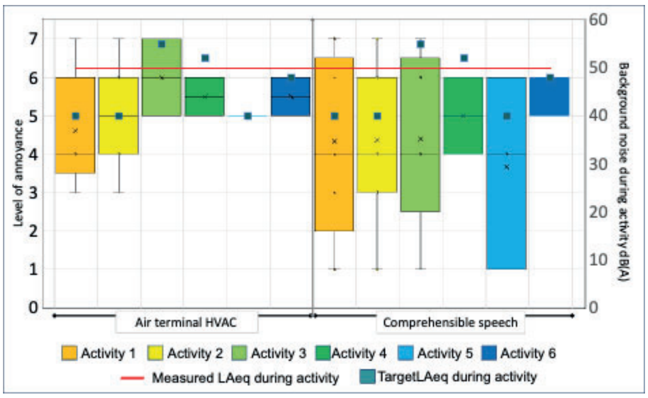

Fig. 10 – Level of annoyance per activity perceived due to unintelligible and comprehensible speech and users' passing by, in cluster 5
Livello di disturbo percepito per attività dovuto alla rumorosità degli impianti e al parlato non comprensibile nel cluster 5

In cluster 6, the most annoying activity is related to text comprehension (Activity n° 1, orange box) averagely rated 5 out of 7, due to unintelligible conversations (Fig. 11). In this case, the measured background noise during the activity is 10 dB(A) higher than the target (40 dB(A)). The least annoying activity is communication call (activity n° 3, green box) a rate of three out of seven, which means all the sound sources. The measured value is lower than the target (55 dB(A)) in this case.

Cluster 6 is the most enclosed cluster: the 1.2 m high shelves separate the desks from the corridors, with one collaborative desk and one informal meeting area. The mineral wool panel in the false ceiling covers 50% of the available area in this area.

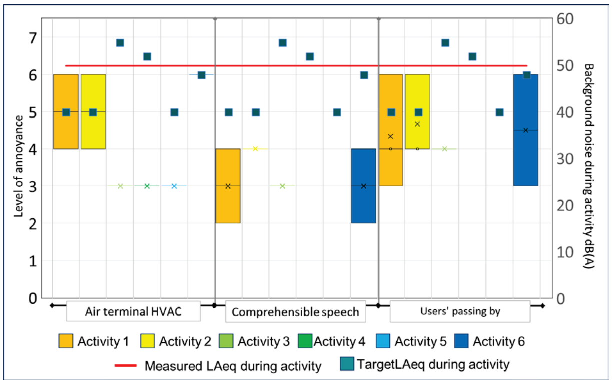

Fig. 11 – Level of annoyance per activity perceived due to unintelligible and comprehensible speech and users' passing by, in cluster 6

Livello di disturbo percepito dovuto al parlato comprensibile, rumorosità degli impianti e il passaggio dei colleghi nel cluster 6

Cluster 7 is close to collaborative desk A, the entrance of a meeting room, and two phonebooths. Moreover, it is the second closest cluster to the entrance after cluster 1. Nevertheless, no sources consistently annoy the activities. Activity n° 4 is the most annoying, with a four out of seven rate. The cluster presents a higher number of mineral wool panels in the false ceiling.

The answers from cluster 8 present a wide range of rates for most activities. Considering the 90% percentile, activity n°1 is the most annoyed by air terminal noise, and the second is mainly annoyed by comprehensible conversations.

Cluster 9 presents a low annoyance of almost all the activities' sources. The most annoying part was the non-comprehensible conversation during the fourth activity. The cluster is between two meeting rooms and the informal meeting area. The latter is compounded by a couch that creates an enclosed space. The conversation from this space can be perceived but not understood.

5 | Conclusions

The paper aims to evaluate the relationship between the acoustic environment of an open office and the fit-out project. The acoustic environment is assessed by integrating objective room acoustics parameters. The paper highlights reverberation time, background noise during activities, and the sound transmission index among these parameters. The decision to include these parameters is supported by extensive literature that identifies comprehensible and unintelligible speech as the most disruptive noises in open spaces. This was also indicated by the questionnaire conducted to gauge perceptions of the overall acoustic quality of the open space and the impact of specific sound sources on frequently performed activities. The architectural features of the fit-out that are primarily studied by cluster include the percentage of absorptive and reflective materials and their positioning within the layout.

The results reveal that the targets established by one relation (higher than or lower than a specific value) do not effectively simplify the evaluation process of acoustic comfort. A compliant RT may not lead to negative perceptions of air terminal noise or intelligible speech, even if the STI meets the target (cluster 1). In this regard, developing scale-based rating systems for each parameter and then creating a unified index could enhance acoustic comfort design and play a more significant role in the overall design process of the open space.

From an architectural standpoint, the layout and positioning of the functions are crucial in defining acoustic comfort. The relationship between the positioning of the cluster and the perception of noise impact on activities depends on the surrounding functions. In the closest cluster to the entrance (cluster 1), the annoyance level of colleagues passing by is rated more annoying than in the cluster where the flow of walking is minimal (cluster 5). This comparison considers identical architectural features in terms of the quantity of absorptive material. Meeting rooms and collaborative desks can heighten the negative perception of comprehensible speech at the work desk, even if the STI adheres to standards.

Moving forward, clarifying these correlations can enhance the acoustic comfort design of open spaces by facilitating smoother communication with stakeholders in the design process, particularly architects. Furthermore, applying this methodology to a larger sample of case studies could help to find more correlations.

Conclusioni

L'articolo si propone di valutare la relazione tra l'ambiente acustico di un ufficio open space e il fit-out. L'ambiente acustico è valutato integrando parametri oggettivi come il tempo di riverberazione, il rumore di fondo durante le attività e il sound transmission index (STI). La decisione di considerare questi parametri è supportata da un'ampia letteratura che identifica il parlato comprensibile e non intelligibile come i rumori più fastidiosi negli spazi open space. Ciò è emerso anche dal questionario condotto per valutare la percezione della qualità acustica complessiva dell'open space e l'impatto di specifiche fonti sonore sulle attività svolte. Le caratteristiche architettoniche, studiate principalmente per cluster (ossia aree con le medesime caratteristiche spaziali e materiche) comprendono la percentuale di materiali assorbenti e riflettenti e il loro posizionamento all'interno del layout.

I risultati rivelano che i parametri stabiliti da una relazione (superiore o inferiore a un valore specifico) non semplificano efficacemente il processo di valutazione del comfort acustico. Un valore di tempo di riverbero conforme può coincidere con una percezione negativa del rumore dei terminali impiantistici o del parlato intelligibile, anche se il valore dello STI è soddisfatto (cluster 1).

Dal punto di vista architettonico, la disposizione e la collocazione delle funzioni sono fondamentali per definire il comfort acustico. La relazione tra il posizionamento del cluster e la percezione dell'impatto acustico sulle attività dipende dalle funzioni circostanti. Nel cluster più vicino al l'ingresso dell'open space (cluster 1), il livello di fastidio del passaggio dei colleghi è valutato in modo più negativo rispetto al cluster in cui il flusso è minimo (cluster 5). Questo confronto considera caratteristiche architettoniche identiche in termini di quantità di materiale assorbente. Le sale riunioni e le scrivanie collaborative possono aumentare la percezione negativa di un discorso comprensibile alla scrivania, anche se l'STI rispetta gli standard.

In futuro, chiarire queste correlazioni può migliorare la progettazione del comfort acustico degli uffici open-space, facilitando l'interscambio di informazioni con gli altri attori del processo di progettazione, in particolare con gli architetti. A questo proposito, lo sviluppo di sistemi di valutazione basati su scale per ogni descrittore e la successiva creazione di un indice univoco potrebbero migliorare la progettazione del confort acustico e riuscire ad incidere in modo più significativo nel processo di progettazione dello open space. Inoltre, l'applicazione di questa metodologia a un campione più ampio di casi studio potrebbe contribuire a identificare nuove correlazioni.

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