



Effects of Conversational Distractions on Information Workers

Approximately 73% of the U.S. workforce (about 100 million people) is composed of information workers who work primarily in open office environments. Worker productivity is simply the relationship between "inputs" (information, materials, instructions, etc.) and "outputs" (tasks, decisions, etc.). Since the "production machinery" in offices consists primarily of people, anything - including noise - that materially affects their work conditions is likely to have some impact on their ability to work productively.

Among professional researchers who have studied the "**productivity**" of office-based information workers for decades, **it is now universally accepted that "conversational distractions" are the biggest cause of lost productivity in open workplaces** and, therefore, the most important factor to limit and control.

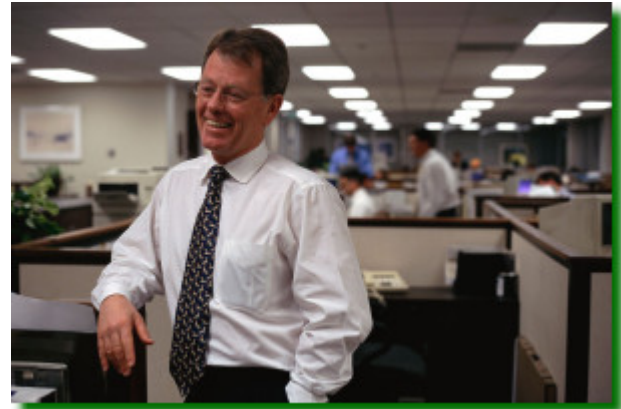
Three recent independent studies using large and statistically valid sample sizes produced interesting results. Two of these studies were conducted under laboratory conditions, and the other was conducted in a field setting (an actual work site).

These studies, all of which have been published in peer-reviewed professional journals, showed the following improvements that resulted from making specific adjustments to the acoustical conditions in open office environments, with the goal of improving speech privacy by removing "conversational distractions":

- **focus:** the ability of office workers to focus on their tasks improved by 48%;
- **distractions:** "conversational distractions" decreased by 51%;
- **error-rates:** performance of standard "information-worker" tasks (measured in terms of accuracy [error-rates] and short-term memory) improved by 10%; and
- **stress:** when measured in terms of the actual physical symptoms of stress, stress was reduced by 27%.

Another recent study conducted by Cornell University found that workers in open-style offices with only low-level noise:

- experienced significantly higher levels of stress,
- made 40% fewer attempts to solve difficult problems, and
- made only half as many ergonomic adjustments to their workstations as did their colleagues in quiet offices.



"**Productivity**" is a broad measure of a variety of aggregate behaviors. Despite interest in the subject, there currently is not a standard methodology that is accepted by economists or finance and accounting professionals for measuring "total-factor productivity. Presently, the seven most frequently studied productivity impacts are:

- the speed with which tasks are performed;
- the accuracy with which tasks are performed;
- the level of stress encountered by workers;
- the impact various stressors (such as noise and vibration) have on the competence and endurance of workers over time;
- the amount of down-time and sick-time (particularly as a result of injuries, for example from hearing damage, back injury, or Carpal Tunnel Syndrome);
- employee turnover rates; and
- various attitudinal measures (i.e., a high rate of satisfaction with workplace conditions usually correlates with increased productivity).

Ironically, it is often assumed by planners, architects, and designers that reducing "conversational distractions" requires developing and specifying "quiet" workspaces. As a result, most offices today have been designed to be too quiet. It turns out that workspaces that are designed to be "quiet" result in conditions where "conversational distractions" are increased - not decreased.

It's like the old adage, "*it's so quiet you can hear a pin drop*". It isn't the absolute "loudness" of the pin drop but rather the absolute "quiet" of the environment that permits the pin drop to be heard.

Much of what is heard in office settings that is considered a distraction is not "absolutely loud" but "relatively loud." In other words, the distraction is louder than everything else in the environment at that time. In fact, in quiet, open workplace conditions, "freedom from conversational distractions" may only be achievable by increasing the levels of background sound, not by decreasing them.



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How Speech Privacy Is Achieved

To achieve "speech privacy" in office environments - whether to comply with the new privacy laws or simply to improve worker productivity - acoustical engineers and consultants traditionally use a method called "the A, B, C's." This convenient acronym literally describes the three factors that need to be controlled to achieve "speech privacy," i.e.:

- **absorption** of sound waves (such as by using a high-**NRC**-rated ceiling tile);
- **blocking** (such as by using high-**STC**-rated panels, partitions, walls, windows, etc.); and
- **covering** (such as adding a source of unstructured [i.e., not music, which is "information" and is therefore distracting], low-level background sound).

Systems that produce this type of background sound (which typically sound like **HVAC** noise) have been in wide use since the 1970s and are generically described as "speech privacy systems" or "white-noise systems" or "pink-noise systems" ("white" and "pink" are often used but highly inaccurate terms), or "sound-masking systems."

"A, B, C's" is a convenient and memorable acronym of three components that must usually be combined in some form to achieve an acceptable level of "speech privacy" to improve workplace productivity. But in terms of the **relative effectiveness** of these three components (absorption, blocking, and covering), the acronym should be spelled "C.A.B's". This is because **the most gain can be achieved least expensively, most quickly, and with the least disruption by starting with "C"- i.e., employing a low-voltage electro-acoustic background sound system.**



Acoustical comfort is an important goal of modern office design. But what factors actually contribute to the perception of acoustical comfort?

Research and experience with the design of open offices over the last 40 years has established the factors that are most important in the users judgment of their acoustical environment. One of the principal factors is achieving adequate reduction from conversational distractions (speech privacy); it is generally agreed to require a **Privacy Index (PI)** of 80% or an **Articulation Index (AI)** of 0.2., or better. Electronic background sound systems are normally necessary to achieve this goal.



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Understanding the Levels of Speech Privacy

An **Articulation Index (AI)** is a measure of the **intelligibility of speech**, expressed as a percentage of speech that is understood by the listener when heard out of context. It is expressed as a number between 0 and 1.

The **American Society for Testing and Materials (ASTM)** E1130-90 precisely defines the levels of Speech or "Oral Privacy" as:

- **"Confidential Privacy"** - "Speech privacy may be described as 'confidential' when speech cannot be understood. This degree of speech privacy is indicated at Articulation Index values at or below 0.05."
- **"Normal Privacy"** - "At Articulation Index values between 0.05 and 0.20, 'normal' speech privacy is indicated. In this range, concentrated effort is required to understand intruding speech."
- **"Unacceptable Privacy"** - "Speech becomes more readily understood at Articulation Index values greater than 0.20. Some describe 'unacceptable' privacy as values above 0.30."
- **"No Privacy"** - At Articulation Index values above 0.40, there is essentially no privacy.

The **Privacy Index (PI)** is a measure for rating the speech privacy performance of an architectural space (or lack of speech intelligibility) where the PI is calculated from the Articulation Index according to the following:

$$PI = (1 - AI) * 100\%$$

- **"Confidential Privacy"** = PI > 95%
- **"Normal Privacy"** = PI between 95 - 80%
- **"Unacceptable Privacy"** = PI between 80 - 60%
- **"No Privacy"** = PI < 60%

NRC - Noise Reduction Coefficient

The measure of acoustical absorption calculated at specific mid-range frequencies.

STC - Sound Transmission Coefficient

A classification of the sound insulating properties of a material or structure.

HVAC - Heat, Ventilating, & Air Conditioning

Articulation Index (AI) is defined by ASTM Standard E1130 [2002], Standard Test Method for Objective Measurement of Speech Privacy in Open Offices Using Articulation Index.



Factors that Contribute to a Sense of Acoustical Comfort when using a Background Sound System

It should be obvious that adequate speech privacy can be obtained if the background sound level is high enough. If a user is seated under a particularly noisy return air grille, he may well not be aware of intruding speech from a colleague and, therefore, clearly has adequate speech privacy, even if he is annoyed by the excessive noise. Similarly, a background sound system can be turned up very loud until everyone in the office has sufficient speech privacy, but this also results in annoyance. However, it is possible to design a system in which both requirements are met - adequate *speech privacy* and *freedom from annoyance*.

The first requirement is proper *tonal quality* or balance of frequencies in the background sound. A second requirement is that the background *sound level should not exceed approximately 45 dBA*, as demonstrated by recent research studies carried out by the Canadian Research Council. Many background sound systems are adjusted for levels well above 45 dBA. This is probably because a majority of the population tolerates higher levels without serious complaint, even though they find it annoying. Finally, the sound must be *spatially uniform*, in both tonality and sound level, at the listener's ear elevation so that his normal moving about in the office does not result in drastic changes in the sound.

The importance of this last requirement, spatial uniformity, is not well understood even by some vendors of background sound systems. It is unusual to find systems that achieve uniformity of better than 4 or 5 dB in the important speech frequencies. Variances of this magnitude result in dramatic changes in speech privacy levels throughout the office if the system is properly adjusted so that the highest levels do not exceed 45 dBA.

As a result, most systems are adjusted for average levels of about 48 dBA to 51 dBA at many locations, causing annoyance to a significant percentage of users. Alternatively, the system is adjusted to a lower average level, compromising speech privacy for a substantial percentage of the users. These factors, unfortunately, have contributed to the opinion among some users that background sound systems are either too loud or are not very effective.

The **VoiceArrest Speech Privacy System** delivers adequate speech privacy and freedom from annoyance at 45 dBA.

dBA - Relationship of perceived sound levels to dBA:
A 10 dBA increase in sound energy is perceived as a doubling in loudness.



Indirect Field Technology

Until recently, virtually all speech privacy systems were designed and installed into the *plenum*. A typical speech privacy system uses loudspeakers *above* the suspended acoustical ceiling that *must be individually adjustable* to provide the correct frequency distribution and precise operating level of ambient sound, *at least if considered on an average basis throughout the space*.

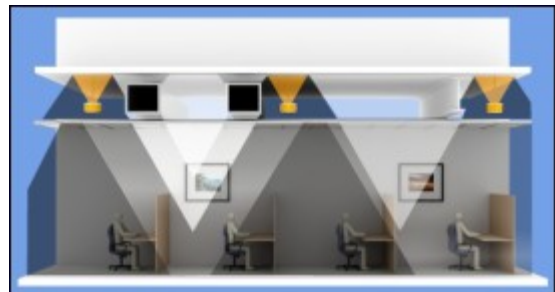
However, achieving adequate spatial uniformity of ambient sound is a serious challenge faced by masking system designers, and it is a challenge that few are able to provide consistently using loudspeakers above the ceiling.

Even a 3 decibel variation from one workspace to another can have a dramatic effect on speech privacy. However, the performance of most systems varies by more than that primarily because of the sound attenuation characteristics of typical ceiling and plenum materials and openings that vary substantially from point to point.

Figure 1 illustrates the difficulty in achieving good uniformity with an above-ceiling system. The conventional wisdom is that the ceiling will "spread out" the sound in the plenum, improving the uniformity. What actually happens is that **the plenum typically causes a lack of uniformity**.

Practical plenums hide large structural elements, such as HVAC ductwork or structural beams, which effectively compartmentalize the sound. Even if the plenum is atypical and contains no large elements, openings in the ceiling for air returns and lighting fixtures permit proportionately more sound to be emitted below them.

Plenum - The space above the suspended acoustical ceiling.



[Click Here for Animated Illustration](#)

Figure 1. Typical plenum and suspended ceiling acoustical variations cause non-uniformity in the background sound below. Ductwork and building beams compartmentalize the sound; acoustically absorbent fireproofing in some areas and not in others causes non-uniformity above, and openings for return air in the ceiling or light fixtures further deteriorate uniformity below. Typical variability below is 4 or 5 decibels.



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 **Direct Field Technology**

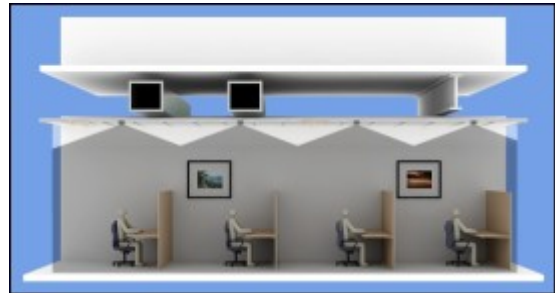
Recent innovations have now made it possible to use a ceiling-mounted speech privacy system that is able to provide much better uniformity of masking sound throughout typical open plan offices. This system uses **Direct Field Technology** with loudspeakers that radiate sound directly into the occupied space below rather than into the above-ceiling plenum.

The principal advantage of emitting the sound directly into the space below is that the non-uniformity caused by HVAC openings in the ceiling, or ventilation slots in lighting fixtures, or by building structural, fireproofing, large ducts or other mechanical components in the plenum no longer have any significant effect on the spatial distribution of masking sound.

By contrast with an above-ceiling system, the uniform gray in Figure 2 illustrates the good uniformity possible with an in-ceiling background sound system. By properly choosing emitters or speakers with ultra-wide dispersion, the background sound is very uniform at the listener's ear elevation.

Practical plenums hide large structural elements, such as HVAC ductwork or structural beams, which effectively compartmentalize the sound. Even if the plenum is atypical and contains no large elements, openings in the ceiling for air returns and lighting fixtures permit proportionately more sound to be emitted below them.

Direct Field Technology - The use of ultra-wide angle dispersion emitters (speakers), radiating sound directly into the designated listening space below.



[Click Here for Animated Illustration](#)

Figure 2. Ultra-wide dispersion emitters radiating directly into the listening space below results in spatial variability of less than 1 decibel throughout the office.

 **The VoiceArrest Direct Field Speech Privacy System Features**

- **Multi-Channel Technology**

VoiceArrest is a true four-channel speech privacy system. It comprises four separate incoherent channels all the way from the digital-generating source to the last emitter (speaker). Four channels accurately simulate the turbulent air eddies characteristic of HVAC system air movement sound generation. This allows the **VoiceArrest System** to sound entirely natural.

Hearing the **VoiceArrest System** is like listening to quadraphonic surround-sound. The sound is full, yet you can't pinpoint exactly where it's coming from even if you're standing beneath one of the emitters. This allows the system to uniformly blend into the office background virtually unnoticed. Few, if any, visitors will even notice the **VoiceArrest System** running, and those who do will think they are hearing the HVAC system.

- **Optimum Spectrum**

The **VoiceArrest Speech Privacy System** provides a sound spectrum that delivers uniformly throughout the coverage area. Direct field technology means the spectrum is not **distorted by** the ceiling assembly or obstructions and variances in the plenum space above.

The **VoiceArrest System** is the only system whose coverage meets the ASTM E1041 requirements for spatial variation and temporal uniformity.

Amazingly, the variation in the spectral balance at any office or cubicle is typically within 1 decibel of optimum at any octave band over the entire critical voice frequency range of 250 Hz to 4,000 Hz.

Although typical plenum-masking systems may appear to exhibit fair uniformity as measured by an **A-Weighted Sound Pressure Level Meter**, their variation within the critical speech bands far exceeds that routinely provided by the **VoiceArrest Speech Privacy System**.

Distorted by the frequency-dependent acoustical transmission loss characteristics of the ceiling assembly or the acoustical spatial variance in the above-ceiling plenum space.

A-Weighted - A-Weighted Sound Pressure Level
The standard measure of sound pressure level that approximates the sensitivity of the human ear at moderate sound levels. A-Weighted Sound Pressure Level de-emphasizes high and low frequencies because the ear poorly perceives these.



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- **Lower Operating Level**

The spatial and spectral uniformity delivered by the **VoiceArrest Speech Privacy System** permits its operation at substantially lower sound levels than competitive systems while maintaining masking effectiveness. While other masking systems must be operated at 48-51 dB in a well-designed open plan office in order to provide acceptable privacy conditions for most occupants, the **VoiceArrest Speech Privacy System** is normally operated at 45 dB under the same conditions.

A frequent comment by users experienced with plenum-based masking systems is that the **VoiceArrest Speech Privacy System** "*is not loud enough*" to provide good speech privacy. Yet objective comparative standard measurements of the **Articulation Index** clearly demonstrate that **VoiceArrest** is at least as effective as louder plenum-based systems. The result is **dramatically reduced acoustical obtrusiveness and user awareness of the system.**

- **Truly Independent Control of Sound Levels in Open and Closed Office Areas**

A common issue in many offices is that the above-ceiling air plenum is shared by both open and closed offices areas. For reasons of economy, the separating walls often do not extend more than an inch or two above the suspended acoustical tile ceiling. Therefore, when masking is delivered to the open area at an appropriate level, sound in an enclosed office typically builds up to excessive levels, even if there are no masking loudspeakers above it. Until now, the only solution was to "starve" the adjacent open areas.

Direct Field Technology used by the **VoiceArrest System** means the masking sound intended for the open office area is entirely restricted to the open area. There is no unwanted bleed over effect into enclosed offices or conference rooms.

If masking is desired in the enclosed space, a separate zone can be provided, and its level is controlled independently.



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- **Cost Effectiveness**

The **VoiceArrest Speech Privacy System** meets a compelling need by providing state-of-the-art speech privacy at a modest price. Configuring and installing does not require hiring engineering consultants, and since it's a low-voltage system, there's no need to run electrical power service to each emitter. Therefore, speech privacy now becomes cost-effective, even for the smallest of office spaces.

The cost-effectiveness of the **VoiceArrest Speech Privacy System** is even more dramatic in larger spaces where a single Control Module can be used to treat up to 30,000 square feet. For areas larger than 30,000 square feet or where zone volume control is desired, simply use additional Control Modules.

With the **VoiceArrest Speech Privacy System**, you receive the highest quality system available, while saving over plenum-based systems.

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- **Determining Specific Needs**

Using **VoiceArrest** "Direct Field Speech Privacy Technology" eliminating the need for on site engineering analysis since the system isn't affected by distortions created by ceiling assemblies, or acoustical spatial variance in the above-ceiling plenum space.

We begin by gathering information about the area(s) in which the system is to be installed. Then by using a "floor plan", and if possible a "**reflected ceiling plan**", we determine the number and placement for the emitters needed.

If you decide to proceed with the project, we have installers nationwide ready to implement your new speech privacy system, or we will assist your own facilities group should they decide to do the installation.

Once installed, the **VoiceArrest Speech Privacy System** provides the proper tonal quality and sound levels with unsurpassed spatial uniformity into the designated areas without the need for time-consuming, costly tuning adjustments to compensate for acoustical effects.

reflected ceiling plan - A layout showing the positioning of the acoustic ceiling grid, and the location of light fixtures, air return grilles, sprinkler heads, or any other elements located on the acoustic ceiling tiles.