It's a Matter of Balance

New Understandings of Open Plan Acoustics

When the bullpens and enclosed offices of the traditional workplace were first transformed into open plan environments in the 1970s, it became apparent that this new office concept was going to present its own functional challenges. One challenge that immediately became apparent was the issue of acoustics.

As experts worked on solutions for corralling sound and reducing distractions in open plan spaces, however, two trends were slowly altering the very landscape that those consultants were fine-tuning: more compact work areas and an increasing need to accommodate teamwork and collaboration.

Both trends emerged over the three decades following the first open plan system design. From the standard 12' x 12' workspaces of the early 1970s, individual workstations are now more likely to be 6' x 6'.[1]

These closer quarters have improved team communications, but they've generated a measure of discontent about acoustics. Office workers who participated in a 2002 study on privacy-related issues conducted by Herman Miller cited overheard conversation as their biggest workday gripe. Most respondents agreed with the statement, "When I am working in my workspace, I'm distracted by conversations of my immediate neighbors."[2]

Another study on office noise and employee performance found that well over 1,000 of the 2,000 participants involved were bothered by noise in the workplace, with conversations and ringing telephones rated as the most annoying sounds.[3] A third study

confirmed that 40 percent of the office occupants polled felt that "workplace acoustics" made it more difficult for them to do their jobs.[4] One researcher has developed a model based on a review of several acoustics studies. It predicts a seven percent reduction in the performance of complex tasks when overheard speech is highly intelligible.[5]

Although employees find other people's voices distracting and irritating, there's a flip side that's also currently getting attention in recent research: These same employees are actively concerned about other people being able to hear *them*. As privacy becomes a more overarching concern in the workplace, the downscaling of today's open plan workstations adds another layer of challenge to office design—how to deliver voice privacy to those who need it.

The more that acoustical experts learn about minimizing the effects of "adjacent racket" in the open plan office, the more confusing it can get for everyone else. Once the language barrier of "interzone attenuation," "sound transmission class," and "noise reduction coefficient" is cleared away, though, it becomes clear why acoustics in the open plan office is such a complex issue.

Face to Face with the Soundscape

Over the past 25 years, there's been a movement in acoustical engineering to closely examine the true sound quality of both environments and products, as opposed to studying noise. When examined from this perspective, it's increasingly clear that "silencing" is not necessarily what occupants of open plan spaces really want. Rather, people want acoustical reinforcement for their feelings about how the quality and appropriateness of the space are expressed.[6]

The sound in an office is what Steve Orfield of Orfield Laboratories has termed "the soundscape," a component of "the perceptual landscape" of a work environment.[7] People hear all sorts of things in an office—keyboarding at computers, the HVAC system cooling the workspace on a hot day, the sound of phones being answered pleasantly and professionally—that reinforce a feeling of being part of a team that's getting work done.

In other words, not all sound is bad, and some of it may actually be necessary to productivity. In the 2002 Herman Miller study noted earlier, it was discovered that fewer people agreed with the statement, "When I am working in my office, I am distracted by background noise from machines, printers, etc." than those who said that conversations bothered them.[8]

Sound Level—It's Not Just Loudness

Although people tend to assert that it's the loudness of noises that distracts them, the reality is more complicated. If the acoustical problem in an open plan office was simply a function of loudness, that would be relatively simple to address. But it's not. In determining where the sound level in an average office falls on the decibel (dB) chart (and recognizing that each additional 10 dBs doubles the loudness), something very interesting becomes obvious. At around 60 dBs, the noise level in the average office is probably four times

quieter than it was in the crowded Paris bistro where Hemingway says he wrote his best stuff, "one true simple sentence" at a time.[9] The street noise was loud, but not distracting, confirmation that there are other factors at play for employees driven to distraction by certain office sounds.

The Psychology of Sound

Sound can be measured. Noise cannot. Noise is subjective; it's whatever an individual finds annoying or distracting. People rarely think of their own conversations, background music, or cell phone ring as "noise," but that doesn't mean it isn't perceived as noise by others. Playing an iPod at 70dBA ("decibels adjusted," an averaging curve that expresses the range of frequencies to which the ear is sensitive) may sound enjoyable to one person, but two colleagues talking about last weekend's game at 55 dBA is loud enough to keep that same person from finishing an e-mail.[10]

In an office, the main distracters are "people noises"—two-way conversations, bits and pieces of phone conversations, throat clearings, squeaky new shoes walking by—anything that "piques the listener's curiosity."[11] Background noises that are regular and predictable are easier to block out; it's variety and suddenness that demand attention. That's why the hum of the HVAC fan doesn't disrupt thinking, but a burst of laughter might.

Speech Intelligibility: How Well We Hear What We Hear

Intermittent noises carry more information than a continuous noise like a hard drive or a copy machine, and therefore they attract more attention, sometimes interfering with tasks and even short-term memory processes.[12] So, although a normal conversation is only half as loud as a ringing telephone or a quarter as loud as a photocopier, the "information content"[13] of that conversation makes it much more distracting than many louder noises in the open plan environment. The information also carries a long, long, way: Even with a sound-absorbent ceiling and carpet, a conversation held in an open space can be understood up to 30 feet away.[14] If the sound of that conversation is heard by a listener above background noises, it is *audible*; if individual words can be understood, it's *intelligible.*[15]

It would appear, then, that one way to help people focus on doing their jobs in an open plan space is to control all of the spreading sound waves generated by other people doing *their* jobs. Panels would seem to be the obvious absorber of choice, but they provide only a partial solution.

Employees as Sound Wave Receivers

Ironically, there's an additional reason why sound seems to travel more readily in an open office, and it has partly to do with the fact that panels are doing their job—as are the carpeting and ceiling. Because large portions of the sound energy have been absorbed, what sounds

are left to travel unimpeded seem clearer, even when they are quieter.[16]

When those sounds reach an office occupant, they find a more available receptor. People's senses are muted in an open plan environment. They are not as visually stimulated as they might be in, say, Hemingway's Paris bistro. Workstation panels block airflow so thermal perceptions are diminished. Unless someone's making microwave popcorn, there's nothing to smell. But the open plan space does not muffle hearing, which is therefore sharpened as the other senses are not as active due to a lack of stimuli. This may be the very reason why so many people complain about acoustics in open plan offices—hearing is put on high alert and is ready to receive whatever sound is bouncing around the office environment.[17]

Sound Paths—Over, Under, Around, and Through

Because sound waves act like light waves—they spread out spherically, in all directions, on all planes at once—the most a workstation panel can do is filter, not block. The panels can act like a lampshade over a light bulb. No matter how large a portion of a sound wave a panel can corral, there will always be portions left free to leap over, creep under, bend around, or seep through the panels. From there, they continue on their way.

To keep as few people from being disturbed as possible, acoustical experts have learned to attack sound waves on each of the paths they take to get into adjacent workstations. (Leaving any one of the paths uncontrolled, they've found, negates what's been achieved with the others.)[18]

These sound paths are as geometrically precise as the angles followed by a billiard ball. There are two bending (diffracting) paths—around the sides and over the top of a panel. There are three reflecting paths—off the ceiling and/or lighting fixtures, off the floor, and off vertical surfaces like walls or furniture components. There is also a direct route that goes straight through office partitions—either through panel joints or the panel itself. Sound travels over all these paths and then recombines, creating the sound that a listener actually hears.[19]

Applying Acoustical Solutions at Three Points

Experts have found that there are three points where sound can be controlled in the workplace: source control, path control, and receiver control. In other words, one can control sound at its place of origin, as it travels, or when it arrives at a listener's workstation.

Source control can be achieved by simply asking people to talk more softly, by changing work surfaces to reorient the direction the talker is facing, or by increasing distance between workers. Improving sound absorption on surfaces that are reflecting sound or applying effective sound blocking are two examples of path control. Two ways to accomplish receiver control are to provide headsets to an employee or install sound-masking technology at a workstation.[20]

Privacy in Open Spaces

Open plan office workers almost universally report they need more acoustical privacy, but as noted earlier,

sound does play a part in overall productivity. It connects us to others and creates a sense of community. That could be one reason why many private-office occupants leave their doors open so much of the time. What workers in an open plan space really want is the same thing that the private-office occupant has: the option for privacy. But the simple fact of the matter is that most employees do not have significant privacy requirements most of the time, while many actually do require higher degrees of collaboration than were needed a few decades ago.[21]

Based on a database with information collected from 13,000 participants in 2002, researchers found that 80 percent of all work the participants did was either quiet, solitary work or noise-producing interactions—discussions or phone conversations—all of which took place within or near the participants' own workspaces.[22] These two incompatible activities underscore just how difficult it would be to create what is termed "confidential privacy" in an open plan space.

But there are ways to make the overall acoustic quality good enough to satisfy those in open plan workstations. A recent study found that the difference in sound levels between private offices, two-person offices, and open plan office areas differed by only 1 dB.[23] That's not a significant difference, but it's perceived as one. Discovering how to improve the *perception* of sound quality, therefore, becomes crucial to having satisfied workers in every type of office.

Privacy and Policy

Privacy is no longer just a personal worker preference; some of it is now legislated. Issues such as identity theft and the privacy of medical records have stepped up the need for voice privacy in specific office settings. Canada's Privacy Act of 1983 was a groundbreaking law that limited the amount of personal information the government was allowed to collect or disclose. In the United States, the Health Insurance Portability and Accountability Act (HIPAA) forbids even accidental disclosures of patient information, such as might be gained from overhearing a doctor on the phone or a face-to-face discussion between two doctors.[24]

In addition to federal laws, there are also some state-specific laws, such as California's new identity-theft legislation. This law requires companies to notify people if there's any kind of breach that suggests personal information has been taken. In order to be more careful and comply with this law, companies may reexamine their office layouts and data storage.[25] It's yet another consideration in balancing privacy, collaboration, and how sound plays a role in both.

Planning: Laying the Groundwork

All these acoustical needs can be addressed effectively in open plan spaces, but only if the project starts with careful planning. It should come as no surprise that in the toolboxes of designers and acoustic consultants, planning is first among important strategies. And the earlier the planning starts, the better.

Evaluating a building's acoustics before occupants move in ensures that the overall space itself will offer the best acoustical quality possible. Building performance can extend beyond acoustics to issues such as natural light accessibility and thermal comfort, but it's especially crucial for sound. In working with an acoustics expert, designers can begin to lay out the broad strokes for the sound solutions they will later have to fine-tune to work with people's voices, outside traffic, office equipment, music, and all the other elements of the office soundscape.[26]

The privacy and collaboration needs of occupants enter into this preliminary work as well. First, however, planning prepares for the success of the space itself, the "careful coordination of the several components, ceiling, wall treatments, furniture and furnishings, heating, ventilation, and air conditioning system, and masking sound system."[27]

Planning that starts early in the building project is also the most cost-effective way to go, because mistakes in the acoustical environment can be much more expensive to fix after an office is up and running. Here's an example of the difference between up-front work and retrofitting: A wall separating a conference room from an open plan area can have sound-blocking materials applied cheaply during construction—a fiberglass blanket and a layer of gypsum board, along with a check of the ceiling's sound-absorption qualities. A retrofitted solution would involve completely rebuilding the wall and replacing the ceiling tiles, at 10 times the expense.[28]

Current facilities costs represent between 5 to 8 percent of an office in operation, while people and information systems make up 92 to 95 percent of the costs.[29] Therefore, planning for a good acoustical environment that satisfies the largest number of employees will protect the biggest resource investment that a business makes—in its work force.

To help the work force be as productive as possible, four specific techniques can be applied during planning and in application to deal with sound waves as they travel on their diffracting, reflecting, and direct paths between sources and receivers. These are increasing the acoustical shadow, sound absorption, sound blocking, and sound masking of a space.

Increased Acoustical Shadow: For Diffracting Paths

The first method actually unbends sound waves and, by doing so, forces them to miss their receivers, like arrows that have overshot their mark. By increasing the height and width of dividing panels, and by adding hang-on components, diffracting sound waves—the ones bending over and around panels—can be flattened. The sound traveling on those flattened paths misses the ears of the neighboring occupants, increasing the "acoustical shadow"[30] in their adjacent workstations.

The effect of these acoustical shadows can be multiplied by moving people closer to their panels; however, this will increase the distraction from sound waves that may come *directly* through the panel.[31] It will also do nothing to protect those people from sound waves bouncing around on any reflecting paths. Direct

and reflecting sound waves must be handled by a second method: sound absorption.

Sound Absorption: For Reflecting and Direct Paths

Everyone knows how rugs and pillows, thick curtains, and overstuffed chairs can take the echo out of a big, empty room. Like a thick paper towel soaking up water, these sound-absorbing materials soak up sound waves; they are trapped in an internal maze of air pockets. As the sound waves work their way through the maze, they slowly lose the sound energy they are carrying. It dissipates into microscopic heat.[32] Emerging from the absorbing material, the waves are weaker and softer in volume.

In the first open plan offices, sound absorption was the only technique that anyone knew to use. By adding sound-absorbent materials such as fiberglass, shredded wood fiber, or paper honeycomb to the structure of ceilings and walls, along with adding carpeting to bare floors, experts learned how to weaken reflecting sound waves.

Today, experts have confirmed that, although a ceiling cannot accomplish the sound absorption task by itself, ceilings with the correct absorption properties, used in combination with correct panel heights, play an especially critical role in office acoustics.[33]

Spray-on applications can be used on beamed ceilings, and sound-absorbing elements can also be hung from the ceiling to improve their absorptive qualities.[34] Incorporating environmentally friendly acoustical enhancing materials—in the form of wall treatments and freestanding elements—absorbs excess sound energy and reduces the echo in a space to make it a more comfortable and pleasing environment.

Floor coverings also present important sound-absorption opportunities—with carpeting absorbing about 10 times the airborne sound that can be dealt with by other flooring materials.[35]

The direct path that sound waves take through panels can be addressed by sound absorption, too—as long as the people in adjacent workstations are more than 12 feet apart. At that distance, direct sound waves are already weakened by the traveling distance and that allows sound absorption to become effective.[36] This tactic obviously has become less useful in today's smaller workstations. That's where sound blocking enters in.

Sound Blocking: For Direct Paths and Shorter Distances

As workstations have become more compact, people are often working and talking only a couple of feet away from the dividing panels of neighboring workstations. Under these conditions, sound waves traveling on direct paths are too strong when they reach a panel to be significantly weakened by passing through its sound-absorbent maze. So the sound waves keep going, carrying easily understood pieces of conversation into the adjacent workstation.[37]

Sound blocking materials added to the panel can help put a stop to this. Although the best sound-absorption materials are lightweight and porous, the best sound-blocking materials are dense and heavy. Solid masonite, metal, or hardboard are good examples of sound-

blocking barriers. With no air space for the sound waves to slip through, panels with tightly packed, sound-blocking interiors cut off the direct paths into these close, neighboring workstations.

Other sound-blocking strategies include slab-to-slab partitions for especially noisy fixed-wall spaces, such as conference rooms; sound seals around any fixed-wall doors; and retractable door bottoms that help seal a door once it's closed.[38]

Sound Masking: Disguising the Sound Waves Left Behind

Even with the best sound absorption and sound blocking, there will always be some sound waves left to travel around an open plan space. These can be dealt with by adding sound, not subtracting it. Sound masking is extra sound, added in a controlled fashion, that masks more distracting noises.

Sound masking works like a water faucet when it's turned on. Someone speaking in another room can be clearly heard before the faucet is turned on. After it's on, the ambient background sound level increases and the ear's sensitivity to the intrusive speech is reduced. Turn the tap on all the way, and the listener may be aware that someone is talking, but won't be able to understand a word of what's being said.[39]

There are two basic types of sound-masking systems. A self-contained system has a series of speakers that can be mounted on panels, poles, or in the ceiling plenum. Each speaker has its own sound source, and in some systems that are available, each speaker's volume can be adjusted independently. These systems work best in smaller spaces, up to 5,000 square feet.[40]

A second type of sound-masking system is centralized, and is used in larger spaces. The speakers are hung above the ceiling and are spaced, arranged, and tuned to meet different masking needs in different zones of the office environment. Each speaker can be controlled from a central location so that changes can be made if new offices are added, occupants move, or individual needs change.[41]

There is also an emerging technology known as voice scrambling that can be used to supplement sound masking. Rather than absorb sound or generate background noise, this technology uses a person's natural voice to create a complex set of voice sounds. These sounds make speech—on the phone or in face-to-face conversations—incomprehensible to others, even within a few feet.[42]

A Delicate Balance

A review of the methods for workplace acoustics may make it seem like relatively straightforward work to balance needs and noise, but even with the right tools, it's a delicate job. An expert eye (and ear) is required to manage not only the whole array of tools, but also the inevitable trade-offs.

There are many judgment calls that go into the mix. For example, while hang-on components can increase acoustical shadow, they also cut down on the

absorbency of panels by using up the sound-absorbing surface space. In compact workstations, hanging components take up a larger proportion of the panel surface, and that lost absorbency must be made up in other ways.

Regaining lost absorbency isn't simply a matter of beefing up the panels' sound absorbency either. An odd thing happens when that's tried: Sound waves from any sound-masking system that's being used get soaked up too fast in the extra absorbent layers. So there's not sufficient ambient noise to cover up intelligible speech.[43] The discussion of last weekend's game once more becomes a distraction.

The sound-blocking qualities of panels needed in smaller, more collaborative open plan layouts present another challenge. Because sound-blocking materials simply send direct waves back where they came from, using sound-blocking materials alone creates reverberations, throwing another set of sounds into the air.[44] What's required to correct this problem are panels with cores that offer a blend of sound-absorbing and sound-blocking materials.

Panels—Playing a Critical Role

From everything that's been noted so far, it's probably obvious that the panels in an office environment play a significant part in managing open plan acoustics. If they have a good sound transmission class (STC) rating, panels can change and redirect the path of sound waves, as noted earlier. But in recent years, it's also been observed that panels need to be at least 65 inches high to have a real impact on speech privacy. The higher the panel, the better the performance. To make a genuine contribution to privacy levels, panels may have to be as much as 80 inches high, because people in offices sometimes stand up when they talk, especially with visitors.[45]

In spaces where the trend continues for lower-height panels—such as in call centers—panels will play no real role in acoustical control. It's important to keep this in mind, especially in workstation areas where speech privacy is now required by law, such as a call center that handles credit card information or medical records.

Workstation configuration can help with these concerns. The orientation of the seated person in a workstation can be changed, altering where his or her voice is directed on a phone call and when talking to visitors. Sound-masking technologies combined with voice-privacy systems can also be applied. Here again, planning is key.

No "One Size Fits All" Solution

Managing sound, a constantly moving and shifting entity, is not simple. Acoustical experts have come to realize that it's futile to attempt a cookie-cutter solution for every open plan office. These spaces vary greatly in both architecture and design. Elements such as room dimensions, ceiling height and structure, and placement of doors, windows, and lighting fixtures will all affect each office's soundscape. Even paint colors and fabrics can play a role in acoustics.

A series of studies recently revealed that color preferences on the part of employees will alter their feeling about whether a space is quiet or noisy. In the studies, workstations with yellow chairs and brown panels were ranked as noisier and less private than other color combinations—suggesting that visual "loudness" actually translated into a feeling of acoustical imbalance.[46] This is an example of sound-quality perception that can be addressed and managed to the benefit of open plan occupants.

Issues like these actually serve to underscore an important point: The flexibility of open plan design is a benefit when dealing with many acoustical issues. The "cave" and "court" (private and public) spaces identified by Fritz Steele[47] require a holistic approach. Planning these spaces may involve facility managers, interior designers, contractors, and manufacturers in the selection of the appropriate components, ceiling and carpeting treatments, and sound-masking systems. As these people with their various areas of expertise work through the details for a space—along with an acoustical expert as a team member—they are much more likely to achieve a favorable balance for the office soundscape.

A Quick Overview of Acoustical Ratings Systems

Rating systems for acoustical products fall into two categories: process ratings and product ratings.

Process ratings provide information about a product's performance under exact testing configurations. They include:

- Articulation Index (AI): measures the combined speech privacy performance of all elements in a systems layout—ceiling, walls, panels, and sound-masking system
- Articulation Loss of Consonants (ALcons): the loss, by percentage, of consonant articulation across a speech channel
- Speech Transmission Index (STI): the percentage of speech intelligibility by the listener
- Rapid Speech Transmission Index (RASTI): the percentage of rapid-rate speech intelligibility by the listener

Product ratings show how specific products have performed when measured for acoustical qualities. They include:

- Noise Reduction Coefficient (NRC): the percentage of sound absorbed by a product under ASTM laboratory procedures, measuring the decay time of a sample in a reverberation chamber
- Sound Transmission Class (STC): the amount of sound reduction passing through a product under a specific ASTM laboratory procedure, measuring the noise reduction of a sample mounted between two reverberation chambers
- Articulation Class (AC): the amount of speech intelligibility and privacy provided by a product under specific ASTM laboratory test procedures, measuring intelligibility levels provided by either reflection from or diffraction over and around a sample

Partitions may have AC, STC, and NRC ratings. Ceiling tiles may have AC, STC, and NRC ratings. Acoustic panels usually have an NRC rating.[48]

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