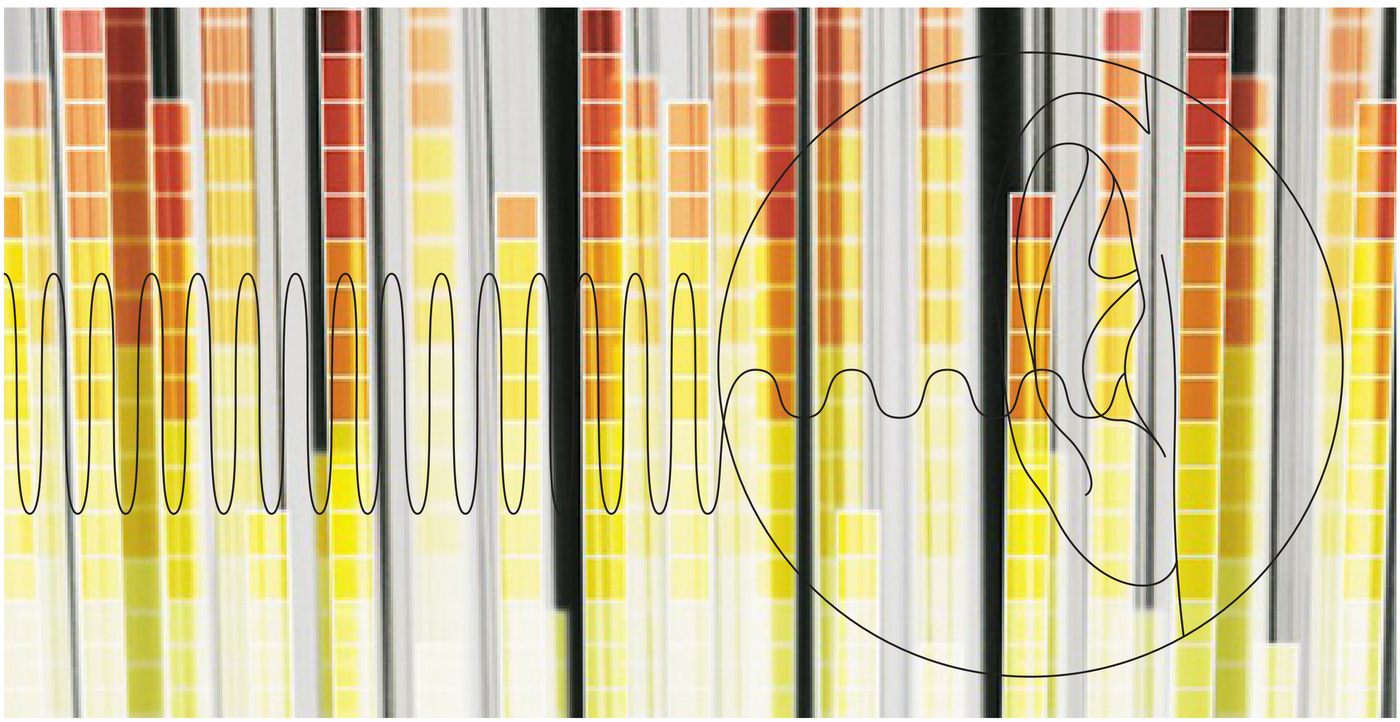
Sound Masking in the Office

REDUCING NOISE DISTRACTIONS TO INCREASE WORKER PRODUCTIVITY



Quiet Technology™ sound masking decreases distractions to improve performance. An ideal sound-masking solution makes speech beyond a 12-to-16-foot radius unintelligible so a person can concentrate on his or her work, collaborate with colleagues, and be more productive.

What We Know

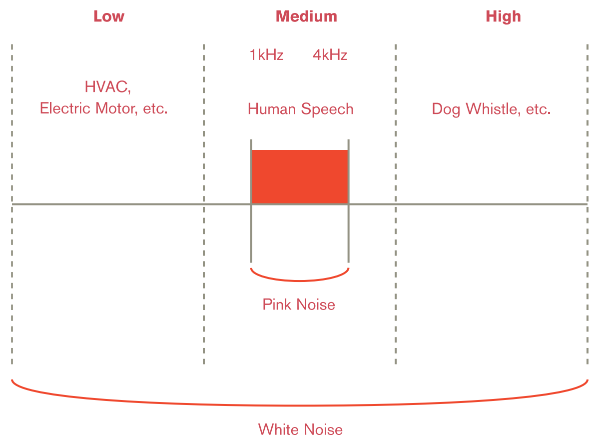
Office workers who participated in a 2002 study on privacy-related issues cited "overheard conversation" as their biggest complaint (Herman Miller, 2002). While people can get used to many office noises, to the point where their brains "tune out" the distractions, some find it nearly impossible to disregard intelligible human speech (Banbury and Berry, 1997, 1998). Without sound masking, human speech can be intelligible up to 50 feet away. Other researchers have documented the impact of noise on employee stress (Cohen, 1980; Evans and Johnson, 2000) and short-term memory (Jones, 1999).

Early sound-masking systems installed in buildings in the 1960s simulated the sound of air moving by electronically filtering random noise produced by gas-discharge vacuum tubes. Loudspeakers in the ceiling distributed the amplified noise signal throughout the office. However, making human speech unintelligible required a volume level so high that the sound masking itself became a distracting annoyance.

In the 1970s, electronically generated sound masking using frequency generators that shaped sound to better mask speech became more practical and worked well when installed correctly. Ten years later, researchers began studying 1/f noise, the phenomenon also known as "flicker" or "pink" noise. Targeting "pink" noise to match the frequencies of human speech raised the threshold of audibility just enough to mask intelligibility without requiring the higher volumes used in earlier systems.

In-ceiling sound-masking systems began using this targeted spectrum of sound. This approach involved sound engineers working with architects to design appropriate sound-masking layouts for new and significantly renovated buildings. The design typically incorporated sound-masking units placed on a grid pattern in the ceiling plenum in order to achieve uniform coverage.

The benefits of sound-masking systems have been studied extensively. Independent research has documented productivity gains of 8 to 38 percent, job satisfaction increases of 125 to 174 percent, and reductions in stress up to 27 percent. Yet, there

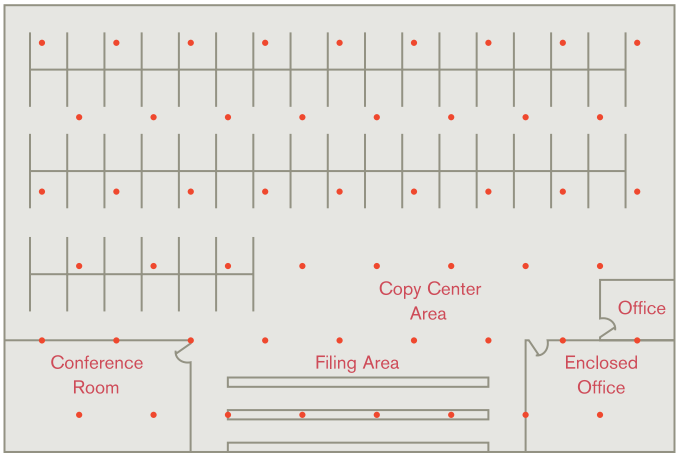


is ongoing skepticism regarding these claims that has limited adoption of sound masking by North American businesses.

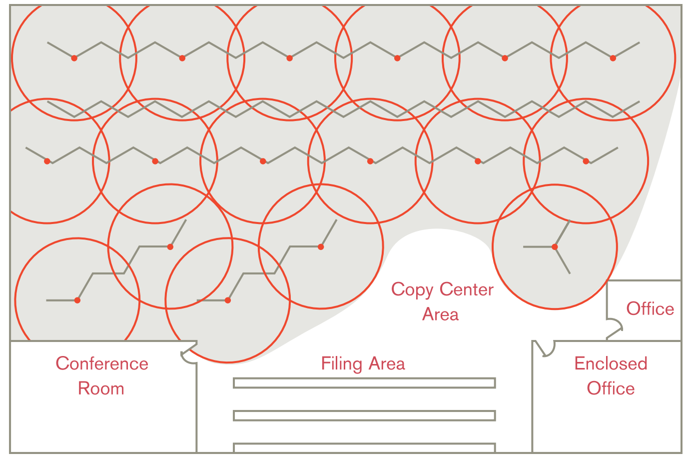
Two factors often make the cost-benefit relationship for in-ceiling systems prohibitive for organizations, especially small and medium-sized ones, and building owners. First, typical in-ceiling systems have hardware-plus-installation costs of $1.00 to $2.00 per square foot. In addition to these costs, the services of a trained acoustical engineer are needed to oversee installation and fine-tuning of the system to coordinate with the acoustical properties of various architectural elements in the space (e.g., reflectivity of ceiling, floor coverings, lights), as well as the furniture layout once workers occupy the space.

Second, in-ceiling systems are considered by many to be, in effect, permanent fixtures within the architectural space even though a leasee who installs such a system could take the components when vacating a space. So, building leasees must be convinced that the cost of adding these systems to their leasehold improvements will yield real benefits whether they eventually take the hardware or leave it. Building owners are reluctant to offer sound masking as part of the base building package because they are unable to increase rents proportionately to cover costs. And, because in-ceiling units are considered part of the building, they must be depreciated over a 30-year schedule, which adds to the problem of recouping the investment.

In-ceiling sound masking results in costly, inefficient coverage because speakers are placed in the ceiling grid before the layout of the space is determined.



Quiet Technology™ sound masking attaches to furniture, so efficient coverage results from targeting only those areas of the space that require sound masking.



Therefore

An effective sound-masking system incorporates the advantages of a human-speech-targeting sound spectrum (i.e., pink noise), the ability to integrate with furniture, and no need for an acoustical designer. The integration feature addresses cost controls through targeted application (only where it's needed and not in hallways, copy/mail rooms, conference rooms, etc.), ease of reconfiguration without the need to go above the ceiling, and a seven-year depreciation schedule equal to the furniture. Additionally, it provides the ability to take the system along when removing furniture in a leasing situation. And it is less dependent on the acoustical properties associated with a building's ceiling height and material type because of the opportunity for precision placement. Most important, research into the value of sound masking demonstrates a link between this technology and productivity increases among workers engaged in cognitive activities.

Design Problem

In undertaking the development of economical, effective sound masking that attaches to its systems furniture products, Herman Miller sought to capitalize on recent advances in the application of sound masking.

Quiet Technology sound masking incorporates a patented sound spectrum that has proven more effective than previous systems in decreasing the radius of potential distraction to 12 to 16 feet from 40 to 50 feet in the typical office without sound masking.

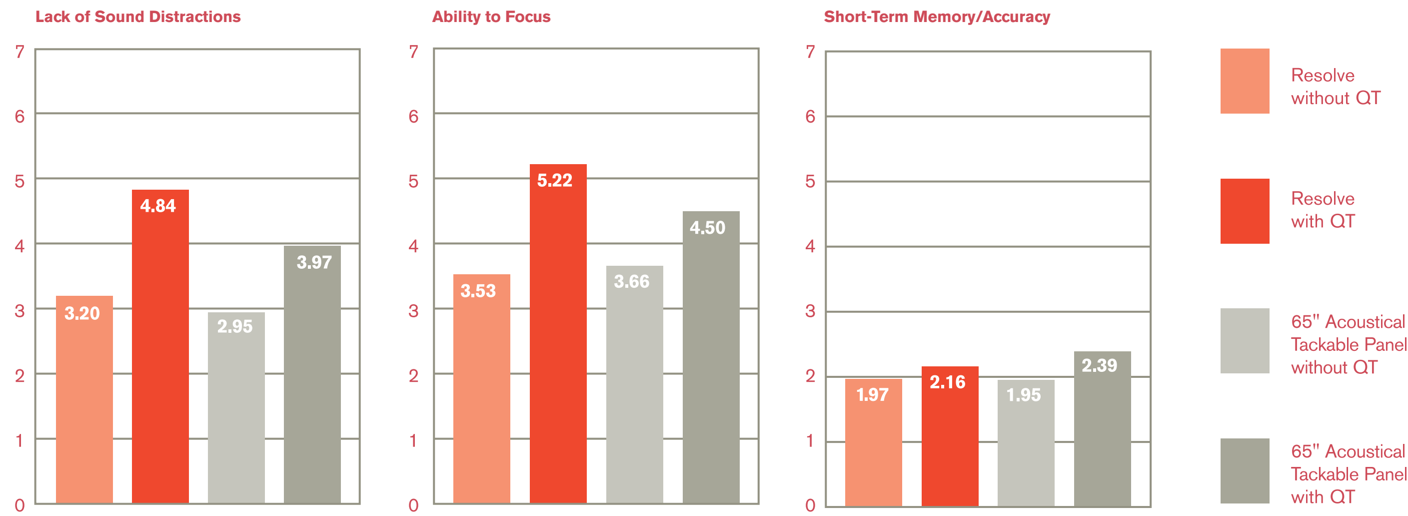
Quiet Technology achieves these results by delivering an Articulation Index (AI) of .2 or less, meaning that few words (20 percent or less) spoken by people 12 to 16 feet away are intelligible.

Because people working in highly collaborative environments stand to gain the most from Quiet Technology sound masking, it made sense to focus initial development efforts on the Herman Miller furniture that is particularly adept at supporting collaboration—the Resolve® system. Incorporating the soundmasking advantages of Quiet Technology would reduce noise distractions to enhance even further the furniture's ability to foster collaboration and productivity.

Design Solution

Working with the developer of Quiet Technology, Cambridge Sound Management, Inc., Herman Miller incorporated a patented sound-masking spectrum into an effective system for delivering masking sounds. Small speakers embedded in the "petals" that attach easily to the top of Resolve tall poles broadcast the patented spectrum.

While straightforward in application, able to be retrofitted, and more economical than in-ceiling systems, Herman Miller's Quiet Technology sound-masking system more importantly addresses the issue of impact on worker productivity. To determine the level of this impact, Herman Miller contracted an independent research group, Ergometrica, to test Quiet Technology sound masking under scientifically controlled conditions on Resolve furniture and 65-inch-high traditional systems environments.



In conducting the tests, the research team used the ΔProductivity Index™ (ΔPI), which compares information inputs to labor output by measuring the rate at which workers perform three cognitive operations that are typical of knowledge work. This method used standard measures of performance and specific variables for four different office environments.

The general theory behind ΔPI states that $\Delta P = f(V_h + V_e)$, i.e., change in productivity (ΔP) can be measured by comparing the performance of a set of cognitive operations (V_h) that are characteristic of typical office work, and the influence of a set of workplace variables (V_e). The three standard cognitive operations are defined as “attention,” “data translation,” and “short-term memory.” The four measures of task performance are “speed,” “accuracy,” “retention,” and “self-reported performance” (attitude).

Researchers built four environments to simulate working conditions in large open-plan offices. These four environments included Resolve with sound masking (AI = <0.2), Resolve without sound masking (AI = >0.6), and 65-inch-high traditional panel systems with (AI = <0.2) and without sound masking (AI = >0.6) in a specialized test facility free from echoes and reverberations. They located speakers at appropriate locations and then broadcast prerecorded, calibrated, male-female conversations similar to those heard in a typical office. Research subjects could take as long as they wanted to complete a series of tasks presented through Web-based interactive software.

The research team recruited knowledge workers from the Boston metropolitan area. They divided 136 participants— 49 percent men, 51 percent women—randomly among the test groups. Other characteristics of participants included:

- Work experience in knowledge industries
- Minimum of eight months experience working in open-plan offices.
- Routine problem solving at work
- Experience using Web browsers

Testing software captured the demographics of the test takers, their speed of performance and task accuracy, as well as their self-reported performance. An analysis of the data found statistically significant improvement in worker productivity on a number of measures for those tested in sound-masked environments. Perhaps most important among these findings was that when Quiet Technology sound masking was present, test subjects reported improved performance independent of the type of furniture environment in which they took the test.

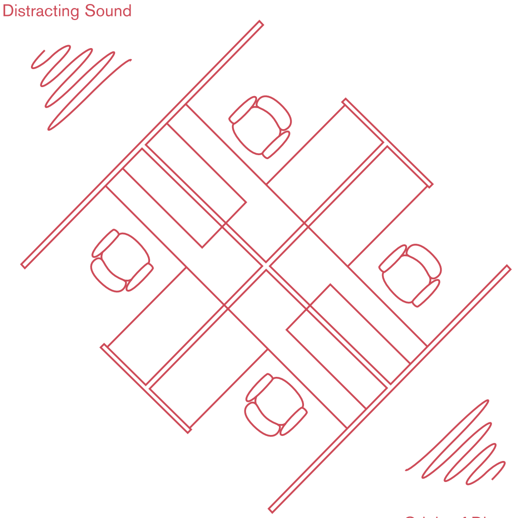
Aggregate numbers for Resolve and 65-inch-high traditional systems furniture with Quiet Technology sound masking compared to these furniture systems without sound masking indicated the following: 43.6 percent improvement in sounds not considered distracting, 34.3 percent increase in ability to focus on tasks, and 16.5 percent improvement in accuracy in performing required tasks.

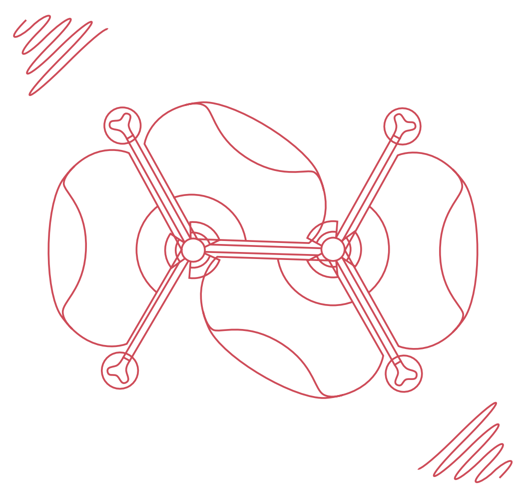
Based on a seven-point scale, with seven being the best possible score, the mean value for all subjects in the Resolve environment with Quiet Technology reporting on the issue of sounds not considered to be distracting was 4.84. Those in the 65-inchhigh traditional systems environment with Quiet Technology had a mean value of 3.97. Thus, subjects reported greater satisfaction in the very open environment of the Resolve system compared to the more enclosed nature of the 65-inch-high traditional system. Without Quiet Technology, Resolve and the 65-inch-high traditional system had negligible differences in mean value scores for the three key measurements.

In addition, test participants adapted to Quiet Technology sound masking immediately. The subjects' improved performance on a half-hour test indicates that people need little or no time to acclimate to this form of acoustic privacy.

Measurement	**Resolve with Quiet Technology compared to Resolve system without sound masking**
Lack of sound distractions	51.4% improvement
Ability to focus on tasks	47.7% improvement
Short-term memory/accuracy	9.6% improvement

The resulting total increase in productivity of 35 percent is calculated by assigning equal weighting to each measure in this equation:
Quiet Technology productivity increase = 51.4%(.33) + 47.7%(.33) + 9.6%(.33) = 35%.





Furniture configuration used in productivity research

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Credits

Elaine Lewis, A.B., Wellesley College; M.P.S., Cornell University; Ph.D., Rennselaer Polytechnic Institute. Dr. Lewis, who codeveloped the ∆Productivity Index™ methodology is a tenured associate professor at Boston University, where she was codirector of the Project for Interdisciplinary Research in Information. Dr. Lewis has directed numerous studies on usability and office system efficiency for large corporations, including United Airlines and Apple Computer. She is currently president of Ergometrica in Cambridge, MA.

Peter H. Lemieux, B.A., Harvard University; Ph.D., Massachusetts Institute of Technology. Dr. Lemieux, president of Cyways, Inc., was a senior lecturer at the Massachusetts Institute of Technology and has taught research methods and statistical methodology at the University of Rochester and the Massachusetts Institute of Technology. Dr. Lemieux codeveloped with Dr. Lewis the Web-enabled software for the ∆Productivity Index methodology used in this project.

David Sykes, A.B., University of California-Berkeley; M.A. and Ph.D., Cornell University. Dr. Sykes was a professor at Boston University, where he and Dr. Lewis codirected the Project for Interdisciplinary Research in Information. He is managing director of The Remington Group, Cambridge, MA, and vice president/strategy of Cambridge Sound Management.

Thomas Horrall, B.S., University of Wisconsin. Mr. Horrall is a physicist and acoustical engineer at Acentech, Inc., (formerly BBN Acoustics) in Cambridge, MA. As codeveloper of the Quiet Technology sound-masking system adapted for use with Resolve furniture, he supervised the preparation of the acoustical test conditions used in this project.

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