YAMAHA'S UNIQUE INFORMATION MASKING SOUND: SUPERIORITY AND TECHNICAL EVIDENCE

Sound Masking System

Sound masking systems reduce unwanted noise distractions and make it more difficult for uninvolved parties to overhear conversations by adding background noise and playing sounds known as "masking sounds." The louder the masking sounds are made, the greater the effectiveness of the masking system will be, but at some point, the masking sounds themselves will also be experienced as a disturbance. A great deal of research has been conducted with the aim of creating masking sounds that offer maximum masking effectiveness without being experienced as a disturbance by the user. Much of this research has focused on identifying a frequency response that offers more effective masking, using a base of background noise that blends in within the target environment, similar to the noise of an air conditioner.

Yamaha Speech Privacy System

More than twenty years ago now, Yamaha turned its attention toward sound masking as an alternative to architectural solutions for creating more comfortable sound environments. As a result of extensive research, it has developed proprietary information masking sounds that offer greater masking effectiveness with more efficiency than conventional masking sounds. Yamaha's information masking sounds are a combination of the following three different types of sounds.
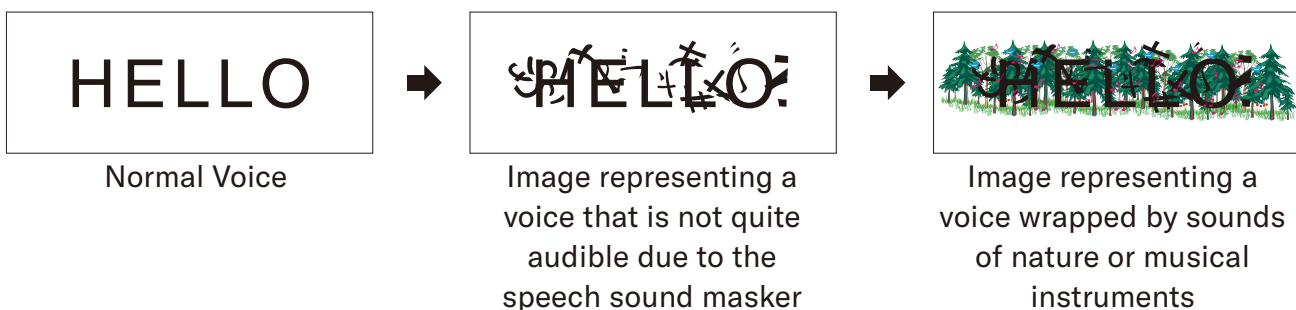
- **Speech sound masker:**
  These are masking sounds synthesized from human speech. They blend in with the actual human speech of a private conversation to make it less intelligible, even when used at lower volumes.

- **Environmental sound:**
  These are environmental sounds, such as ambient forest sounds, the sound of murmuring brook, or the sound of room air conditioner. Based on user preference, these can be combined with speech sound masker sounds to increase masking effectiveness while also contributing to a more comfortable environment.

- **Sound effect:**
  These are sound effects, such as sounds of musical instruments or electronic devices, that add a bit of variation to the environmental sounds. They help draw the attention away from nearby conversations that a user does not want to hear.

| Normal Voice | Image representing a voice that is not quite audible due to the speech sound masker | Image representing a voice wrapped by sounds of nature or musical instruments |

Yamaha's speech privacy system uses these proprietary information masking sounds to achieve greater masking effectiveness at lower volumes than required by conventional sound masking systems. By adding environmental sounds and sound effects, it also creates more comfortable sound spaces.

Yamaha Speech Privacy System   VSP-2

Technical Evidence

The abovementioned features have been technically verified for both English and Japanese speech and presented at academic conferences, as demonstrated by the following in-house and third-party testing data.

1.In-house verification of effectiveness for English speech

Research by Yamaha compared masking effectiveness with conventional noise masking sounds when used with English speech.

| Method	Based on Modified Rhyme Test as specified by ANSI/ASA S3.2-2009. A listener is asked to identify a spoken word played together with masking sounds from a selection of six choices and rate of accuracy is evaluated. An "Inaudible" choice is added to compensate rate of accuracy for words that are not only unintelligible, but also completely inaudible.
Results	・When used with English speech, equivalent masking effectiveness was achieved using volumes reduced by up to 8 dB compared to conventional noise masking sounds. ・Equivalent or greater results in volume differences were also achieved when evaluated using with Japanese speech.
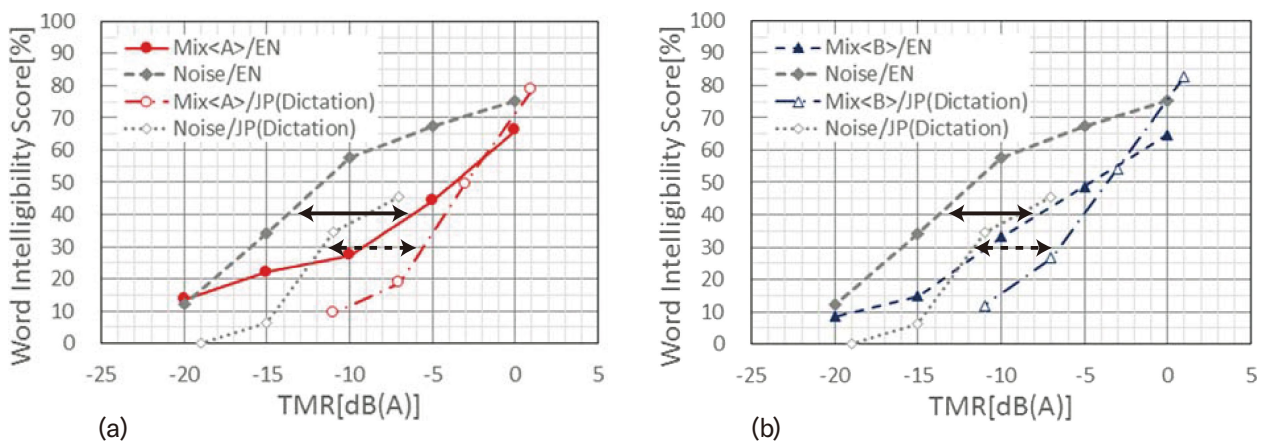
(a)

(b)

Relationship between TMR* and word intelligibility score

*TMR: Target/Masker Ratio is the ratio of speech and masking sound volumes.

Note: In the legend, "Mix" indicates Yamaha masking sounds and "Noise" indicates conventional masking sounds.

(a) Ambient forest sounds used as environmental sound

(b) Air conditioner noise used as environmental sound

Reference: Yamaha(2015) "The masking efficiencies of 'Mix-masker', which is composed of speech-like sound and environmental sound, and 'Noise-masker'" Acoustical Society of Japan Technical Committee of Architectural Acoustics

2.Third-party verification of effectiveness for Japanese speech

In addition to the above testing, research in collaboration with the Tokyo Institute of Technology demonstrated increased masking effectiveness at lower volumes when used with Japanese speech.

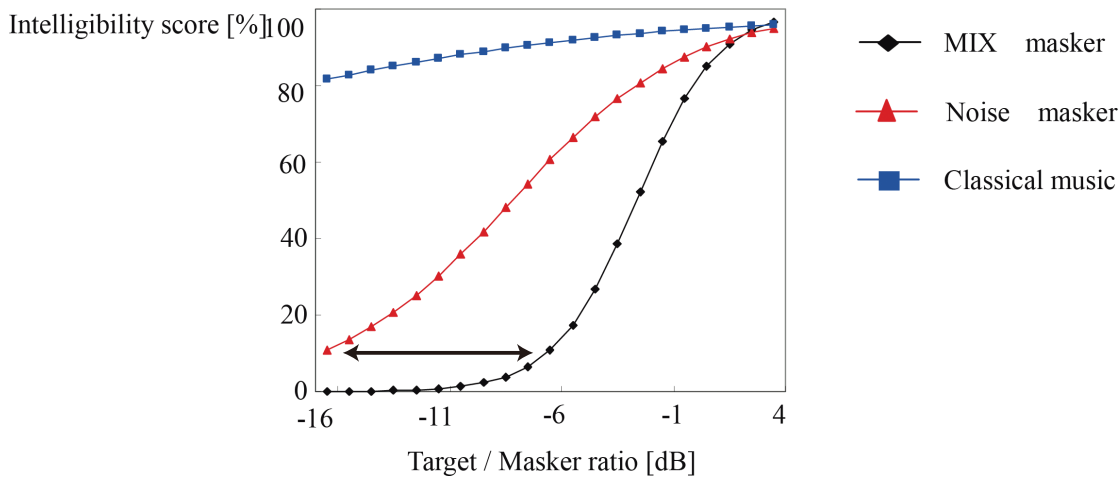### 2-1. Evaluation of word intelligibility score within a pharmacy-type environment

Research compared masking effectiveness with conventional noise masking sounds and classical music when used with Japanese speech.

Method	Listener is asked to write down the contents of human speech played together with masking sounds and rate of accuracy is evaluated.
Results	・Compared to conventional noise masking sounds, volumes reduced by up to 9 dB were demonstrated to produce an intelligibility score of 10% or less, the amount considered necessary to effectively protect privacy when speaking within a pharmacy environment. ・An intelligibility score of 10% or less could not be achieved using classical music.

Relationship between TMR* and word intelligibility score

*TMR: Target/Masker Ratio is the ratio of speech and masking sound volumes.

Note: In the legend, "MIX masker" indicates Yamaha masking sounds and "Noise masker" indicates conventional masking sounds.

Reference: Tokyo Institute of Technology and Yamaha(2011)"Experimental Study of Speech Privacy with a Sound-masking System in Pharmacies"INTER-NOISE 2011

2-2. Evaluation of sense of speech intelligibility and sense of noisiness within an office-type environment

Research compared masking effectiveness with conventional noise masking sounds when used with Japanese speech.

Method Human speech is played together with masking sounds and listener is asked to rate "sense of speech intelligibility." "Sense of noisiness" is also evaluated.

Results ・Compared to conventional noise masking sounds, equivalent sense of speech intelligibility, and thus equivalent masking effectiveness, was achieved using volumes reduced by up to 8 dB.
・Sense of noisiness remained unchanged at equal volumes when compared to conventional noise masking sounds. Yamaha masking sounds were demonstrated to be less disturbing than conventional masking sounds by providing equivalent masking effectiveness at lower volumes.

Relationship between masking sounds and sense of speech intelligibility

Sense of speech intelligibility

(Complete sentence audible) 4 ... (not at all) 1

Masker level (dB)
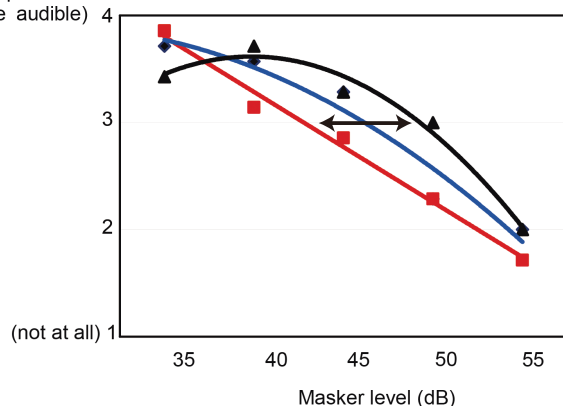
MIX (SLM of low mix level)[1]
MIX (SLM of high mix level) [2]
NOISE[3]

[1] R^2=0.98
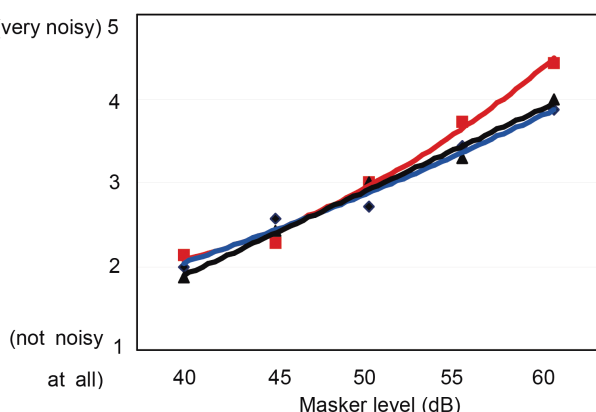[2] R^2=0.95
[3] R^2=0.99

Understanding of conversations (four levels)
1 : Not audible
2 : Audible, but words unintelligible
3 : Words intelligible partially
4 : Completed sentence intelligible

Relationship between masking sounds and sense of noisiness

Sense of noisiness

(very noisy) 5 ... (not noisy at all) 1

Masker level (dB)

MIX (SLM of low mix level) [1]
MIX (SLM of high mix level) [2]
NOISE[3]

[1] R^2=0.99
[2] R^2=0.99
[3] R^2=0.98

Noisiness (five levels)
1 : Not noisy at all
2 : Not very noisy
3 : Somewhat noisy
4 : Noisy

Note: In the legend, "MIX" indicates Yamaha masking sounds and "NOISE" indicates conventional masking sounds.
*SLM: Speech-like masker. Same as "speech sound masker" sounds previously mentioned.
*1SLM of low mix level: Mix using 1:9 ratio of SLM to air conditioner noise
*2SLM of high mix level: Mix using 3:7 ratio of SLM to air conditioner noise

Reference: Tokyo Institute of Technology and Yamaha(2013) "Subjective evaluation of a masking sound environment in a contemporary open plan office"INTER-NOISE 2013