REFERENCES

Brand, T. and Kollmeier, B. (**2002**). "Efficient adaptive procedures for threshold and concurrent slope estimates for psychophysics and speech intelligibility tests" J. Acoust. Soc. Am., **111**, 2801-2810.

Efron, B. and Tibshirani, R. J. (**1993**). *An introduction to the bootstrap*. New York, NY: Chapman and Hall.

Gibson, E. (**1998**). "Linguistic complexity: locality of syntactic dependencies" Cognition, **68**, 1-76.

Kim, S. Kim, M. and Chun, M. M. (**2005**). "Concurrent working memory load can reduce distraction." in *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, **102**, 16524-16529.

Knoeferle, P., Habets, B., Crocker, M. W., and Müntje, T. F. (**2008**). "Visual Scenes Trigger Immediate Syntactic Reanalysis: Evidence from ERPs during Situated Spoken Comprehension" Cerebral Cortex, **18**, 789-795.

Kollmeier, B. and Wesselkamp, M. (**1997**) "Development and evaluation of a German sentence test for objective and subjective speech intelligibility assessment" J. Acoust. Soc. Am. **102**, 2412-2421.

Schriefers, H., Friederici, A. D., and Kühn, K. (**1995**). "The processing of locally ambiguous relative clauses in German" Journal of Memory and Language, **34**, 499-520.

Tanenhaus, M. K., Spivey-Knowiton, M. J., Eberharda, K. M., and Sedivy, J. C. (**1995**). „Integration of Visual and Linguistic Information in Spoken Language Comprehension" Science **268**, 1632–1634.

Tewes, U. (1991). *Hamburg-Wechsler-Intelligenztest für Erwachsene - Revision 1991 (HAWIE-R)*. Bern, Stuttgart, Toronto: Huber.

Uslar, V. N., Ruigendijk, E., Hamann, C., Brand, T., and Kollmeier, B. (**2011**). "How does linguistic complexity influence intelligibility in a German audiometric sentence intelligibility test?" Int. J. Audiol., **50**, 621-631.

Uslar, V. N., Carroll, R., Hanke, M., Hamann, C., Ruigendijk, E., Kollmeier, B., and Brand, T. (***in preparation***). "On the interdependence of linguistic complexity, listening condition and cognitive abilities in speech intelligibility measurements: findings for listeners with normal hearing using new sentence material"

Uslar, V. N, Kollmeier, B., Brand", T. (***in preparation***). "On the interdependence of linguistic complexity, listening condition and cognitive abilities in speech intelligibility measurements: findings for older listeners with and without hearing loss"

Wendt, D., Kollmeier, B., and Brand, T. (***in preparation***). "How does linguistic complexity influence eye movements during the recognition of sentences in an audio-visual task ?"

Wendt, D., Kollmeier, B., and Brand, T. (***in preparation***). "The influence of linguistic complexity and noise on speech comprehension: Evidence from eye movements"

Speech intelligibility in fluctuating maskers

INGA HOLUBE

Institute of Hearing Technology and Audiology, Jade University of Applied Sciences, D-26121 Oldenburg, Germany

Within several experiments, the influence of different maskers on the speech reception threshold (SRT, signal-to-noise ratio for 50% speech intelligibility) was examined using the Oldenburg sentence test (OLSA). The maskers were stationary noises, speech or speech-like signals. The speech and speech-like signals were intelligible or non-intelligible, composed of different languages with natural or destroyed fine structure (ICRA5-like) but similar pause durations and long-term average speech spectra (LTASS). The SRT differences for normal-hearing German listeners, normal-hearing foreign native listeners and hearing-impaired Germans were small with stationary noises, but enlarged with fluctuating maskers. Intelligibility of the masker increased the SRT only slightly, whereas the ICRA5-like maskers resulted in a significant SRT increase. SRT also increased for an older normal-hearing listener group compared to a younger listener group. Composition of same or different speakers to babble noise increased the SRT even beyond its stationary noise value. Different masker levels showed a significant effect on the SRT for fluctuating maskers. Open (free oral response) and closed (response on a touch screen) test settings led to significant differences for the fluctuating masker but not for the stationary maskers. Additionally, measured reaction times for the vocal response and subjective listening effort ratings in some of the experiments were related to speech intelligibility results and independent of masker type.

INTRODUCTION

Speech intelligibility in background noise has been investigated in many studies (see Bronkhorst, 2000, for a review). Several features of the background noise, e.g., long-term average speech spectrum (LTASS), temporal gaps, fine structure, speaker sex, number of speakers, and intelligibility, influence the speech intelligibility results. Previous studies are difficult to compare because of differences in measurement methods, signals presented and subject groups. Therefore, this study used the same speech test in several experiments applying different maskers and subject groups. These experiments were an extension of the studies of Wagener and Brand (2005) and Wagener *et al.* (2006), who found a 14 dB lower speech reception threshold (SRT) for a fluctuating masker relative to a stationary masker for normal-hearing listeners, but less benefit of the temporal gaps for hearing-impaired subjects, and a higher variability in the results for fluctuating maskers. Parts of the data were published in Holube *et al.* (2009), Taesler and Holube (2009) and Holube *et al.* (2011).

Proceedings of ISAAR 2011: Speech perception and auditory disorders. 3rd International Symposium on Auditory and Audiological Research. August 2011, Nyborg, Denmark. Edited by T. Dau, M. L. Jepsen, J. Cristensen-Dalsgaard, and T. Poulsen. ISBN 87-990013-3-0. EAN 9788799001330. The Danavox Jubilee Foundation, 2012.

METHODS

Oldenburg sentence test (OLSA)

The SRT for speech in background maskers was determined with an adaptive procedure resulting in the signal-to-noise ratio (SNR) for a speech intelligibility of 50% using the Oldenburg sentence test (OLSA, Wagener *et al.*, 1999). The sentences had the structure “name verb numeral adjective object”, with 10 possibilities each, and were spoken by a male speaker. The data were collected using the Oldenburg measurement applications (OMA) distributed by HörTech gGmbH. All stimuli were presented diotically using Sennheiser HDA200 headphones. The speech tests were performed in an open test setting, i.e., the subjects repeated the perceived sentences orally and the experimenter confirmed every correct word on a PC screen, except for the experimental condition in which all response alternatives were shown to the subjects on the monitor (closed test setting) and the subjects marked the understood words using a PC mouse. For the normal-hearing subjects, the masker level was always 65 dB SPL except for the experimental condition with different masker levels. For the hearing-impaired subjects, the masker level was increased by half of their hearing loss in dB HL at 500 Hz but was at most 85 dB SPL. All maskers were normalized to their overall RMS level without spectral weighting and keeping all pauses within the signals. Due to the learning effect of the OLSA, two training lists were administered prior to data collection.

Vocal response time and listening effort

Different blocks of five sentences from the OLSA were presented at five different fixed SNRs each: the individual SRT, +3, +6, +9, and +12 dB. The subject’s oral response was recorded. The vocal response time was determined as the duration from the end of a presented sentence until the start of the subject’s repetition. After each block of five sentences, the subjects rated their subjective listening effort for each SNR on a scale using seven categories from “no effort” to “extreme effort” (listening effort scale, proposed by Gabriel and Meis, 2001).

Maskers

The SRT was determined using the following maskers in randomized order within the experiments:

- OLnoise: Stationary noise composed by overlaying the speech material of the Oldenburg sentence test several times, resulting in the same LTASS as the speech material (Wagener *et al.*, 1999). This is the standard masker used in the OLSA.
- ICRA5-250: Fluctuating masker proposed by the International Collegium of Rehabilitative Audiology and described by Dreschler *et al.* (2001). The envelope of this signal was taken from a single speaker but the fine structure is noise-like. Wagener *et al.* (2006) shortened the pause durations within the signal to 250 ms.

- ISTS (International Speech Test Signal): The signal was developed for hearing instrument measurements (Holube *et al.*, 2010) and is included in the new standard IEC 60118-15 (2010). The ISTS includes pause durations of up to 650 ms and was filtered to meet the LTASS of international female speech (Byrne *et al.*, 1994). The signal has the same spectral and temporal characteristics as one single speaker. It is not totally intelligible but in small segments.
- IFnoise (International Female Noise): Stationary noise composed by overlaying the speech material of the ISTS several times, as done for the OLnoise, resulting in the same LTASS as the ISTS.
- IFFM (International Female Fluctuating Masker): To avoid variability in intelligibility due to longer speech pauses, pauses in the ISTS were shortened to 250 ms. To increase the distinction to the ISTS, the order of the speech segments was also varied.
- NFIM (Native Female Informational Masker): The original recordings for the ISTS were filtered to the same LTASS as the ISTS and pause durations were limited to 250 ms. The signal was presented in the listener’s native language or in a language not spoken by the listener (Mandarin for all listeners except for the Chinese listeners, for whom Spanish was used).
- NFFM (Native Female Fluctuating Masker): The production process used for the ISTS was also applied to the NFIM variations, resulting in maskers of one single speaker but with randomized order of short segments.
- OLHA5: To examine the influence of the fine structure, the construction procedure of the ICRA5 was applied to the IFFM.
- 1M: Concatenation of sentences of the Göttingen sentence test spoken by the same male speaker as in the Oldenburg sentence test.
- 1F+1M: The signal 1M was mixed with the German version of NFIM by summing the time signals.
- 2M, 4M, 8M, 120M: The signal 1M was mixed several times (number of times indicated by the leading number) with time-shifted versions of itself.

Subjects

Several subject groups participated in the experiments. The normal-hearing listeners had a hearing loss of at most 20 dB HL in the frequency region of 250 Hz to 6 kHz.

- Four groups of young, normal-hearing listeners with German as their first language (NH1: 15 subjects, mean: 23 years; NH2: 15 subjects, mean: 24 years; NH3: 10 subjects, mean: 28 years; NH4: 20 subjects, mean: 24 years).
- 18 normal-hearing foreign native listeners (FNH) of six nationalities (2 Arabic, 10 Chinese, 2 English, 2 French, 2 Spanish, mean: 27 years) with an average speaking experience in German of 6.4 years. The average hearing loss of this subject group was approximately 4 dB worse than that of NH2.
- 15 elderly normal-hearing listeners (ENH), aged between 50 and 63 years (mean: 55 years). The average hearing loss of this subject group was approximately 9 dB worse than that of NH1.

- 12 hearing-impaired listeners with an average sloping hearing loss from about 20 to 60 dB HL with a mean age of 60 years (SH1).
- 8 hearing-impaired listeners with a flat hearing loss of about 50 dB HL on average and a mean age of 44 years (SH2).

RESULTS

Table 1 gives the SRT values in dB for the different maskers and subject groups. The results are described and compared to exemplary findings in the literature in the following sections. Comparisons of the resulting SRT are based on median values. Interquartile ranges were usually larger for fluctuating than for stationary maskers. Differences between the masker conditions within a subject group were tested for significance using the Wilcoxon test, and differences between the subject groups were tested for significance using the Mann and Whitney U-Test.

	OLnoise open	OLnoise closed	ISTS open	ISTS closed
NH1	-7.9	-8.5	-20.1	-21.3
ENH	-7.1	-7.1	-18.5	-19.7

	IFFM 55 dB	IFFM 65 dB	IFFM 80 dB	OLHA5
NH4	-15.6	-18.5	-19.8	-15.5

	OLnoise	IFn	ICRA5-250	ISTS	IFFM	NFIM first	NFFM first	NFIM unsp.	NFFM unsp.
NH2	-7.8	-8.4	-20.5	-21.2	-21.6	-19.6	-21.8	-22.7	-22.3
FNH	-6.3	-6.4	-15.9	-15.7	-16.4	-15.0	-15.7	-17.4	-17.3
SH1	-5.1	-5.3	-10.6	-12.4	-12.7	-12.5	-14.1	-14.1	-13.5

	OLnoise	1F	1M	1F+1M	2M	4M	8M	120M
NH3	-7.9	-21.6	-19.4	-6.9	-5.8	-3.9	-4.6	-7.1
SH2	-5.2	-11.5	-6.3	-1.8	-1.9	-2.0	-2.3	-4.7

Table 1: Median SRT values, in dB, for the maskers and subject groups.

Open versus closed test procedures

The OLSA was administered to NH1 in an open and a closed test setting for the maskers OLnoise and ISTS. The SRT for the closed test procedure was 0.6 dB lower for the OLnoise and 1.2 dB lower for the ISTS than for the open test setting. Similar results were collected for ENH. The difference for the OLnoise was not statistically significant, consistent with Brand *et al.* (2004). The difference for the ISTS was statistically significant. Holmes *et al.* (1988) also showed a statistically significant difference between open and closed test procedures when determining speech in quiet. All other data were collected with the open test procedure.

Masker level

For subject group NH4 and the IFFM, the SRT decreased significantly by about 4 dB for increasing masker level from 55 to 80 dB SPL. This finding is in contradiction to the results of Wagener and Brand (2005), who did not find a level effect for the stationary masker OLnoise, and to Summers and Molis (2004), who showed increasing SRTs with increasing masker levels for different masker types due to a rollover effect. All other data in this contribution were collected with a masker level of 65 dB SPL.

Masker spectrum

Since most of the fluctuating maskers used in the experiments had the LTASS of female speech and were therefore different from the male speaker of the OLSA, the masking of the respective stationary noises OLnoise and IFnoise was compared. Table 1 shows that there was a small but significant difference of 0.6 dB for NH1 and NH2. This result is contradictory to Festen and Plomp (1990), who showed more masking of female-shaped stationary noise on male speech than male-shaped stationary noise.

ICRA5-250 and ISTS

The SRTs for the fluctuating maskers ICRA5-250, ISTS and IFFM were about 13 dB below the SRT for OLnoise for NH2, which is in agreement with Wagener and Brand (2005), but a smaller difference was reported in other studies (see, e.g., Bronkhorst, 2000). The SRTs for ISTS and IFFM were not significantly different. Therefore, the different pause durations of the two signals (650 and 250 ms, respectively) did not seem to influence the SRT. Also, no statistically significant difference was found between the two maskers and the ICRA5-250, which is in contradiction to the findings of Francart *et al.* (2010), who showed an increased SRT for ISTS with pause durations shortened to 100 ms. Since IFFM and ICRA5-250 have different LTASS, the IFFM was also compared for subject group NH4 to OLHA5, resulting in a significant increase for OLHA5 by 3 dB due to the missing fine structure.

Intelligibility of masker

Group NH2 compared the IFFM to the NFIM and NFFM for German (first language) and for Mandarin (language not spoken by subject). Small but significant differences (approx. 2 dB) were found between the IFFM and the intelligible German masker (NFIM) on one side and the Mandarin maskers (NFIM and NFFM) on the other side. No significant differences were found between the NFIM and the NFFM versions within each language. Therefore, the concatenation procedure does not seem to influence the SRT. The differences between German and Mandarin are consistent with those reported by Van Engen and Bradlow (2007), but are much smaller than the effect of the masker's intelligibility proposed by Rhebergen *et al.* (2005). In contradiction to the expected increase in SRT for the masker using the same male voice as the speech material (1M) compared to the intelligible female masker NFIM (1F) (see, e.g., Bronkhorst, 2000), no significant difference was determined for subject group NH3.

Mixture of speakers

The SRTs for different masker mixtures was determined for subject group NH3. Bronkhorst (2000) suggested that the advantage of the temporal gaps within speech when used as a masker disappears when four or more maskers are temporally overlayed. Here, this disappearance could be observed for a mixture of only two maskers (2M and 1F+1M), for which the SRT was nearly equal to the SRT for OLnoise. The SRTs for more overlays of the same male speaker (4M, 8M, and 120M) were even higher than the SRT of OLnoise.

Foreign native listeners

The group of foreign native listeners showed a small but significant difference of about 1.5 dB to the group NH2 for OLnoise, but larger differences of about 5-6 dB for the other maskers. The SRT for the intelligible masker in the first language of the listeners was significantly higher (2.4 dB) than that of the masker in the unknown language. Both of these findings were inconsistent with the findings of Garcia Lecumberri and Cooke (2006), who found larger differences in stationary than in single talker maskers and no influence of the language of the masker for foreign native listeners.

Hearing impairment

Two hearing-impaired subject groups (SH1 and SH2) showed significant differences of 2.7 dB to the young, normal-hearing groups for OLnoise, and differences of up to 13 dB (1M) for the other maskers, resulting in the expected disappearance of the temporal gap advantage for some of the subjects (Festen and Plomp, 1990; Wagener and Brand, 2005). The SRT of the intelligible masker in the first language of the listener was again significantly higher (1.6 dB) than that of the masker in the language not spoken by the listener. For this subject group, the SRT for ICRA5-250 was increased relative to the ISTS/IFFM by 2 dB. The hearing-impaired listeners also showed a significant difference between 1M and 1F and therefore were much more disturbed by the male masker than by the female masker.

Listener's age

Both hearing-impaired subject groups had higher average ages than the normal-hearing listener groups NH1-4. Therefore, some of the data were also collected for an older group of normal-hearing listeners (ENH). They showed a significant increase in the SRT for OLnoise by 0.8 dB and a nearly significant increase in the SRT for ISTS by 1.6 dB, as expected from other studies, e.g., Dubno *et al.* (2002).

Vocal response time and listening effort

Both the vocal response time and the listening effort decreased with increasing intelligibility, independent of the masker type (stationary maskers OLnoise and IFnoise and fluctuating maskers as used for the subject groups NH2, FNH and SH1 described above). The response time tended to be lower for NH2, and FNH tended to rate the listening effort lower than did NH2 and SH1 for the same intelligibility.

ACKNOWLEDGEMENT

This contribution is based on the diploma thesis of Stefan Taesler and three student projects. Ideas, data collection and analysis by Sabine Blab, Timo Böld, Katrin Fürsen, Timo Gerdes, Silke Gürtler, Christina Imbery, Britta Jensen, Achim Klein, Christoph Kowalski, Florian Kramer, Katrin Meisenbacher, Jana Müller, David Nguyen, Katharina Schmidt, Constanze Schmuck, and Lisa Wilholt are gratefully acknowledged. This work was supported by the European Regional Development Fund (ERDF).

REFERENCES

Brand, T., Wittkop, T., Wagener, K., and Kollmeier, B. (**2004**). "Vergleich von Oldenburger Satztest und Freiburger Wörtertest als geschlossene Versionen" Annual Meeting of the German Audiological Society.

Bronkhorst, A. W. (**2000**). "The Cocktail Party Phenomenon: A Review of Research on Speech Intelligibility in Multiple-Talker Conditions" Acustica – acta acustica, **86**, 117-128.

Byrne, D., Dillon, H., Tran, K., Arlinger, S., Wilbraham, K., Cox, R., Hagerman, B., Hetu, R., Kei, J., Lui, C., Kiessling, J., Nasser Kotby, M., Nasser, N. H. A., El Kholy, W. A. H., Nakanishi, Y., Oyer, H., Powell, R., Stephens, D., Meredith, R., Sirimanna, T., Tavartkiladze, G., Folenkov, G. I., Westerman, S., and Ludvigsen, C. (**1994**). "An international comparison of long-term average speech spectra" J. Acoust. Soc. Am., **96(4)**, 2108-2120.

Dreschler, W. A., Verschuure, H., Ludvigsen, C., and Westermann, S. (**2001**). "ICRA noises: artificial noise signals with speech-like spectral and temporal properties for hearing instrument assessment" Audiology, **40**, 148-157.

Dubno, J. R., Horwitz, A. R., and Ahlstrom, J. B. (**2002**). "Benefit of modulated maskers for speech recognition by younger and older adults with normal hearing" J. Acoust. Soc. Am., **111(6),** 2897-2907.

Festen, J. M., and Plomp, R. (**1990**). "Effects of fluctuating noise and interfering speech on the speech-reception threshold for impaired and normal hearing" J. Acoust. Soc. Am., **88(4)**, 1725-1736.

Francart, T., van Wieringen, A., and Wouters, J. (**2011**). "Comparison of fluctuating maskers for speech recognition tests" Int. J. Audiol., **50(1),** 2-13.

Gabriel, B., and Meis, M. (**2001**). "Optimierung eines Messverfahrens für die Höranstrengung" Z. Audiol. Suppl. IV, 100-103.

Garcia Lecumberri, M. L., and Cooke, M. (**2006**). "Effect of masker type on native and non-native consonant perception in noise" J. Acoust. Soc. Am., **119(4)**, 2445-2454.

Holmes, A. E., Kricos, P. B., and Kessler, R. A. (**1988**). "A closed- versus open-set measure of speech discrimination in normally hearing young and elderly adults" Br. J. Audiol., **22(1)**, 29-33.

Holube, I., Blab, S., Fürsen, K., Gürtler, S., Meisenbacher, K., Nguyen, D., and Taesler, S. (**2009**). "Einfluss des Maskierers und der Testmethode auf die Sprachverständlichkeitsschwelle von jüngeren und älteren Normalhörenden" Zeitschrift für Audiologie, **48**, 120-127.

Holube, I., Fredelake, S., Vlaming, M., and Kollmeier, B. (**2010**). "Development and analysis of an International Speech Test Signal (ISTS)" Int. Journal of Audiology, **49**, 891-903.

Holube, I., Böld, T., Gerdes, T., Jensen, B., Müller, J., and Schmuck, C. (**2011**). "Internationales Sprachtestsignal (ISTS) als fluktuierender Maskierer im Satztest" Annual Meeting of the German Audiological Society.

IEC 60118-15 (**2010**). "Electroacoustics – Hearing aids – Part 15: Signal processing in hearing aids" International Electrotechnical Commission.

Rhebergen, K. S., Versfeld, N. J., and Dreschler, W. A. (**2005**). "Release from informational masking by time reversal of native and non-native interfering speech" J. Acoust. Soc. Am., **118(3)**, 1274-1277.

Summers, V., and Molis, M. R. (**2004**) "Speech Recognition in Fluctuating and Continuous Maskers: Effects of Hearing Loss and Presentation Level" Journal of Speech, Language, and Hearing Research, **47**, 245-256.

Taesler, S., and Holube, I. (**2009**). "Einfluss verschiedener Störer auf die Sprachverständlichkeit und die Höranstrengung" Annual Meeting of the German Audiological Society.

Van Engen, K. J., and Bradlow, A. R. (**2007**). "Sentence recognition in native- and foreign-language multi-talker background noise" J. Acoust. Soc. Am., **121(1)**, 519-526.

Wagener, K. C., and Brand, T. (**2005**). "Sentence intelligibility in noise for listeners with normal hearing and hearing impairment: Influence of measurement procedure and masking parameters" International Journal of Audiology, **44**, 144-156.

Wagener, K. C., Brand, T., and Kollmeier, B. (**1999**). "Entwicklung und Evaluation eines Satztests für die deutsche Sprache I: Design des Oldenburger Satztests" Zeitschrift für Audiologie, **38(1)**, 4-15.

Wagener, K. C., Brand, T., and Kollmeier, B. (**2006**). "The role of silent intervals for sentence intelligibility in fluctuating noise in hearing impaired listeners" Int. Journal of Audiol., **45**, 26-33.

Speech intelligibility with binaurally linked hearing aids

IRIS ARWEILER[1], JÖRG M.BUCHHOLZ[2] AND TORSTEN DAU[1]

[1] *Centre for Applied Hearing Research, Technical University of Denmark, DK-2800 Lyngby, Denmark*

[2]*Department of Linguistics, Faculty of Human Sciences, Macquarie University, NSW-2190, Australia and National Acoustic Laboratories, NSW-2067 Chatswood, Australia*

Conventional compression algorithms in bilateral hearing-aid fittings distort the interaural level differences (ILD's) due to independent gain characteristics at the two ears. By transmitting signals between hearing aids, the compression can be coordinated and the same gain can be applied to both ears, thus preserving the ILD's. The present study investigated the influence of such "binaurally linked" hearing aids on speech intelligibility. Hearing-impaired listeners with a symmetric hearing loss were fitted with hearing aids connected to a hearing aid research platform (HARP). Speech reception thresholds (SRT's) were measured in a loudspeaker setup with the target speech and the masker spatially separated. Slightly, but not significantly better SRT's were achieved when the hearing aids were binaurally linked and combined with slow compression than when unlinked fast compression was used. The difference between monaural and binaural speech intelligibility was independent of the hearing aid algorithm. Thus, the preservation of the exact ILD information does not seem to be critical for binaural processing and speech intelligibility in the considered conditions.

INTRODUCTION

Wireless technology has become an integral part of modern hearing aids. In a bilateral fitting it has become possible to link the hearing aids on the left and right ear wirelessly and to exchange information between them. The transmission of either data parameters or the raw audio data is possible. Transferring low bit-rate data parameters is used to synchronize settings in the two hearing aids, e.g. volume, program or microphone mode settings.

The transmission of the raw signal data is realized with near-field magnetic induction (NFMI) and has proven useful to restore binaural sound cues (Behrens, 2008). In particular, interaural level differences (ILD's), which would be altered by the compression algorithms of two independent hearing aids (Moore *et al.*, 1992), can be preserved by applying linked amplification. While spatial cues are obviously useful for the localization of sound they can also provide an advantage for speech intelligibility. When a masker signal is spatially separated from a speech signal, the

Proceedings of ISAAR 2011: Speech perception and auditory disorders. 3rd International Symposium on Auditory and Audiological Research. August 2011, Nyborg, Denmark. Edited by T. Dau, M. L. Jepsen, J. Cristensen-Dalsgaard, and T. Poulsen. ISBN 87-990013-3-0. EAN 9788799001330. The Danavox Jubilee Foundation, 2012.