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Hurtigtale – A Danish version of QuickSIN

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Abstract[1+2]

Objective: This presentation describes the development of Hurtigtale, a Danish version of the speech test QuickSIN. **Design:** The Danish material consists of five-word sentences in a newly constructed four-person babble noise. A test list was used, consisting of seven five-word sentences in a decreasing signal-to-noise ratio (SNR). The number of correctly repeated words was subtracted from a constant in order to obtain a measure for SNR-50, and thus an estimate for speech-related hearing loss. As the Danish language differs from English, an estimate of the constant was derived in two tests, HearVal and Hurtigtale with normal hearing participants. Furthermore, the study had a parallel experiment including participants with hearing loss where Hurtigtale were evaluated through this experiment. **Study sample:** Twenty-four normal-hearing participants and thirty-four participants with hearing loss. **Results:** In the present study four lists were used, of which the average SNR-50 was registered, based on the estimated constant found in the present study. The measurement was carried out on participants with normal hearing, and the recorded results compared with results from HearVal (a Dantale II matrix test). From the results and the execution of the test, an idea could also be derived of the test's robustness and general usability. Additional experiences were recorded from tests performed on clients in a clinical environment (Ref. parallel experiment). **Conclusion:** This project provides and refines the 'Danish constant' for obtaining the SNR loss, as well as information on whether Hurtigtale has the potential to represent a speech-in-noise test that is as clinically implementable as its American cousin QuickSIN.

Keywords: QuickSIN; SNR Loss; words lists; speech intelligibly in noise; Dantale II

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Introduction[1+2]

One of the most common problems with hearing aid users is the difficulty of hearing speech when there is background noise. In real-life situations we are constantly surrounded by various kinds of background noise, such as conversations, electric sounds, and traffic sounds. Therefore, it is important to deal with this issue as it impacts the individual who has a hearing impairment. Moreover, this issue might be the reason hearing aids mostly are not deemed as positive or satisfactory (Killion et al., 2004). Even though it is known that monosyllabic word lists are an insufficiently reliable tool for selecting and fitting hearing aids, many audiological clinics still choose to rely on them when making important amplification conclusions (Taylor, 2003). However, a sentence-type speech-in-noise test like QuickSIN, which is reviewed below, is very quick to administer and leads to a better hearing aid selection choice (Taylor, 2003).

Although two people may have matching audiograms and word recognition scores, they might not score similarly when it comes to hearing speech in noise. Therefore, it is very important to measure signal-to-noise ratio (SNR) loss, as the understanding of speech in noise is not perfectly or reliably measured simply by testing the pure tone audiogram (Killion & Niquette, 2000). Currently discrimination loss (DS) and speech recognition threshold (SRT) are the most widely recognized speech tests in the Danish clinical environment (Retsinformationen, 2009).

SNR loss is defined as the dB increase in SNR required by a hearing-impaired person to understand speech in noise, compared to a person with normal hearing. The value of SNR loss is derived from the SNR-50, which means that the individual can listen to and repeat a sentence 50% correctly (Etymotic Research, 2001). An example of a SNR test is Quick Speech in Noise, also called QuickSIN, which is, as the name suggests, a quicker version of the first and original Speech-In-Noise (SIN) test that was invented by Etymotic Research. QuickSIN was developed to overcome the limitations of the original SIN test: its length, its inadequate number of lists, and the inability of some patients to achieve 50% correct sentence identification (Duncan & Aarts, 2006). QuickSIN is used in English-speaking countries and has been developed, among other things, to enable an audiologist to quickly measure the hearing ability of a patient in noise (Taylor, 2003; McArdle & Wilson, 2006). It consists of a series of IEEE sentences (Institute of Electrical and Electronics Engineers [IEEE], 1969) presented in a four-talker babble noise. It includes six sentences with five words in each sentence, giving the patient the opportunity to score five points in each sentence (McArdle &

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Wilson, 2006; Etymotic Research, 2001). Etymotic Research has pre-recorded the SNR and set it to decrease in 5 dB steps, starting at 25 dB and ending at 0 dB.

The QuickSIN test uses sentences spoken with natural dynamics instead of monosyllabic words, as this is a more reliable and effective representation of speech in the real world. The sentences include words that typically do not have anything in common with the surrounding context, which results in a similarity with NU-6 monosyllables (Rabinowitz et al., 1992; Etymotic Research, 2001). Additionally, this test is a variable SNR test, which means that either the level of the speech or the level of the noise is varied. In the present study it was decided to only use sound field presentation. When comparing pre- and post-hearing aid fitting, it introduces unwanted calibration complications to switch the mode of presentation between headphones and sound field. The latter was chosen because the use of hearing aids calls for a sound field presentation.

Several clinicians from different countries have had good experiences using this test, and therefore a Danish implementation is a natural step (McArdle & Wilson, 2006; Strom, 2003; Taylor, 2003). According to Taylor (2003), it is an ideal test to use clinically as the noise level varies automatically while the sentences remain fixed. Additionally, this test is designed to give audiologists a very quick method to determine a patient's ability to understand speech in noise as an SNR instead of a percent-correct score (Duncan & Aarts, 2006). There have been several examples of tests that were easy to administrate but unfortunately did not become generally available in the audiological clinics in Denmark. However, many studies recommend the speech-in-noise test as a component of the standard audiologic test battery (Killion et al., 2004). Therefore, the purpose of the present study is to introduce Hurtigtale. Moreover, more realistic results can be obtained if the speech test material is constructed with a background noise that better represents the patient's difficulties of hearing in noise in line with reality. Furthermore, the first goal for the present study is finding the Danish constant and the second goal is to evaluate Hurtigtale as a possible clinical tool, including measurement of its reliability and validity.

According to a study by Killion et al. (2004), the choice of speech and background noise materials when developing a speech-in-noise test is a compromise between realism and reproducibility. When designing Hurtigtale this present study uses words from Dantale II as this is already an accepted and well documented material. Furthermore, the sentences in Dantale II contain five words per sentence, which fits well with the structure of the QuickSIN test from Etymotic Research.

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Method & Material

Participants[1]

The study used a cross-sectional design, where each participant only had to be present once to be tested. Each session took approximately 15 minutes per participant. The participants consisted of 24 listeners, who ranged in age between 14 and 40, with a mean age of 23.5. None of the participants reported any history of otologic concerns or problems. Before the test, an otoscopy examination and air-conduction threshold was taken for each participant for verification purposes. For each patient, otoscopic examination revealed a clear ear and an intact tympanic membrane. Inclusion criteria for this study included the following: 1) Normal hearing threshold (ISO7029) within 20 dB HL from 250 Hz to 8000 Hz in both ears; 2) The participant could understand and speak Danish fluently or as a native language. An additional experiment was performed, which we decided to name; the parallel experiment. This parallel experiment was performed with a new group of thirty-four hearing impaired listeners.

The HearVal test[1]

For the HearVal test, the Dantale II material was run in the HearVal program that was developed by FORCE Technology. The Dantale II material consists of 16 lists of sentences, with each sentence containing five words. All sentences from the Dantale II material are constructed with the same grammatical structure, where each word belongs to its own word class. The first word is a name, the second a verb, the third a number, the fourth an adjective, and the fifth a noun (Hansen & Ludvigsen, 2001; Wagener et al., 2003). The test is performed by varying the strength of speech and noise adaptively, so that a certain percentage of the words in the sentences are perceived correctly (Hansen & Ludvigsen, 2001). The content of the sentences is not meaningful, even though they are syntactically correct; this is so that the individual cannot predict the words. In addition to the Dantale II material, there was a specific noise signal that was developed for the test. The noise signal is constructed from the test sentences at repeated overlays, and therefore it has the same frequency content as the sentences (Wagener et al., 2003).

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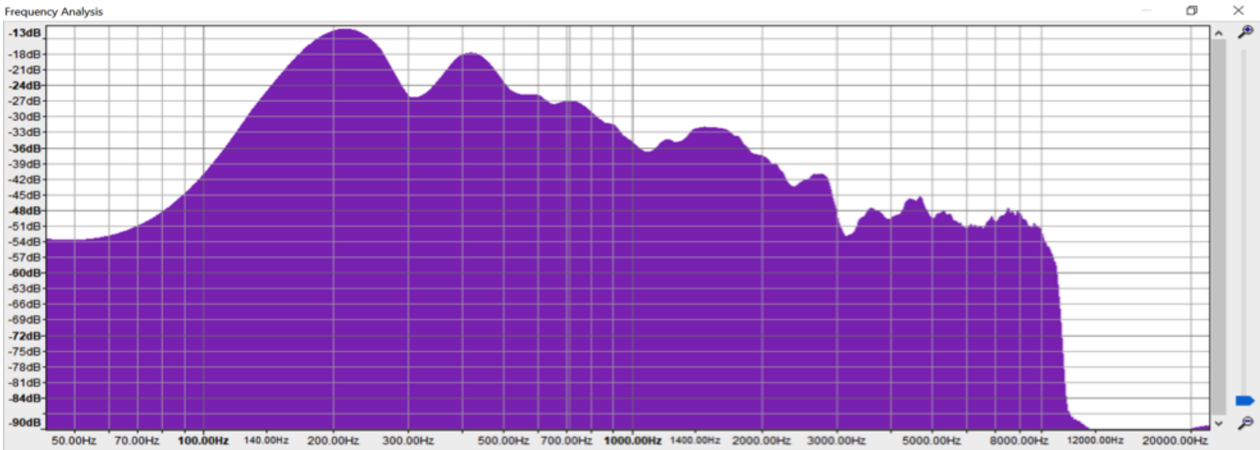
Hurtigtale[2]

Hurtigtale is a Danish version of the American Speech Test QuickSIN, which is based on scoring a number of five-word sentences. The sentences are presented in a babble noise (modulated speech noise) that decreases by 5 dB in SNR for each sentence, thus increasing the speech intelligibility of each sentence. The material used in Hurtigtale was made on the basis of Dantale II, similarly to the HearVal test. Instead of the slightly modulated speech noise associated with the material, a clearly modulated four-talker babble mix was made of four tracks of running speech: the Dantale I track with the Samsø story (Keidser, 1993). This signal was subjectively assessed to resemble the U.S. equivalent noise signal.



For speech processing, 16 lists were used, each list containing seven sentences with five words per sentence, to yield a total of 35 words per trial. The test sentences were made in Audacity, the speech in the right track recorded at -15 dB relative to full digital equipment without clipping (hereafter referred to as dB (U)), and the noise in the left channel varying from approximately -40 dB (U) to approximately -10 dB (U). In making Hurtigtale, there was a fixed SNR where it was varied by 8 dB in calibration. The initial audio files were made so that the seven sentences were at a constant level, while the noise gradually increased from an SNR of 26 dB (U), making speech comprehension more difficult. After assessing the first lists during the setup for the test, it was decided to further change the signal-to-noise ratio by changing the calibration of the two speakers so that the SNR decreases from +18 to -11, making the SNR considerably worse than that described in the QuickSIN manual from Etymotic Research. This change was made as we wanted the participants to reach a point in the trials where they were not able to repeat many words in the last sentences. The final (or worst) SNR of the sentences was 7 dB lower compared to the QuickSIN manual.

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For the setup in the parallel experiment, to make the calibration simpler, the loudspeakers were calibrated to the same level, so that the only SNR variation was in the files made in Audacity.

Procedure[2]

For the present study, the participants were instructed which loudspeaker to face, and when to repeat the sentences spoken by the target talker. In this study we first tested the participants with the HearVal test, and then with Hurtigtale. The participants were not presented with a 'training round' because we wanted to make this project as realistic as possible, and in the clinics the patients do not have the opportunity for a training round.

The HearVal test has a procedure for determining the SNR, named the estimated SRT. The estimated SRT is determined from the Method of Maximum Likelihood (MML) procedure. For the HearVal test, the participants were instructed to face the speaker 'Højtaler 2' (see Table 1). After finding the estimated SRT with the HearVal test, we then tested the participants with Hurtigtale. For Hurtigtale, participants were asked to turn and face the speaker 'Højtaler 1' (see Table 1). The presentation level for the signal was set, according to Dantale II directions, at 65 dB SPL (Hansen & Ludvigsen, 2001). The participants were told that they would be tested with four lists, each consisting of seven sentences. Each participant was required to correctly repeat the five key words in each sentence. The total number of words repeated correctly in each trial was totaled and averaged.

The parallel experiment was conducted at a different site with different equipment but a similar setup. Furthermore the test procedure was slightly different compared to the present experiment, as the discrimination loss was tested. Moreover the parallel experiment only tested Hurtigtale with one trial instead of four. The test was conducted without the participants' hearing aids.

The Setup[1]

The project's setup took place at FORCE's smallest meeting room on Edisonsvej in Odense. Due to the small size of the room, it was possible to ensure that the room had optimal acoustic circumstances. To avoid sound being reflected from the walls, there were added absorbers at strategic places on the walls.

The location for the speakers for the present study was slightly different from the location recommended in the QuickSIN manual. The change in the location of the loudspeaker was made because we wanted to make a realistic setup, similar to conditions in the clinics.

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The stimuli for both Hurtigtale and the HearVal test were delivered from a two-channel system (in a sound field) and presented through a loudspeaker located at 0° azimuth, whilst the background noise was presented 180° behind the participant. The output levels of the speech stimuli and background noise were calibrated at the position to be occupied. A white noise calibration track of -15 dB (U) was calibrated so that, when it was running, the level of the target talker was about 65 dB SPL.

It was also highlighted exactly where the mid-point between the two loudspeakers was, and it was emphasized that it was important for the participant to keep their head fairly precisely around this point, so as not to change the SNR too much. Table 1 shows a sketch of the layout. In accordance with TAL's free field guidance and the ISO 8253-3 standard, the conditions for a free field +/-10 cm from the reference point were implemented and checked (DELTA, 1999)

The reverberation in the room was measured at approximately 0.2 sec in the 63-8 kHz frequency range, measured with the AudioTools app.

In the parallel experiment, the room was bigger than that used in the present study, which may have had an impact on the results.

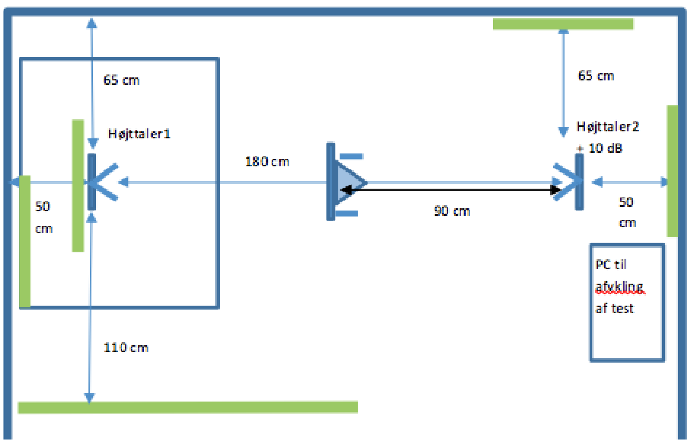

Table 1: Illustration of the setup for both experiments

Results[2]

The primary purpose of this study was to establish a Danish constant for Hurtigtale, so that this test could be introduced in clinics in Denmark as a tool for hearing loss assessment and verification of hearing aid outcome. The data from this study is presented in Figures 1.1 and 1.2, for the HearVal test and for Hurtigtale respectively. For the parallel experiment, the data is presented in Figures 2.1,

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2.2, and 2.3. Descriptive statistics were conducted on the scores in order to answer the present study's goals. Analyses were carried out using Microsoft Excel.

Figure 1.1 shows an illustration of all the participant data that was collected from the HearVal test in this study. The presentation level of each sentence presented to the participant through the speaker 'Højtaler 2' was determined based on how many words the participants repeated correctly in that sentence. The estimated SRT was determined from the MML procedure, where an estimate is made for the most likely S-curve for each time the participant has given a correct response (Pedersen, 2007). It can be seen that each participant had a negative SNR, which means that the background noise was higher than the speech signal of the target talker. These results were expected, as all the participants had a normal hearing within 20 dB HL.

The last column in Figure 1.1 shows that the mean score for all the participants' measured SRT was -15 dB. The mean result illustrates the average SNR across all the participants. This number is needed for the formula that will result in the constant for Hurtigtale. In Figure 1.1, the minimum and maximum SNR values are -20 and -11: this means that normal hearing scores vary by 9 dB across the tests, corresponding to a standard deviation (SD) of 2.57. Additionally, the deviation in this test plays an important role for the Danish evaluation of the clinical use of Hurtigtale, including its reliability.

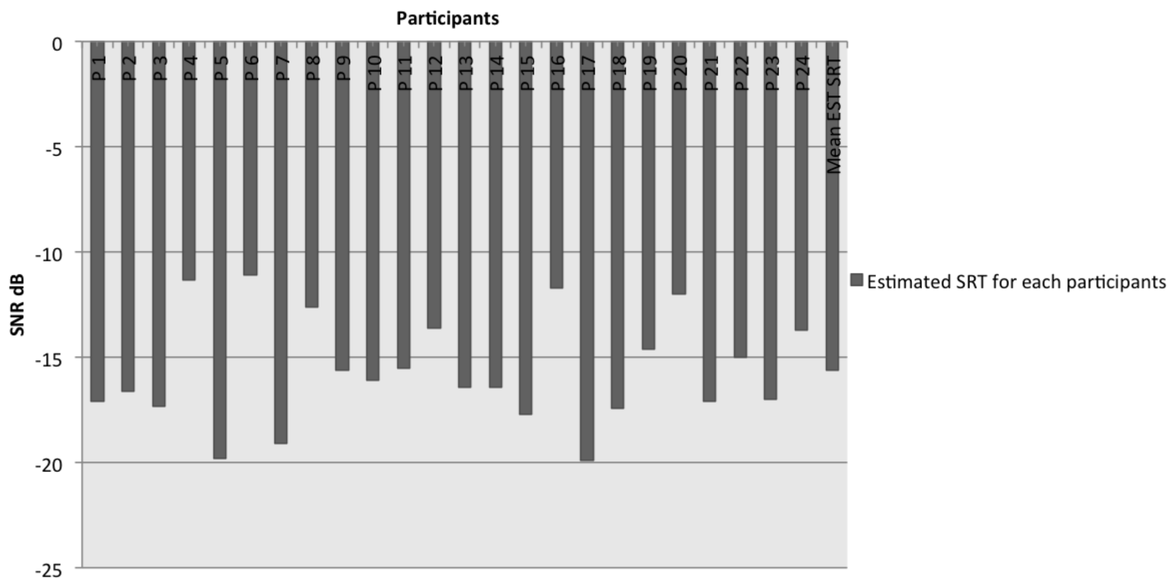

Figure 1.1: Illustration of data collected from the HearVal test

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From the results of the execution of the speech material for Hurtigtale, it can be observed that it is especially for the last two sentences that the SNR drops down to -7 or -11dB. The majority of the participants have difficulty repeating the last sentences in all four lists. We can thus say that there is a significant difference in the last two sentences compared to the first five sentences in the lists. The mean count of words for the participants was calculated to be 33.4. According to this, a normal listener should therefore hear 33.4 words on average, or something between 33 and 34 words. Again, Figure 1.2 shows that the total mean count of words is very close to 35, which is the highest score for each list. Regarding the further processing for finding the constant for Hurtigtale, this is a valid number and can represent people with normal hearing, which is close to 35. As the mean count of words is 33.4, this means that not every participant could repeat all the words from the sentence. We can safely conclude that this test was not too easy for listeners with normal hearing, and therefore this test could serve as a reference for patients with hearing loss.

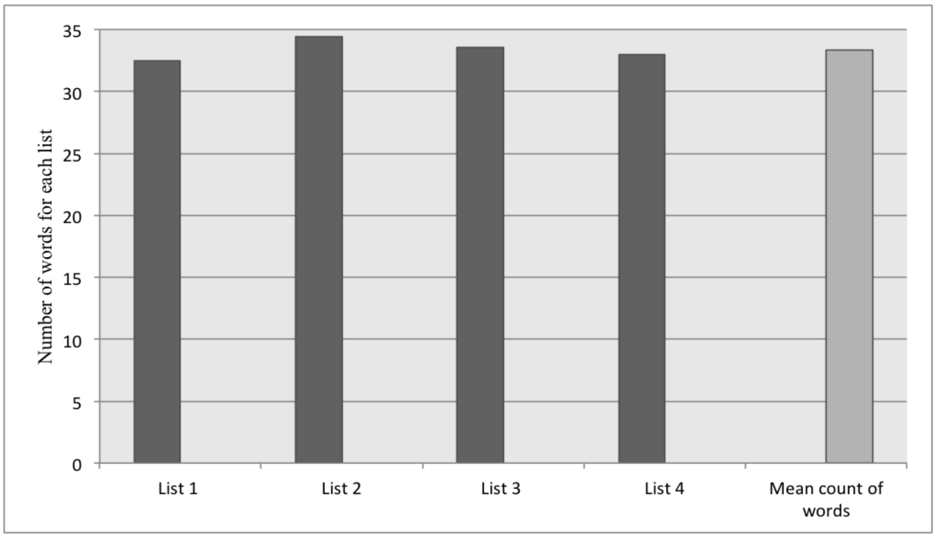

Figure 1.2: Illustration of data collected from Hurtigtale.

The result from the HearVal test shows that the average SNR-50 of people with normal hearing is -15, which was used for the calculation of the Danish constant. The mean count of words from Hurtigtale was also used to compare with the Danish constant. The calculation of the Danish constant was devised according to the Etymotic Research manual recommendations. According to the QuickSIN manual, the constant appears when taking the highest SNR and adding it to half the step size. For the Danish material, the highest SNR is 18 dB, and the step size is 5 dB, so the calculation is as follows: 18 dB + 2.5 dB = 20.5 dB. However, figure 1.1 must be corrected for the SNR-50 for

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normal hearing for the current speech material. Therefore, the Danish constant in theory must be 35.5 dB.

For the second goal, we were interested to see how the participants were distributed by looking at the standard deviation (SD). The SD for the participants in Hurtigtale is measured to be 0.80. This means that on average the participants deviate 0.80 from the mean. To believe that the development of Hurtigtale is stable and reliable, the SD must be as low as possible. Regarding the intrapersonal differences, participant 14 had an SD of 2.9, whereas participants 18 and 20 had an SD of 0. A practice trial was not conducted with the participants, which may explain why some of the participants were unsure of the instructions for the test in the beginning. While for participants 18 and 20, SD=0, this may mean that they did not need a thorough explanation about the test or a practice trial. This is also to be expected, as people are individuals who undertake tasks differently. Comparing the standard deviation from Hurtigtale test with the HearVal test, it can be said that the HearVal (SD=2.57) test had a higher deviation than Hurtigtale (SD=0.80).

According to the parallel experiment there is a positive correlation between the discrimination score (DS) and the number of correct words from Hurtigtale. It can be seen that the participants with the highest DS also reach the highest score in Hurtigtale. The major result from the present study is that the mean count of words is 33.4; this is close to the Danish constant, which is 35.5 dB. In the parallel experiment, the participants only managed to score 19 words on average. Even the four participants who were classified with normal hearing or with only mild hearing loss still scored as low as 28.75 words on average. This was expected, as the mean score should decrease the lower the DS the participants have.

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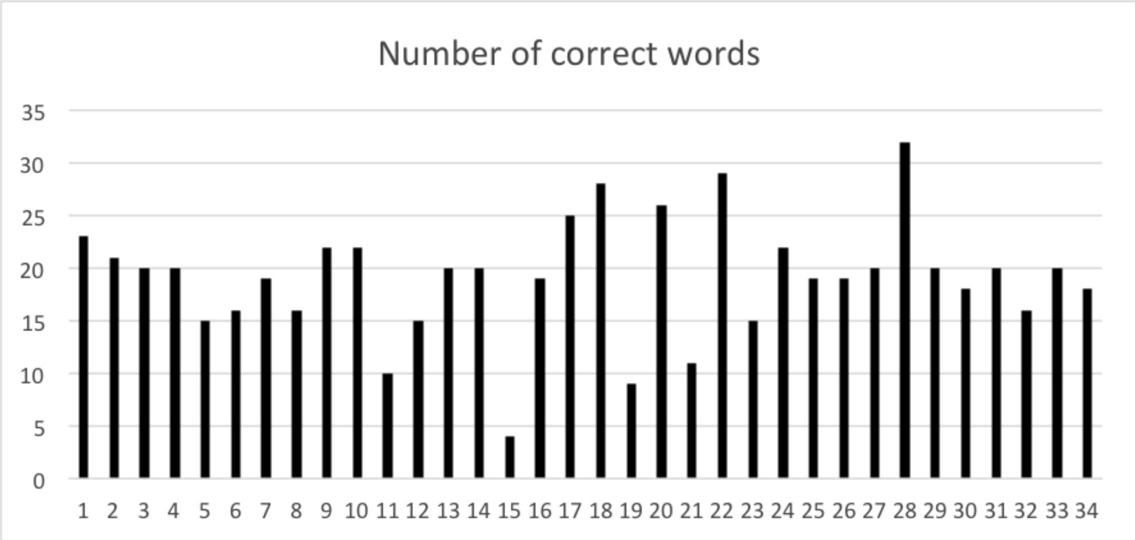

Figure 2.1: Number of correct words (one trial) between the participants from the parallel experiment.

The correlation between the DS scores and total correct words scored using Hurtigtale is shown in Figures 2.2 and 2.3. As seen in both figures, there is a positive correlation between both test scores. This again confirms the reliability of Hurtigtale.

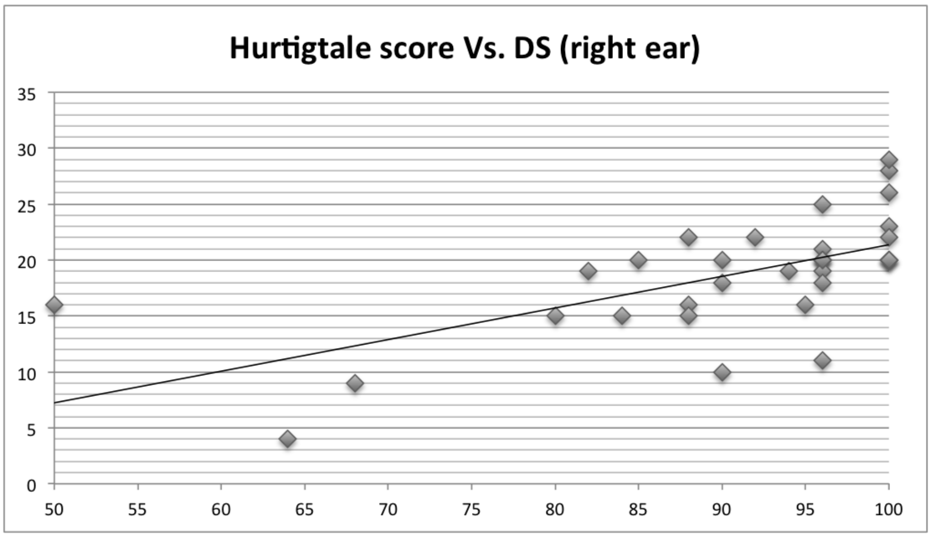

Figure 2.2: Correlation between Hurtigtale score and DS for the right ear

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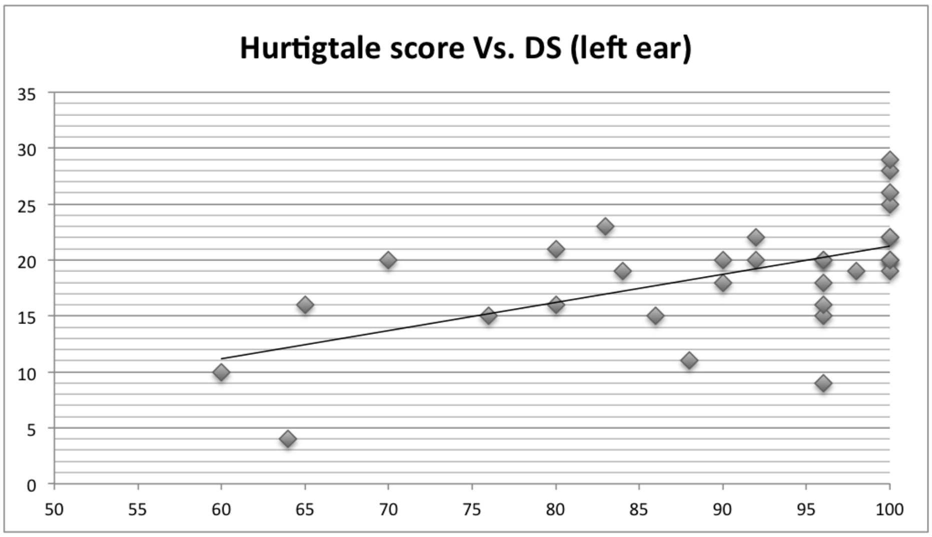

Figure 2.3: Correlation between Hurtigtale score and DS for the left ear

Discussion[1]

Despite the general reliability of speech-in-noise tests, there are still some parameters such as stress, concentration problems and other individual psychological factors that play a role and thus influence the test results (Arbejdsmiljøinstituttet, 2006). Therefore, it is important to keep in mind that we are dealing with human participants who are individuals and each of whom will therefore act differently in the test. Other parameters or sources of error may be how the authors conducted their interpretation of the empirical data. Regarding the SD, it can be seen that Hurtigtale has a lower SD than the HearVal test. Therefore, it can be said that Hurtigtale is quite reliable in its results when testing listeners with normal hearing. Although it is a test that is quick to administer, it still represents a stable and reliable measure. When comparing these two tests, Hurtigtale should be the instrument of choice. Having said this, it is relevant to point out that in this study, HearVal in a way operated as a training round for the participants, which could therefore explain the higher SD. The sensitivity of the tests was only investigated in the comparison between the thresholds for those with normal hearing and the hard of hearing. Here it can be seen that there is a good separation in the mean word count between the two groups. A more sensitive test is however required to investigate the difference between participants with and without hearing aids, or even the same participants using different brands of hearing aids. Sensitivity to that level has not been investigated in the present study.

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The study's first goal was answered by examining the descriptive statistics and reliability information, and the Danish constant was calculated from instructions in the QuickSIN manual. There are a number of parameters in the present study whose impact on the results should be considered. The result of this study has major implications for the development of Hurtigtale. The study was based on the Dantale II material, as this material is already accepted and used in Denmark. This raises the question of why we do not just work with Dantale II. According to several studies, it was found that QuickSIN is a speech-in-noise test that is quick to administer (Taylor 2003; Duncan & Aarts, 2006; McArdle & Wilson, 2006). First of all, QuickSIN also in its Danish version, Hurtigtale, only contains seven sentences, whereas Dantale II contains 20 to 30 sentences. Furthermore SNR in Hurtigtale is very variable, which means that the professionals do not need to pre-set the conditions. This impacts the duration of the test and therefore makes it faster. The large range in SNR of Hurtigtale offers the possibility of reducing the number of sentences, thus shortening each test run and facilitate repetitions of the test in order to making it more accurate.

Based on the theoretical calculation, the Danish constant was determined to be 35.5. The Danish constant was calculated following the Etymotic Research manual and the HearVal program, which determined the participants' average SNR to be -15. This is better than what is normally expected, which is approximately -6 or -9 (Pedersen & Juhl, 2014; Hernvig & Olsen, 2005). A reason for this could be the 180° spatial separation of noise and speech, which is different from what we normally see in the matrix test (Dantale II).

We used the Danish constant to compare with the development of Hurtigtale, where we obtained a participant mean word count of 33.4 dB. According to the Danish constant, the average listener with normal hearing should hear at least 35 words in total, which they did not reach on average in Hurtigtale. There may be several reasons for this not being consistent with the Danish constant. One of the reasons is that people with normal hearing could not reach more than 35.5 correct words, as the total number of words per trial was 35. If the Dantale II average was 2 dB higher, then the constant would be 33.5, which would be absolutely consistent. So the question is if the 2 dB difference is due to generic differences between the tests or to some calibration issue. Despite the fact that the calibration was conducted before the beginning of the experiment, there could have been factors that affected it: for instance, if the room was used for other purposes, or the sound came from two speakers instead of one.

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The setup for the present study was slightly different from that recommended in the QuickSIN manual, as the speakers were mounted flat against the wall, rather than being positioned at an angle. The purpose of locating the speakers in this way was to support the directional cues, so that the participants could better capture the sounds coming from the front, and therefore their sensitivity to the sounds coming from behind would be reduced. Furthermore, it also meant that spatial release of masking would improve the participants' performances as there was a spatial separation between the speakers. The location of the loudspeakers and the chosen test room could both be a deviation, and therefore important to consider. Therefore, it can be said that when a test is performed in such specific circumstances, the results obtained will say something about this specific situation. In addition, there may be other methodological reasons regarding the variation between the participants. The distance of the speakers from the participants and external factors may also have an effect on the values obtained. Before the start of the test, the participants were instructed about how far they should sit from the speakers. This instruction was important, as it could have affected the SNR if the participants moved from their position.

When taking measurements with Dantale II, it is possible to observe a learning effect, including participants learning the procedure of the test and familiarizing themselves with the test material (Hernvig & Olsen, 2005). An initial trial was not done in neither HearVal or Hurtigtale. According to Etymotic Research (2001), a training round is recommended. This trial session is not intended to significantly reduce the learning effect, but rather to make the participants more aware of the test procedure and the test material. This will give the participants a better understanding of the test, thus avoiding errors in the results due to misunderstandings in the test. In this way it is debatable whether the study would have had more valid results if we had implemented a trial session with the participants.
As we first tested the participants with the HearVal test and then afterwards with Hurtigtale, it could be argued that the participants became familiar with the test material from Dantale II, which was used for both tests. Nevertheless, this does not have an impact on the results as we only used Hurtigtale test as a comparative. It is possible that this factor would play a role if we had conducted the trial by starting with Hurtigtale. However, we would not really expect this to be a large difference, as Hurtigtale is a very simple test and the instructions should not be difficult to understand.

Simply stated, measurement of SNR loss and the information from this is essential throughout the entire hearing aid selection and fitting process. Therefore, it is relevant to have SNR tests included

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as a component of the standard audiologic test battery (Taylor, 2003). In addition to this, it is important to ensure that people are being tested in circumstances with the most optimal and realistic conditions, including speech test materials that reflect noise which the individual can relate to in their everyday life. The present study found the Danish constant to be 35.5, but it would be utopian to believe that one can directly transfer to everyday situations the results from tests of understanding speech in noise. This is because it is difficult to set up a situation that is exactly similar to the sound environments that we encounter in daily life, where there will always be external variations and noise from all directions. Having said that, the professional can, by using speech-in-noise tests, manage expectations early as to what patients with a greater than 10 dB SNR loss can realistically expect of their hearing aids (Taylor, 2003). Although we try our best to conform to best practice and therefore fit patients with the latest devices, patients still have difficulties hearing in noisy environments, if such environments are not identified as a potential problem during the initial evaluation. Identifying the patient's likelihood of being in noisy envirnoments it is necessary when deciding which type of hearing aid is appropriate for the individual (Taylor, 2003). Throughout the test process, it seemed that the participants understood the tests and performed them according to instructions. Regarding the viability of Hurtigtale, it can therefore be argued that this test is a possible clinical tool.

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