

The role of cognitive abilities in younger and older normally hearing adults when listening to speech under adverse conditions

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Introduction

- Cognitive inhibition and WMC are important for speech processing, especially under adverse listening conditions.
- In order to assess different difficulties that can arise in everyday listening situations, solid methods for measuring cognitive abilities are of great importance.

Participants

- Twenty-four normally-hearing young individuals (mean age of 25 years (SD= 5.4)), and 24 normally-hearing elderly individuals (mean age 59 years (SD= 6.5)).

Purpose

- The purpose of this study was to examine how individual cognitive inhibition, and WMC relate to speech-recognition-in-noise when different types of maskers, containing noise without speech, or with speech or speech-like characteristics, are used. Various maskers have different effect on speech recognition, and some properties of a masker can facilitate speech recognition, while other properties hinder recognition.

Test Materials

Tests of cognitive abilities:

- **Reading Span** - simultaneous explicit processing and short-term storage. Sets of 2-5 sentences, each with 3 words are presented on a computer screen. The participant is asked to decide if the sentence is a meaningful sentence or an implausible sentence, and to remember either the first or the last word in each sentence. After each set of sentences the participant is asked to report either the first or the last word back.
- **The Swedish Hayling task** - Predictable sentences, divided in to three lists, where the last word is omitted, are to be completed by either a logical word or a semantically unrelated word. The test assesses the individuals' ability to fast lexical access and initiation speed, and the ability to inhibit logical responses, yielding measures of response suppression ability and thinking time.

Auditory tests:

- **The Hagerman speech-in-noise test** – Closed-set sentence material with identical structure and a limited set of words, making them highly redundant on a syntactic level but not on a semantic level.
- **HINT**- Open-set, short meaningful everyday sentences which are redundant on a semantic level.
- In both tests the sentences were presented with 4 different maskers; slightly modulated (10%) speech-shaped noise (SSN), the International Speech Test Signal (ISTS), recordings of a single female talker reading from a Swedish daily news paper, and lastly a modulated noise constructed by modulating the SSN with the envelope from the female talker. The participants rated self-perceived listening effort on a scale (Borg scale) combining ratio and category scaling from 0= none at all, to 10 (or more)= extremely great.

Results

Table 1. The correlations between hearing thresholds (PTA4), WMC, and HINT (50% correctly repeated words or sentences) and Hagerman speech-in-noise-tests (SRTs targeting 50% and 80% speech intelligibility), and self perceived listening effort (Borg). Ns= non-significant, * $p < .05$, ** $p < .01$.

TEST	Hagerman SSN 50%	Hagerman ISTS 50%	Hagerman Talker 50%	Hagerman SSN modulated 50%	Hagerman SSN 80%	Hagerman ISTS 80%	Hagerman Talker 80%	Hint ISTS words	Hint talker words	Hint modulated SSN words	Hint ISTS sentence	Hint talker sentence	Borg Hagerman ISTS	Borg Hagerman Talker	Borg Hint SSN	Borg Hint Talker	Borg Hint ISTS
Reading Span	**	*	*	ns	ns	*	ns	ns	ns	ns	**	ns	**	*	**	**	**
Hayling task	ns	*	ns	ns	ns	ns	*	*	*	*	ns	ns	ns	ns	ns	*	ns
PTA4	**	*	*	**	*	*	ns	ns	ns	ns	**	*	*	ns	ns	ns	ns

Discussion

- Response suppression ability on the Hayling task and the speech-in-noise-tests with maskers containing speech or speech-like characteristics, were positively correlated. The results indicate that individuals with difficulties in inhibiting verbal responses, need more favourable signal-to-noise-ratios when listening to target speech when maskers with competing speech are used.
- WMC is negatively correlated with HINT when ISTS is used as masker. Negative correlations can also be found between WMC and Hagerman masked with SSN, ISTS and the single female talker, indicating that WMC is of importance when the maskers used have no pauses to listen in, or when the noise containing speech competes with the target speech.
- Pure Tone Average 4 (PTA4) is positively correlated with all maskers in the Hagerman speech-in-noise-test targeting 50% word recognition, and with SSN and ISTS when targeting 80% word recognition, indicating that the Hagerman sentences, with low redundancy on a semantic level, are difficult to segregate from the target speech, especially when the listening situation is difficult. In the HINT, correctly repeated sentences when the ISTS and the talker were used as maskers also correlated with PTA4, suggesting that competing speech makes it difficult to perceive complete sentences, even when the material is redundant on a semantic level.
- WMC correlates with how the participants rate their self-perceived listening effort. The effort of listening to speech under adverse conditions seems to be interconnected with how much cognitive resources, i.e WMC or inhibition, are deployed, especially if the masker and target both contain speech.
- **In conclusion**, WMC and cognitive inhibition are important abilities when listening to speech under adverse conditions.
- **In effortful** listening situations, more cognitive resources are deployed to aid in the endeavour to reach comprehension.