Introduction
Noise impairs speech understanding and has a negative impact on remembering heard speech. Ng et al. (2013, 2015) demonstrated that, using the Sentence-final Word Identification and Recall (SWIR) test, a hearing aid signal processing algorithm alleviated the negative impact and improved memory for speech heard in noise. In these two studies, auditory stimuli were pre-processed offline, simulating possible real-time hearing aid signal processing.

The present study aimed to 1) measure the benefit of a noise reduction system implemented in hearing aids when all auditory stimuli were processed in real-time; and 2) compare the benefit in terms of memory performance at different presentation levels (SNRs predicting 95% and 70% speech intelligibility in noise). These levels were chosen because the auditory stimuli would be presented in positive SNRs, at which everyday communication (ecological listening conditions) takes place (Lunner et al., 2016; Smeds et al., 2015).

Methods
Participants
Twenty-six experienced hearing aid users of 38 to 69 years of age (mean = 63.5, SD = 6.5) with symmetrical sensorineural hearing loss of 37 to 66 dB HL (mean = 49.1, SD = 7.0) were tested. All were native Swedish speakers.

Sentence-final Word Identification and Recall test (SWIR)
All participants listened to 40 lists of sentences, which are a subset of Swedish HINT sentences (Hallgren et al., 2006). Each list contained 7 sentences. The tasks were to 1) repeat the final word of each sentence, and 2) recall all 7 final words when the end of a list was reached. An example sentence list is shown here:

<table>
<thead>
<tr>
<th>Serial position</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primacy</td>
<td>Pappa ska laga min faölj</td>
</tr>
<tr>
<td>Asymptote</td>
<td>Rokkorn log fram kastrullen</td>
</tr>
<tr>
<td>Recency</td>
<td>Solvet täcktes av en vit mata</td>
</tr>
<tr>
<td></td>
<td>Praktan packades i sex labor</td>
</tr>
<tr>
<td></td>
<td>Plånboken låg kvar på tisen</td>
</tr>
</tbody>
</table>

Results
Results are shown in Table 1. Recall performance in each test condition was analyzed in terms of serial list position. An ANOVA with three within-subject factors (presentation level, noise reduction and serial position) was performed.

There were three significant main effects:
- Presentation level (95% > 70%), F(1, 25) = 11.0, p < 0.01
- Noise reduction (ON > OFF), F(1, 25) = 15.2, p < 0.01
- Serial position (recency > primacy > asymptote), F(2, 50) = 56.3, p < 0.001

A two-way interaction (presentation level x serial position) was approaching statistical significance, F(2, 50) = 2.5, p = 0.087, suggesting that recall performance, particularly for words in the primacy position, was better at 95% speech intelligibility than that at 70%.

The three-way interaction (presentation level x noise reduction x serial position; see Figure 1) was statistically significant, F(2, 50) = 3.3, p < 0.05.

Discussion
- This is the first study showing that a real-time noise reduction algorithm significantly improves memory recall for speech heard in noise.
- At 95% speech intelligibility: When speech is highly intelligible, noise reduction improves memory recall across all serial positions. This suggests that noise reduction alleviates the adverse effect of noise on memory for heard speech by freeing up cognitive resources.
- At 70% speech intelligibility: The benefit was greatest in primacy position when listening situation becomes challenging. Better performance in the primacy position corresponds to better encoding of words into long-term memory, which is an ecologically important aspect of speech understanding under adverse conditions.

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