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SuddenSound Stabilizer for veterans

Tailoring help for veteran-specific hearing problems

ABSTRACT

Elevated acoustic startle and sensitivity to short, abrupt sounds is a well-known problem in veterans with psychological challenges after combat exposure, such as post-traumatic stress disorder (PTSD). When audiological problems are accompanied by sound sensitivity due to psychological challenges, less desired hearing aid adjustments (like decreasing gain) may be necessary. SuddenSound Stabilizer (SSS) in Oticon Real™ instantly attenuates sudden sounds that may otherwise startle the user without compromising on essential speech information in the signal. It provides a wide range of fitting options which can be personalised for individual needs. We investigated whether SSS could help veterans cope with disturbing sudden sounds by recording the brain responses of 13 Danish veterans using electroencephalography. Participants were fitted with Oticon Real 1 and asked to watch TV while disruptive and unpredictable sudden sounds were presented. During the recording, SSS was alternating between Off and On (set to Max). We found that the participants' brain responses to sudden sounds were significantly reduced with SSS On. In this scenario, participants further showed a strong preference for listening with SSS On compared to Off. This suggests that SSS may potentially benefit users who are particularly sensitive to disruptive sounds.

EDITORS OF ISSUE

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Introduction

Unexpected loud sounds are startling to most of us. For hearing aid users, abrupt sounds may cause problems if their hearing device does not adapt amplification to mitigate sudden sounds. Some populations develop sensitivity to sudden, unexpected sounds through psychological changes in the way they respond to their surroundings. One such population is veterans that return from deployment with psychological challenges after exposure to combat. For these veterans, this sensitivity may present as a specific problem as they may exhibit an elevated startle response to sudden acoustic stimuli, potentially evoking other symptoms related to combat trauma, such as hyperarousal, fear, anxiety, or anger (Butler et al., 1990; Heesink et al., 2017).

Studying auditory cognition in veterans is important for many reasons. Audiologists may focus on hyperacusis, or other hearing problems evoked by exposure to the extreme acoustics of combat events. However, these adverse sound scenes also pose risks in other health domains: Explosions may induce neurological challenges, due to blast damage or brain injury. Psychological stress associated with combat may lead to e.g., persisting hyperarousal, elevated startle sensitivity or potentially post-traumatic stress disorder (PTSD), a disorder encompassing persistent and severe symptoms of reexperiencing of traumatic events, avoidance of stimuli related to the events, hyperarousal, and changes in cognition and mood, including changes in startle reactivity (American Psychiatric Association, 2022). Combat exposure may thus alter the way you hear your world in more aspects than the audiological. In US veterans from missions in Iraq and Afghanistan, an estimated 19% are affected by audiological problems such as hearing loss or tinnitus. In the same population, prevalence of psychological challenges such as PTSD is estimated to 23% (Fulton et al., 2015; Swan et al., 2017).

The BrainHearing approach to sudden sounds

We believe that understanding auditory cognition and the brain processing involved in encoding our acoustic surroundings is central to improving the life of the hearing impaired (Man & Ng, 2020). In some cases, auditory perception is altered by and interacts with other factors, such as mental health. It is therefore crucial for us to investigate how cognitive challenges can affect hearing, so that hearing care professionals can better tailor the help for users with specific problems such as high sensitivity to sudden sounds.

We conducted the current study to investigate how SuddenSound Stabilizer (SSS) would change brain responses to sudden sounds in veterans, as well as to learn how veterans would experience the adaptive amplification of sudden sounds inherent in the feature. To do so, we invited a mixed sample of veterans with and without known audiological problems and with and without known psychological sequels to combat exposure. In this way, we tested the new feature with a heterogeneous veteran group, reflecting the mixed profiles of veterans seeking help in health services.

Sensitivity to sudden sounds in veterans

Symptoms of hypervigilance, hyperarousal, and elevated startle to sounds are among known potential sequels to exposure to combat and included in the PTSD diagnosis. Sudden sounds can act as triggers evoking an alert, aroused state. For example, studies have found that heart rate increased more in response to sudden sounds in veterans with PTSD compared to a control group (Carson et al., 2007), and elevated acoustic startle is a well-documented problem in veterans evoking hyperarousal and anxiety (Butler et al., 1990; Heesink et al., 2017; Maples-Keller et al., 2019; Morgan et al., 1995; Morgan et al., 1996; Robison-Andrew et al., 2014). Veterans with PTSD have also been found to have difficulties in adapting to startling stimuli (Jovanovic et al., 2009).

Veterans seeking help for audiological problems, but with cooccurrence of such psychological challenges, may benefit from hearing aid technologies that limit the impact of sudden sounds that otherwise may evoke symptoms (Papesh et al., 2021).

Santurette et al. (2023) showed that SSS can reduce listening effort. Based on these findings, we hypothesised that SSS may further alleviate elevated sensitivity to startling transient sounds in veterans who present with this problem.

SuddenSound Stabilizer

SuddenSound Stabilizer (SSS) in Oticon Real is part of MoreSound Amplifier™ 2.0. It is a feature that instantly attenuates sudden sounds ranging from soft to loud while enabling instant and precise balancing of all sounds. Activating SSS even to the High setting does not affect speech understanding (Santurette et al., 2023). SSS in Real 1 has six different settings, with more than 30 dB attenuation of sudden sounds in the Max setting. This allows for great personalisation. For users who are vulnerable or sensitive to sudden sounds, we recommend setting SSS to High as a starting point. For users with severe sound sensitivity, a successful hearing aid fitting requires extra precautions. For this population, we recommend setting SSS to Max (Rumley et al., 2023). Technical details of SSS are given in a recent Oticon whitepaper by Santurette et al. (2023).

The P50 brain response and sound sensitivity

Event-related potentials (ERPs) are brain responses to stimuli such as sudden sounds. In the current study, we investigated the P50 ERP response, which is a positive wave occurring approx. 50 ms after the sound was presented. The P50 ERP response is thought to be generated in the primary auditory cortex and the superior temporal gyrus (Thoma et al., 2003). On the pathway from ear to brain, this response happens between early stages such as the brainstem and later stages involving attention and memory (Remijn et al., 2014).

The P50 ERP response follows the perception of any sound, and can be argued to reflect pre-attentive arousal caused by a new auditory event (Pratt et al., 2008). The P50 is not entirely pre-attentive though, as it may also to some extent reflect the psychological state of the participant (White & Yee, 2006), e.g. an elevated sensitivity towards startling sounds. P50 amplitude increases with stimulus intensity and with state of arousal (Ninomiya et al., 2000; White & Yee, 2006). In normal-hearing populations without PTSD, if a stimulus is preceded by an identical stimulus, the P50 response is reduced (Remijn et al., 2014), indicating that most listeners quickly get used to the sound. This reflects the central nervous system's adaptation to repetitive stimuli, a phenomenon known as *sensory gating* (Neylan et al., 1999). Conversely, individuals with PTSD are often reported to exhibit reduced habituation: the P50 response tends not to diminish as much after the second stimulus compared to the first (Orr et al., 2002). The P50 brain response correlates with other startle responses, such as eye blinks and muscle contractions (Holstein et al., 2010), and these measures similarly indicate that habituation is reduced in PTSD patients (Orr et al., 2002).

Benefits of sudden sound attenuation in an experimental setting

To investigate whether SSS has the potential to help people with elevated reactions to startling sounds, we conducted an electroencephalography (EEG) study measuring the P50 brain response after exposure to abrupt bursts of white noise.

Methods

Participants

The study included 13 veterans (30-63 years old, mean age: 48 years, 1 female). Half of them (N = 7) had mild to moderate hearing loss. All had been deployed with the Danish Defence in Afghanistan, Iraq, and similar conflict zones, and reported exposure to events such as witnessing civilian or military casualties, participating in or witnessing combat, or being under artillery or missile attacks. Half of the participants (N = 7) reported

elevated startle responses. In this way, the sample reflected the heterogeneity that is one of the hallmarks of studying veteran populations (DiMauro et al., 2014).

Prior to the testing, audiometry was performed on all participants. They were fitted with Oticon Real 1, adjusted to their individual hearing thresholds. To ensure a tight fit, all participants were fitted with Grip Tips, and in case of smaller ear canals, Power Domes were used.

Stimuli

Stimuli consisted of series of paired noise bursts. Each trial presented two consecutive short bursts of white noise of 85 dB peSPL from a loudspeaker in front of the participant. The paired noise bursts were separated by a 500 ms interval. The inter-trial interval was varied between 7.5 and 8.5 seconds, making the trials unpredictable. Participants were exposed to six blocks of 40 trials. The blocks alternated between SSS On (set to Max) and SSS Off. We measured the P50 brain response comparing the two SSS conditions and the two stimulus presentations for each trial. We hypothesised that the P50 brain response would generally be reduced when the participant was listening with SSS On compared to Off, and that it would be weaker in the second stimulus compared to the first.

Procedure

We used a 64-channel BioSemi ActiveTwo EEG with a sample rate of 1024 Hz. Participants were placed in a comfortable chair in a sound studio, watching a movie with low sound, instructed to focus their attention on the movie. Paired white noise bursts were presented at irregular intervals through a frontal loudspeaker during the movie.

EEG results

Average brain responses in the first 200 ms with SSS Off and SSS On are represented in figure 1, comparing the first and second stimulus in each noise burst pair. The P50 responses (indicated by magenta bars) peak at around 50 ms after the stimulus presentation.

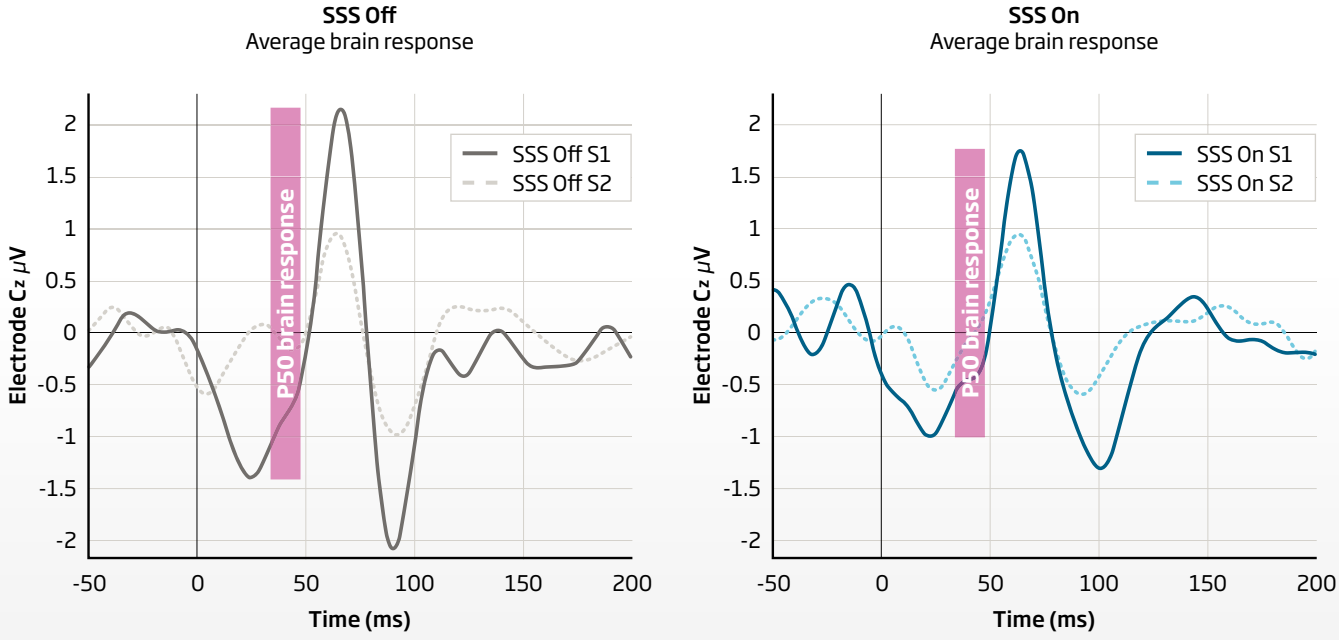

Figure 1: Average brain response to the first (S1) and second (S2) noise burst with SSS Off and SSS On. The P50 brain response is the most positive peak at approx. 50 ms computed from the preceding negative trough, as indicated by the magenta bars.

The P50 brain response to startling sounds was significantly suppressed with SSS On compared to SSS Off (the average P50 brain response to S1 stimuli was 19% lower with SSS On compared to SSS Off (4.2 µV and 5.2 µV, respectively), $p < 0.05$), see figure 2. This indicates that SSS could potentially be of benefit to those who are particularly sensitive to disturbing sounds. Generally, SSS On produced lower peaks, and the peak was lower for the second stimulus compared to the first ($p < 0.01$). This indicates that the participants' brains adapted to the repeated stimuli.

The participants preferred SuddenSound Stabilizer On

In addition to the electrophysiological measures, we asked the participants to indicate the level of comfort and irritation in the two conditions on a scale from 0 to 100.

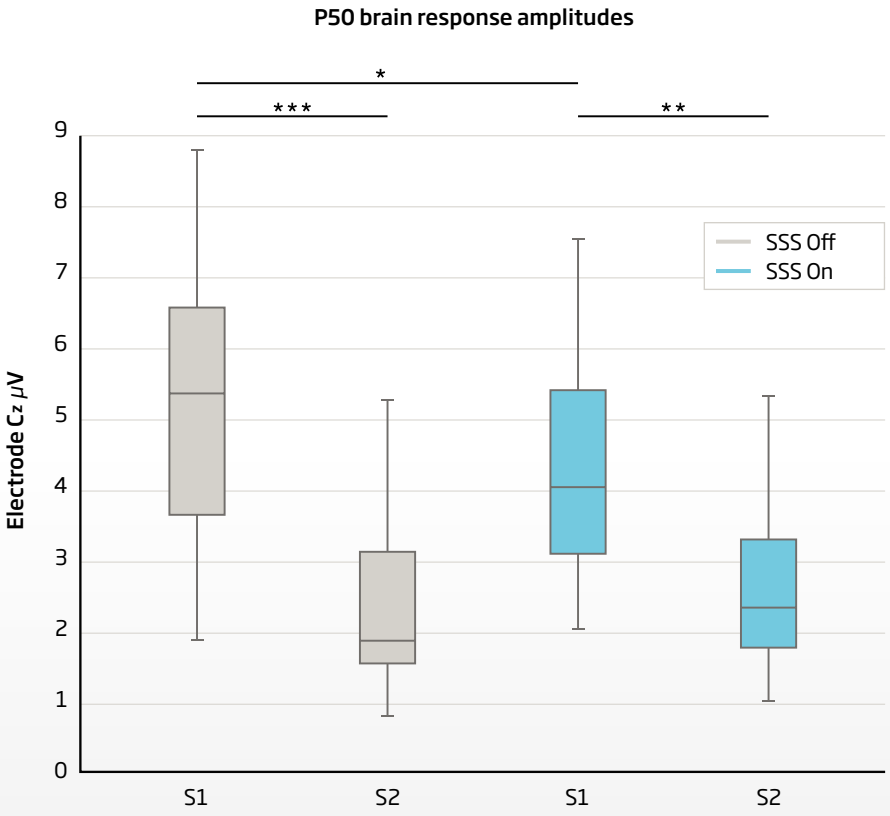

*Figure 2: P50 brain response amplitudes for the first (S1) and second (S2) noise burst in each trial with SuddenSound Stabilizer Off and On. The P50 brain response to the S1 noise burst is lower with SSS On compared to SSS Off. The line in the boxes represent the median value. * p < 0.05; ** p < 0.01; *** p < 0.001*

As illustrated in Figure 3, the participants rated the listening experience significantly more comfortable and less irritating with SSS On compared to Off, showing a great clinical benefit for this specific population.
On average, listening with SSS On was rated 18 percentage points more comfortable and 22 percentage points less irritating than with SSS Off.

Asking the participants to give more details about their choice of rating reveals some of the benefits that SSS may bring in everyday life. Figure 4 highlights select participant testimonials which show a more nuanced picture of their attitude toward the SSS.

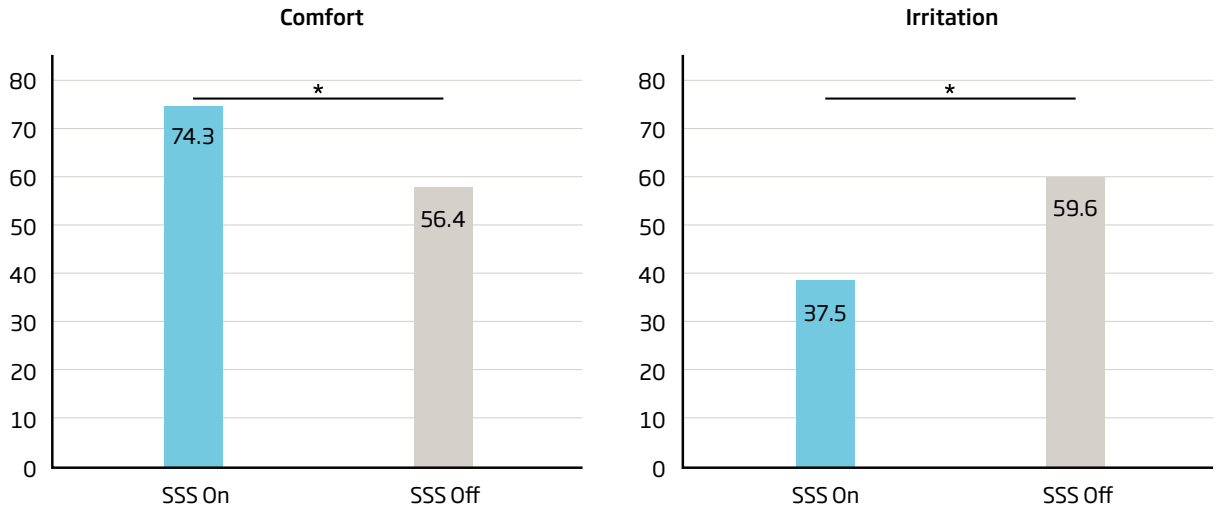

*Figure 3: Mean comfort and irritation ratings. * $p < 0.05$*

"With [SSS On] the sounds are softer, like if they came from a greater distance. With [SSS OFF] they are really in your face."

"With [SSS On] I easily adapt to the sound and after a short while, they don't distract me from the movie - I don't pay attention to them. In the other programme [SSS Off] they keep taking my attention away."

"I hear the sounds, but I can easily ignore them with [SSS On]. In the other programme [SSS Off] they irritate me."

"In one of the programmes [SSS Off], the clicks had a lot of presence and treble, really loud. In the other [SSS On], they just sounded distant and a lot lower."

"In the first programme [SSS Off], the sounds remind me a little of gunshots. In the other [SSS On] they are more diffuse - after a while I hardly notice them."

"In one programme [SSS Off], the clicks sound like somebody is knocking on a window close by with a metal object. In the other [SSS On], the sound feels like it's coming from outside, far away."

"In the first programme [SSS On], the sounds get a lot softer, and they sound distant. In the other [SSS Off], they're up close and have a nasty high pitch."

Figure 4: Testimonials on the listening experience with and without SuddenSound Stabilizer.
Disclaimer: These statements come from a specific group and may not be representative of all clients' experiences.

Several participants stated that the sounds appeared softer, more distant, and less distracting or intrusive. In this way, the subjective ratings of the participants align with the objective brain recordings. It is therefore safe to conclude that SSS may provide help to those who find sudden sounds disturbing.

Some people may feel that SSS helps them, while others may not – hearing comfort is a matter of personal preference, so using SSS with its enhanced means of customisation can make it easier for hearing aid users to try out which setting suits them the best. The results of this study indicate that SSS has the potential to help a wide range of clients.

Final remarks

As many as 71 percent of hearing aid users have trouble managing situations with disruptive sounds (Gade et al., 2023). Combat veterans are a group who is liable to experience discomfort when hearing sudden sounds. We have shown that SuddenSound Stabilizer could potentially help this population. In general, participants preferred being exposed to sudden disruptive sounds with SSS On compared to SSS Off, and the P50 brain response was significantly lower with SSS On. This means that SuddenSound Stabilizer effectively reduces the physiological response to the stimuli, suggesting that Oticon Real may benefit veterans with heightened sensitivity to these kinds of sounds. Some veterans may experience less startle as a result of the reduction of sudden sounds provided by SuddenSound Stabilizer.

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