Low intensity white noise improves performance in auditory working memory task: An fMRI study

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Abstract

Research suggests that white noise may facilitate auditory working memory performance via stochastic resonance. Stochastic resonance is quantified by plotting cognitive performance as a function of noise intensity. The plot would appear as an inverted U-curve, that is, a moderate noise is beneficial for performance whereas too low and too much noise attenuates performance. However, knowledge about the optimal signal-to-noise ratio (SNR) needed for stochastic resonance to occur in the brain, particularly in the neural network of auditory working memory, is limited and demand further investigation. In the present study, we extended previous works on the impact of white noise on auditory working memory performance by including multiple background noise levels to map out the inverted U-curve for the stochastic resonance. Using functional magnetic resonance imaging (fMRI), twenty healthy young adults performed a word-based backward recall span task under four signal-to-noise ratio conditions: 15, 10, 5, and 0-dB SNR. Group results show significant behavioral improvement and increased activation in frontal cortices, primary auditory cortices, and anterior cingulate cortex in all noise conditions, except at 0-dB SNR, which decreases activation and performance. When plotted as a function of signal-to-noise ratio, behavioral and fMRI data exhibited a noise-benefit inverted U-shaped curve. Additionally, a significant positive correlation was found between the activity of the right superior frontal gyrus (SFG) and performance in 5-dB SNR. The predicted phenomenon of SR on auditory working memory performance is confirmed. Findings from this study suggest that the optimal signal-to-noise ratio to enhance auditory working memory performance is within 10 to 5-dB SNR and that the right SFG may be a strategic structure involved in enhancement of auditory working memory performance.

Keywords

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1. **Acoustic noise reduction in MRI using Silent Scan: an initial experience** — Times Cited: 37
By: Alibek, Sedat; Vogel, Mika; Sun, Wei; et al.
DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY Volume: 20 Issue: 4 Pages: 360-363 Published: JUL 2014

2. **Copland, White noise enhances new-word learning in healthy adults** — Times Cited: 1
By: Angwin, A. J.; Wilson, W. J.; Arnott, W. L.; et al.
Sci. Rep. Volume: 7 Pages: 2-7 Published: 2017
[Show additional data]

3. **Improving reasoning skills in secondary history education by working memory training** — Times Cited: 16
By: Aries, Roel Jacobus; Groot, Wim; van den Brink, Henriette Maassen
BRITISH EDUCATIONAL RESEARCH JOURNAL Volume: 41 Issue: 2 Pages: 210-228 Published: APR 2015

4. **The Contribution of Attentional Control and Working Memory to Reading Comprehension and Decoding** — Times Cited: 62
By: Arrington, C. Nikki; Kulesz, Paulina A.; Francis, David J.; et al.
SCIENTIFIC STUDIES OF READING Volume: 18 Issue: 5 Pages: 325-346 Published: 2014

5. **Noise-enhanced convolutional neural networks** — Times Cited: 25
By: Audhkhasi, Kartik; Osoba, Osonde; Kosko, Bart
NEURAL NETWORKS Volume: 78 Special Issue: SI Pages: 15-23 Published: JUN 2016

6. **Working memory: Looking back and looking forward** — Times Cited: 2,350
By: Baddeley, A
NATURE REVIEWS NEUROSCIENCE Volume: 4 Issue: 10 Pages: 829-839 Published: OCT 2003

7. **The episodic buffer: a new component of working memory?** — Times Cited: 2,937
By: Baddeley, A
TRENDS IN COGNITIVE SCIENCES Volume: 4 Issue: 11 Pages: 417-423 Published: NOV 2000

8. **Backward recall and benchmark effects of working memory** — Times Cited: 26
By: Bireta, Tamra J.; Fry, Sheena E.; Jalbert, Annie; et al.
MEMORY & COGNITION Volume: 38 Issue: 3 Pages: 279-291 Published: APR 2010