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# Enhancing Neuromodulation-Induced Analgesia Through Personalized Neuro-Visual Stimulation

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## Introduction

Epidural spinal cord stimulation(SCS) is an approved treatment for truncal and extremity neuropathic pain. However, up to 50% of patients may not respond to conventional SCS and its efficacy may reduce overtime time. Recent advances in cognitive neuroprosthetics can extend the analgesic effect of virtual reality (VR) (based on distraction) with multisensory stimulation involving bodily signals. Here we merged, for the first time, VR and SCS linking SCS-induced paresthesia with personalized visual feedback on patient's body, provided through a wearable headset. We tested the analgesic properties of this new digital therapy hypothesizing stronger pain reduction than conventional SCS.

## Methods

Twenty subjects with implanted SCS were screened and 15 underwent neuro-visual stimulation under three different experimental conditions: SCS ON and visual illumination of the body part where patients perceived paresthesia from SCS (congruent neuro-visual stimulation); SCS ON and visual illumination of a another sector of the visual field without paresthesia (incongruent neuro-visual stimulation); SCS OFF and illumination of the congruent body part (baseline condition). The primary outcomes variable was pain reduction on 10-point scale, as quantified by subjective pain rating across conditions and physiological measures (e.g. heart rate variability).

## Results

All patients tolerated the procedure and embodied legs presented in the VR scenario. Patients experienced significant pain reduction (2.72 ±0.6 SEM points) following congruent neuro-visual stimulation, which represents a reduction of 44% over baseline. This pain reduction was 1.8-fold higher with congruent than the incongruent condition. Analgesia following congruent neuro-visual stimulation significantly improved with the duration of stimulation than the incongruent ($t(14)=3.74$, $p=0.006$), or baseline ($t(14)=3.56$, $p=0.009$) conditions. None of the experimental conditions was associated with significant changes in heart rate variability.

## Conclusions

By integrating the advance in neuroscience of body perception with SCS into an immersive mixed reality platform, we were able to increase the analgesic effect associated with SCS. The utility of this approach as a home-based therapy should be tested in future trials.

## Learning Objectives

1.Neuro-visual stimulation in congruent condition increased the analgesic effect of SCS.

2.The duration of neuro-visual stimulation further improved SCS induced analgesia.

3.The utility of home-based neuro-visual stimulation should be tested in a clinical trial of neuropathic patients with implanted SCS.

## References

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