Directional discrimination is better for discrete stimuli than continuous lines

Center for Neuroplasticity and Pain

Ken Steffen Frahm, Adam Kamakh Asaad, Asger Ahlmann Bech, Emilie Vinter Bisgaard, Andreas Holmberg Busch, Cæcilie Victoria Bergmann Engers, Susanne Khalaf, Pernille Kristensen, Laura Øbo Larsen, Mia Daugaard Madsen, Troels Yding Pedersen, Line Pejstrup Søndergård, Emil Stiil Vium

[2] Neural Engineering and Neurophysiology group, SMI Integrative Neuroscience group, Center for Neuroplasticity and Pain (CNAP), SMI®, Dept. of Health Science & Technology, Aalborg University, Denmark

Correspondence: ksf@hst.aau.dk

Introduction

- **We have previously demonstrated that the sensory system can discriminate the direction of a moving noxious laser stimuli [1].**
- **However, the underlying mechanism behind directional discrimination is still poorly understood [2].**
- **Studies have suggested that direction sensitive neurons, which were silent during punctate stimuli may exist in the sensory cortex [3]**
- **If such neurons exist for noxious stimuli, then it can by hypothesized that discrimination of continuous moving stimuli are better compared to discriminate a stimulus which is moved in discrete steps, i.e. stimulation only at certain points along the line.**

Aim

The aim of this study was to investigate the directional discrimination of noxious laser stimuli using both continuous and discrete lines.

Methods

- 9 healthy subjects participated in this preliminary study.
- Subjects received infrared laser stimulation in the right volar forearm. The infrared laser stimuli were delivered using a CO_2 laser with a scanner head allowing rapid displacement of the laser beam across the skin (Fig. 1).
- The laser displacement velocity was 10 mm/s for all stimuli [2].
- Following each stimulus the subjects had to report the perceived direction of the stimulus – towards the hand or towards the elbow (forced choice) and the perceived intensity on a Numerical Rating Scale (NRS). The NRS was set as 0: No perception, 3: Pain threshold, 10: Maximum pain.

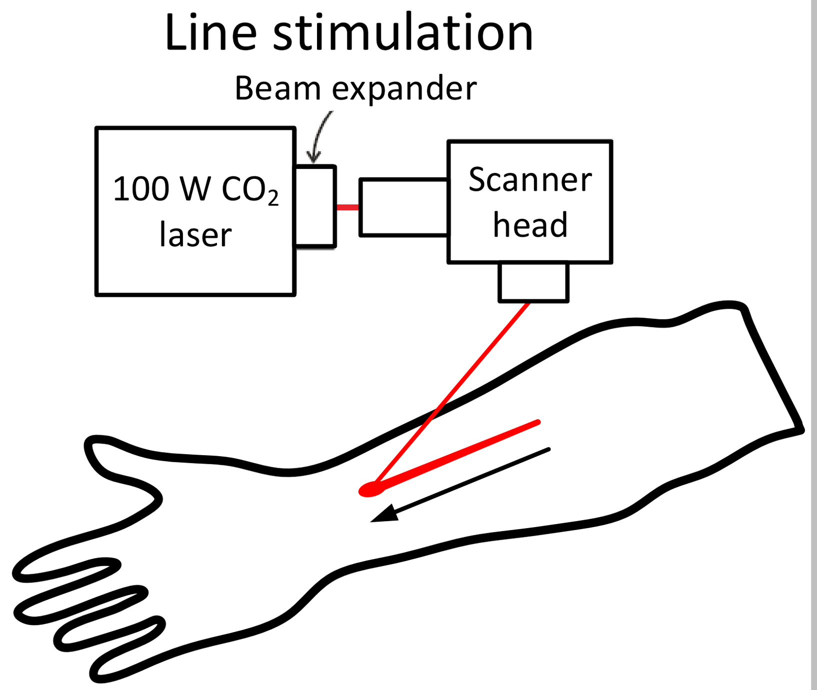

Figure 1. Laser stimulation setup

Ethical

- The experiment was approved by the local ethical committee (VN-20190005). The experiment was conducted in accordance with the declaration of Helsinki.

Methods (cont.)

Stimulation paradigms

- Three different stimulation paradigms were used to test the directional discrimination (Fig. 2). First a continuous stimulation (line) as in [1], and additionally two discrete lines where stimuli only was delivered in steps of either 10mm (P10) or 20mm (P20).
- For each paradigm, five different stimulation lengths (20, 40, 60, 80, 100 mm) in randomized order were delivered. The direction of the stimulus was either distally towards the wrist or proximally towards the elbow. Each combination of direction and length was repeated twice in randomized order.
- The stimulation temperature was adjusted to obtain equal temperature for all paradigms, thus, the temperature was 46.7±1.2°C for the continuous line, 47.0±1.4°C for the discrete P10 line, and 46.7±1.6°C for the discrete P20 line.

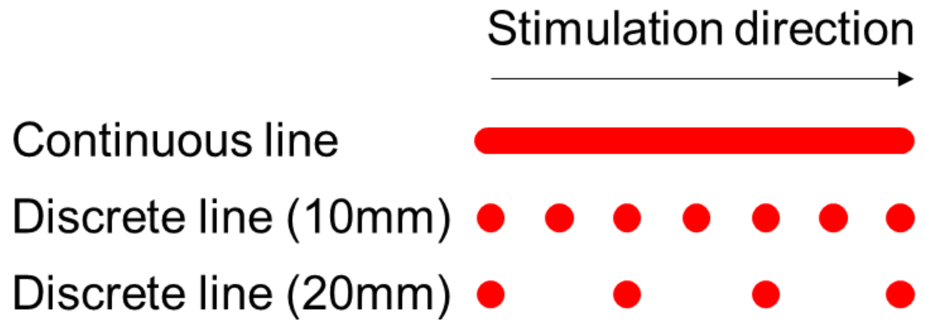

Figure 2. Stimulation paradigmes.

Data analysis

- To calculate the directional discrimination threshold (DDT) the data was fitted to a sigmoidal curve [1,2]. The 95 % confidence intervals (CI) of the fits were calculated.
- To analyze differences in NRS a 3-way ANOVA was used. Factors were stimulation paradigm and stimulation direction, stimulation length was included as a covariate.

Results

Directional discrimination

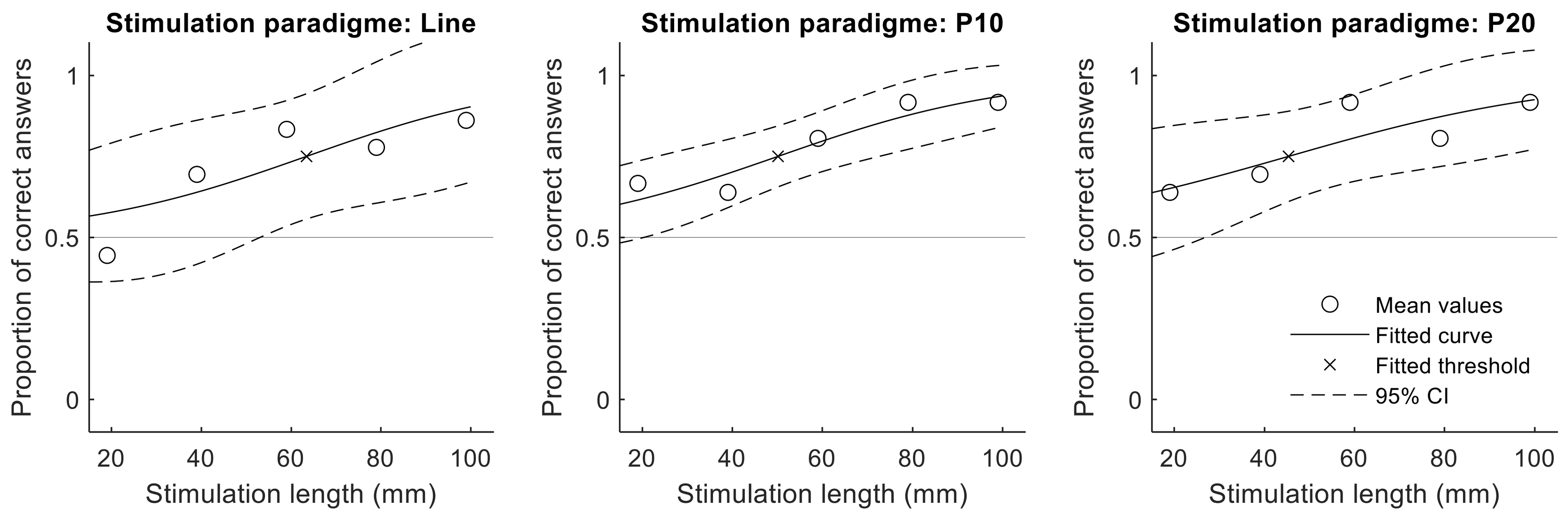

Figure 3. Directional discrimination. Left: continuous line, middle: discrete lines step of 10 mm (P10), right: discrete lines step of 20mm (P20)

- The DDT for the continuous line stimulation was 63.4mm (r^2: 0.7, 95% CI: 23.7 - 103.1mm).
- The DDT of the discrete line P10 paradigm was 50.1mm (r^2: 0.9, 95% CI: 30.6 - 69.6mm).
- The DDT of the discrete line P20 paradigm was 45.4mm (r^2: 0.7, 95% CI: 10.2 - 80.5mm).

Results (cont.)

Perceived intensities

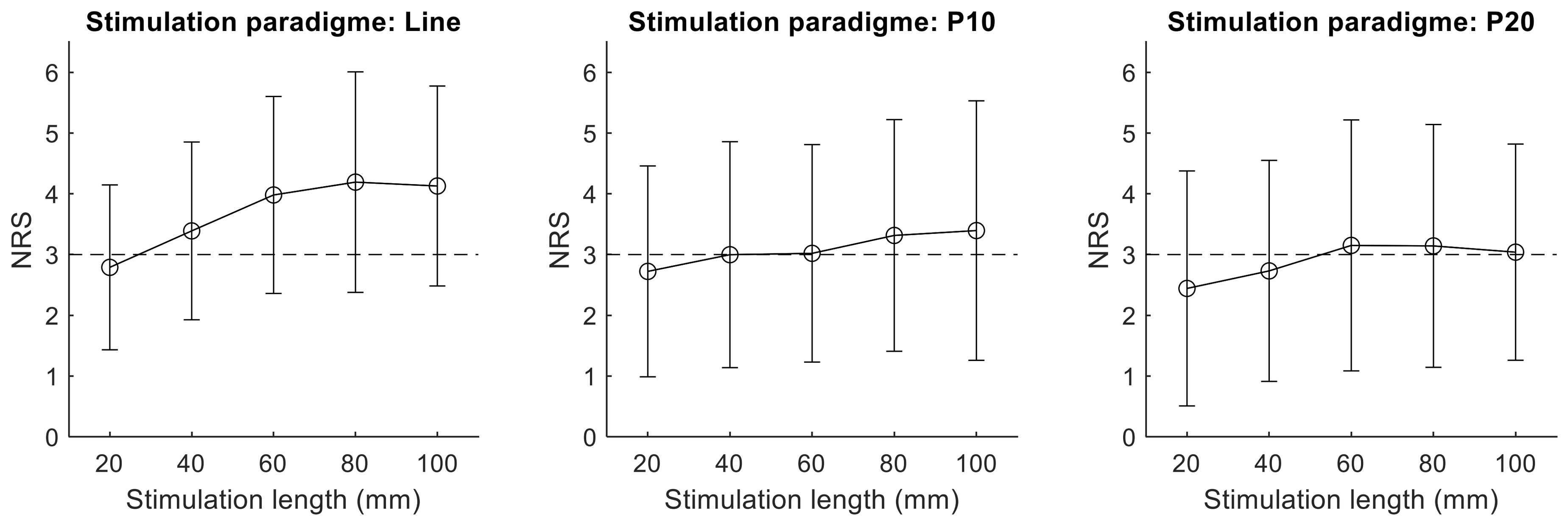

Figure 4. Perceived intensities (mean±SD). Left: continuous line, middle: discrete lines step of 10 mm (P10), right: discrete lines step of 20mm (P20). The dashed line in NRS = 3 indicate pain threshold.

- The average NRS for the continuous line was 3.7, for the discrete line P10 it was 3.1, and for the discrete line P20 it was 2.9.
- Significant difference in NRS in relation to stimulation paradigm (ANOVA, p<0.001), the NRS reported following continuous line stimulation was significantly higher than the other two paradigms.
- The NRS increased significantly with stimulation length (ANOVA, p<0.001).
- There was no significant differences in NRS in relation to stimulation direction.

Conclusions

- Moving punctate stimuli are discriminated more accurately, but perceived less intense, than continuous line stimuli of similar intensity.
- The better discrimination of punctate stimuli is somewhat surprising as such punctate stimuli may not activate the same direction-sensitive neurons as the continuous stimuli may.
- These findings cast doubt of the importance of direction sensitive neurons underlying directional discrimination.

References

[1] Frahm KS, Mørch CD, Andersen OK. Tempo-spatial discrimination is lower for noxious stimuli than for innocuous stimuli. Pain 2018 Oct 30;159(2):393–401.

[2] Frahm KS, Mørch CD, Andersen OK. Directional discrimination is better for noxious laser stimuli than for innocuous laser stimuli. Eur J Pain 2019 13]1521.

[3] Costanzo RM, Gardner EP. A Quantitative Analysis of Responses of Direction-Sensitive Neurons in Somatosensory Cortex of Awake Monkeys. J Neurophysiol 1980;43(5):1319–41.

IASP 2021 VIRTUAL WORLD CONGRESS ON PAIN 9-11 June • 16-18 June 2021

Poster no. 1038227

This study was funded by the Danish National Research Foundation (DNRF121)

Danmarks Grundforskningsfond Danish National Research Foundation