Investigating Neural Signatures of Visual and Multi-Sensory Finger Stretching

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Introduction

Chronic hand-based pain affects around 1 in 6 people in the UK (NHS, 2018). Current pharmaceutical interventions have been reported as minimally effective:

- 60% of patients report no improvement in pain after taking pain medications (Dworkin et al., 2010).

- Current NICE guidelines advise against using pharmaceutical treatments for chronic pain conditions.

- Surgical interventions are typically only offered to patients over the age of 60 (Perrot & Menkes, 1996) and 23 – 34% of patients report unfavourable outcomes (Beswick et al., 2012).

Due to ineffective current therapies = clear need to find non-pharmaceutical / non-surgical therapy options for chronic pain.

Multi-sensory (MS) Illusory finger stretching reduces pain in osteoarthritis (Preston & Newport, 2011; Preston et al., 2020). MS illusions include tactile and visual inputs, however how MS illusions reduce pain is unclear. MS illusions are associated with oscillation changes in Theta / Gamma bands over frontal / parietal regions (Kanayama & Ohira, 2007; Kanayama, Hara & Kimura, 2021). Frontal Theta oscillations link to multisensory dis-integration and parietal Gamma oscillations link to multisensory integration.

Aim = Investigate difference between multisensory and uni-modal visual (UV) illusions, to uncover neural underpinnings using EEG and assess validity of using UV illusions as treatment options.

Exploratory Hypotheses:

1) Stronger parietal Gamma band power (30 – 90Hz) will be elicited during MS compared to UV conditions.

2) Greater frontal Theta band power (5 – 7Hz) will be elicited during asynchronous conditions (AS) compared to no illusion conditions.

3) Illusion strength will be greater in MS compared to UV, which will be greater than AS conditions.

Power analysis of illusion data from previous research shows minimum sample size of 26 participants needed (d = .67, power = .95, alpha = .05).

Due to previous research having small sample size (n = 9) and current study using EEG which was not used previously, sample size of 26 participants doubled to around 50 participants.

Study pre-registered on OSF with clear exploratory hypotheses.

Scan for OSF Preregistration!

Methods

Pilot / Positive Control:
17 participants (47% Chronic Pain, 53% Healthy) had either synchronous or asynchronous multimodal manipulations first. Chronic Pain Participants asked to rate pain on scale of 0-10 on the morning of the study, before and after the first condition and again before and after the second condition. After, chronic pain and healthy participants were given an illusion scale.

Study 1:

48 participants (83.5% Female. 14.5% Male, 2% Non-Binary; Mean age = 21 years) were given visual and tactile manipulations to their right-hand whilst wearing an EEG cap. Participants were then asked to rate their illusory experience using a questionnaire.

Scan for finger stretching video!

Figure 1: Image of Augmented Reality System used to Deliver Illusions. Participant Wearing an EEG Cap.

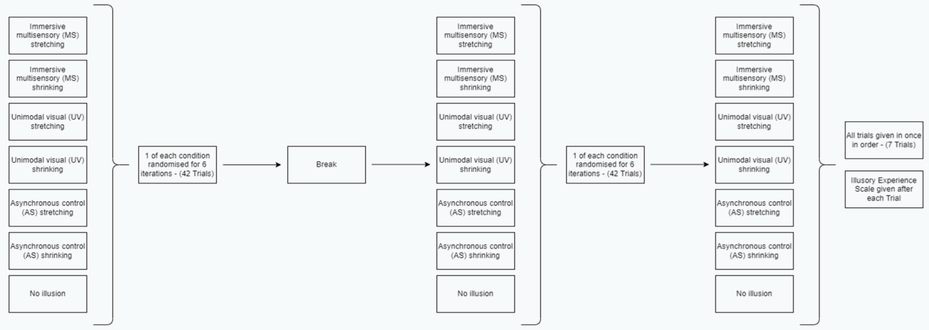
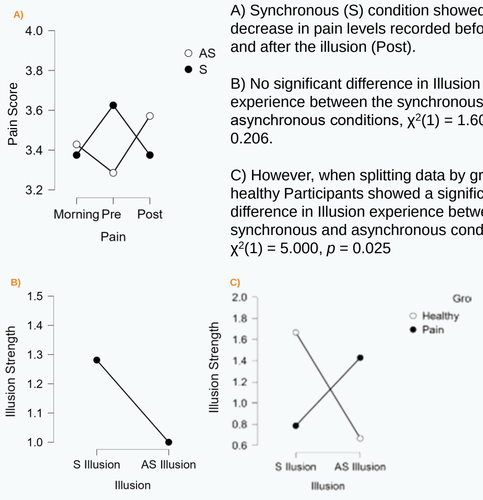


Figure 2: Timeline of Events in Study 1.

Pilot / Positive Control Results

Positive control check of the new augmented reality system to alleviate pain levels and produce illusion.



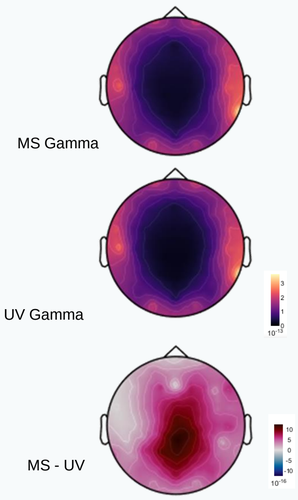
A) Synchronous (S) condition showed decrease in pain levels recorded before (Pre) and after the illusion (Post).

B) No significant difference in Illusion experience between the synchronous and asynchronous conditions, $\chi^2(1) = 1.600$, $p = 0.206$.

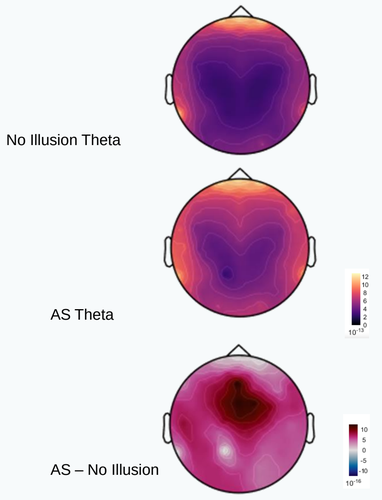
C) However, when splitting data by group, healthy Participants showed a significant difference in Illusion experience between the synchronous and asynchronous conditions, $\chi^2(1) = 5.000$, $p = 0.025$

Study Results

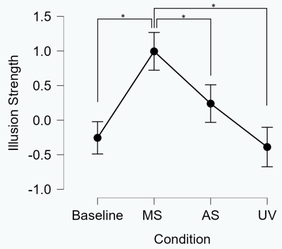
Hypothesis 1:



Hypothesis 2:



Hypothesis 3:



Statistical analysis for EEG data is yet to be completed, but scalp topographies show parietal Gamma elicited more during MS compared to UV conditions, and frontal Theta elicited more during AS compared to the no illusion condition.

An issue facing open science practices in psychology / neuroimaging is the loss of statistical power during multiple comparisons tests, to address this, a mass univariate approach (Cluster Correction) will be used to compare EEG data across electrodes without loosing statistical power.

There was a statistically significant difference in illusion strength depending on which condition was being experienced, $\chi^2(3) = 40.936$, $p < .001$. Post hoc analysis (Bonferroni correction for 6 comparisons ($p < .008$)) showed significant differences between Baseline and MS ($p < .001$), MS and AS ($p < .001$), and MS and UV conditions ($p < .001$).

Conclusion

Positive control results indicate that the augmented reality system was able to deliver a significantly greater illusion in synchronous compared to asynchronous conditions, confirming the success of the positive control. Pain reduction was also seen in chronic pain patients after experiencing the synchronous condition, in line with previous research.

Hypothesis 1 & 2 appear to be likely supported by EEG data, although statistical analysis is yet to be completed.

Hypothesis 3 has been partially supported due to illusion strength being significantly greater in MS conditions compared to UV, however, cannot be supported fully since AS conditions showed illusion strength to be greater than in UV conditions, although not significantly greater.

A second research project will be conducted that will be based on this study, looking at the effect of the illusion in chronic pain participants, which I hope to complete as a registered report. All data collected will be placed in an online repository so that other researchers have access to the data to check findings or use for the basis of future research.

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