The Effects of Verbal Suggestion on Body Perception A-10876

Progress report 3 – Final Report

To recap, **Progress Report 1** described 3 experiments. Experiment 1 showed that verbal suggestions for hand shrinkage produced a significant reduction in hand size perception during the explicit but not the implicit task. Experiment 2 demonstrated that there were no effects (implicit nor explicit) during identical procedures when the verbal suggestion was for hand enlargement. Experiment 3 used a verbal suggestion (hand enlargement) in combination with a hand-warming procedure and demonstrated enlargement effects for the hand for both implicit and explicit tasks.

Progress Report 2 focused on 3 behavioural experiments (Nrs 4-6) involving tickle. In Experiments 4-6, tickles were delivered to the palm of the hand using a 'Tickling' Machine; the methods and procedures were largely based on those of Blakemore, Wolpert and Frith (1998). In Experiments 4 and 5, the left and right hands were randomly stimulated (tickled) on 23 sites marked on the palm of the hand. In Experiment 6, the left hand was randomly tickled on 6 sites, including the centre of the palm (Blakemore, Wolpert and Frith, 1998) and the tip of each finger.

In this final **Progress Report 3,** a further 8 experiments (Nrs. 7 – 14) are presented. The aim of **Experiment 7** was to further assess the impact of verbal suggestions on tickle and itch perception and to examine these effects over time. Inspired by Blakemore et al.s' (1998) tickle machine, 2 identical battery-powered 'machines' were constructed to deliver the same tactile stimulation to the palm of each hand in turn (Figure 1A). Twenty participants were randomly divided into a Tickle (N=10) and an Itch (N=10) group. The experimental procedures were identical for both groups, differing only in the written verbal suggestions provided to participants before tactile stimulation. The Tickle group received a suggestion that their left hand is ticklier than their right hand, while the Itch group was informed that their left hand is itchier than the right hand.

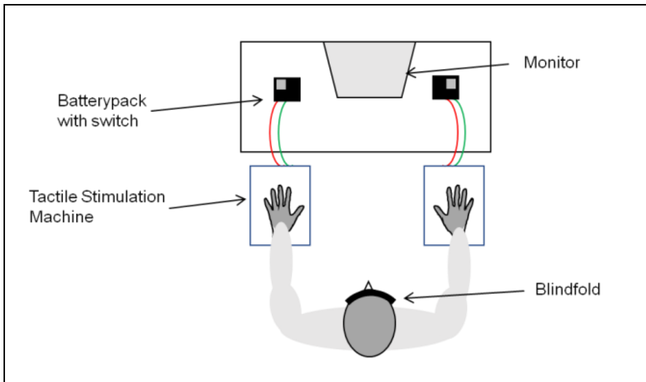

Figure 1A. Experiment 7 set-up showing the blindfolded participant seated and with each hand placed on top of a 2 Hz motor tactile stimulating machine.

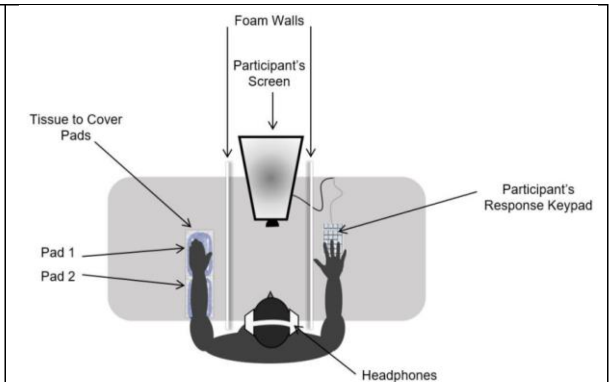

Figure 1B. Experiment 8 set-up. During the task the left hand and forearm rested on two pads which could be heated independently to 38.4^{o}. In a baseline condition both pads were kept at room temperature.

Results from Experiment 7 demonstrate that machines can successfully delivered precise tactile stimulations in combination with verbal suggestion. Tactile perception can be manipulated by verbal suggestion. Simply labelling a tactile stimulation as 'tickle' or 'itch' influences how the stimulus is experienced.

In **Experiment 8**, we used a combination of verbal suggestion for limb enlargement in combination with limb warming procedures to target either the left forearm or the hand. Participants were asked to resize distorted images of these limbs to what they felt their veridical size was. Twenty-five participants (12 females) participated in the study after giving informed consent. Experiment 8 demonstrates that verbal suggestion in combination with a warming procedure, targeting the size of an individuals' hand and forearm, modulated the explicit representation of the forearm only with no effect on hand or the control object (Figure 1B). There was no effect of verbal suggestion combined with the heating procedure on the hand. However, there was effect of verbal suggestion on the left forearm.

Experiment 9 introduces an arm lowering protocol which is then used for the remaining experiments (Exps. 9 – 14). This case study (one female participant; aged 25 years) used video technology to *objectively* measure the effects of verbal suggestion on arm movements, based on a (hand lowering) test item from the Harvard Group Scale of Hypnotic Susceptibility (HGSHS:A). This new protocol was tested in a non-hypnotic context. The participant is of low-medium hypnotic suggestibility (HGSHS:A). Part 1 of this study was performed in a laboratory setting and consisted of the hand lowering condition only. Part 2 was performed remotely via MS Teams and consisted of 3 randomly presented conditions (hand level; hand raising; hand lowering). Results showed that the video protocol was effective and distinctive arm movement response to verbal suggestion was recorded in each condition. This experiment demonstrates that objective quantification of the effect of verbal suggestion on item 3 (hand lowering) of the Harvard Group Scale of Hypnotic Susceptibility Form A (Shor and Orne, 1962) can be implemented remotely, as well as in laboratory conditions.

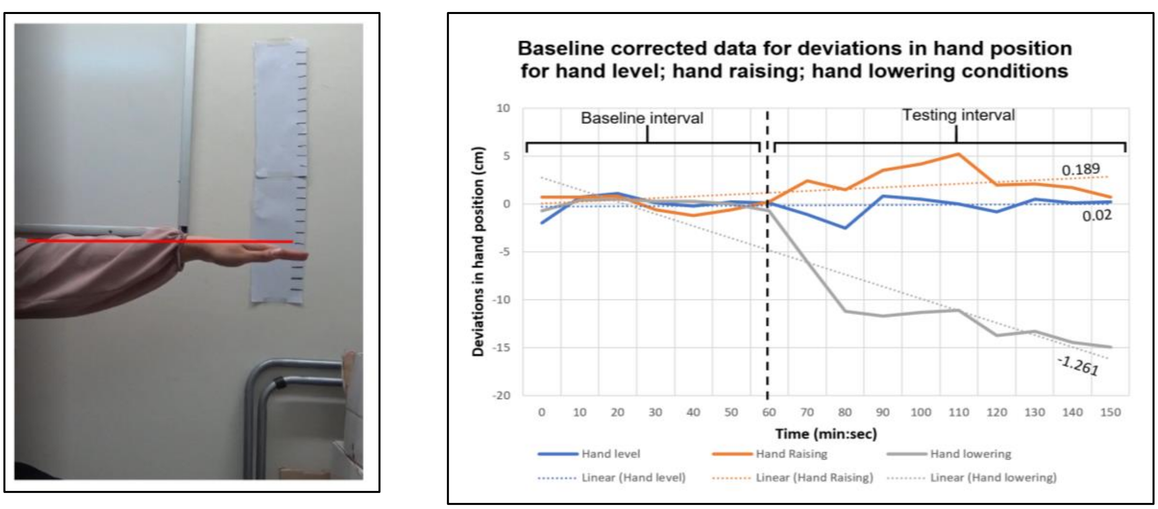

Figure 2: Video frame during arm heaviness procedure (left panel) and data from 3 experimental conditions (arm level, feelings of lightness (raising) and heaviness (lowering). The procedures and results were replicated in a remote setting using MS Teams.

Experiment 10 again uses video capture of hand lowering behaviour in response to direct verbal suggestion. In this preliminary study, a 2x2 repeated measures design was used to investigate hand lowering in response to direct verbal suggestion (DVS) for arm heaviness, based on the Harvard, using objective scoring methods. Participants were 11 individuals (1 male, 10 females) with a mean age of 22.8 years (SD=6.4). Edinburgh Handedness Inventory (EHI) scores between -100 to -40 indicate left-handedness, between -40 to +40 suggests ambidexterity, and 40 to 100, right-handedness. Participants' mean score was 63.4 (SD=44.4). The experimental procedure was approved by the King's College Research Ethics Committee (Reference Number: LRM-21/22-10339) and conducted in accordance with the Helsinki declaration (2013). Neither small weights (20g or 100g) attached to the arm (Figure 3), nor subtle variations in wording ("slightly" versus "extremely" heavy) of the suggestions influenced arm displacement. Self-report estimates of hand lowering (M=9.8cm) did not significantly differ from objective video findings (M=12.9cm). However, mismatches occurred between participants' estimates and their judgement about passing or failing the item, questioning the reliability of self-report techniques.

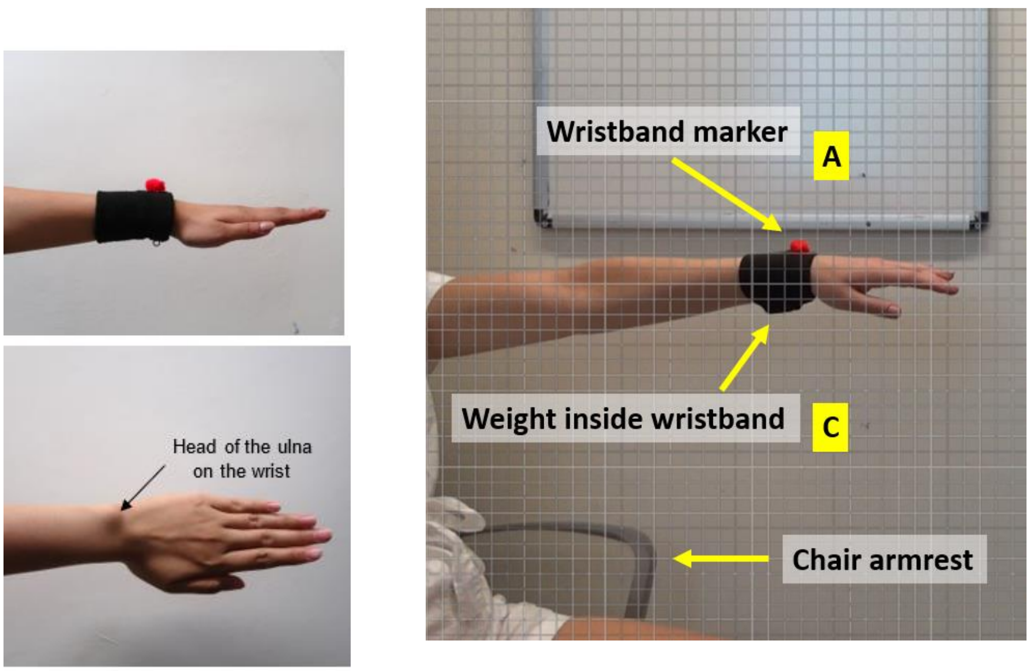

Figure 3. During the experiment, participants were instructed to sit up straight, close their eyes and extend their left arm in front of them. Image shows a seated participant with a black weighted wristband (including red marker over head of the ulna) attached to their elevated left arm at the start of a trial. Wall markings A-D which were used to positionally lock the video analysis are also labelled. Grid lines were superimposed during video analysis to facilitate measurement

Experiment 11: Direct Verbal Suggestion (DVS) refers to forthright, repeated verbal statements, intended to influence cognition and behaviour. DVS has traditionally been considered within a hypnotic context, but more recently also focuses on standalone test-items, which objectively measure responsiveness to suggestion without hypnosis. Susceptibility to DVS is a stable trait, however, manipulations of expectancy can moderate response. Experiment 11 used a within-subjects design study, and in 4 blocks, the participants' left arm was video-recorded as they completed test-item 3, of the Harvard Group Scale of Hypnotic Susceptibility. Twenty-two participants (18 female) completed the study; mean age 25.2 (SD=6.0 years). Eighteen participants self-reported as right-handed on an adapted version of the Edinburgh-Handedness Inventory (Oldfield 1971), (Mean EHI score = 79.5, SD = 19.6). Blocks 1 and 4 replicated Harvard procedures, and participants simply responded to suggestions for arm lowering. In the two counterbalanced intermediate blocks, a 150-gram weight – either large or small in appearance but identical in weight was attached to the participant's wrist (Figure 4). Traditional Bayesian approaches would predict that the larger weight viewed at the start of each block, would be estimated as heavier than the smaller weight and therefore result in greater arm lowering. A proprioceptive account, based on felt weight alone, would predict no difference in arm lowering for the small and large weights, as both weighed 150-grams. Results showed that there was no difference in the amount of arm lowering for the small and large weight conditions. Therefore, proprioceptive rather than Bayesian accounts better explain these results. Surprisingly, participant's arm lowering did not differ for the 'no weight' (Blocks 1 and 4) and 'weight' (blocks 2 and 3) conditions.

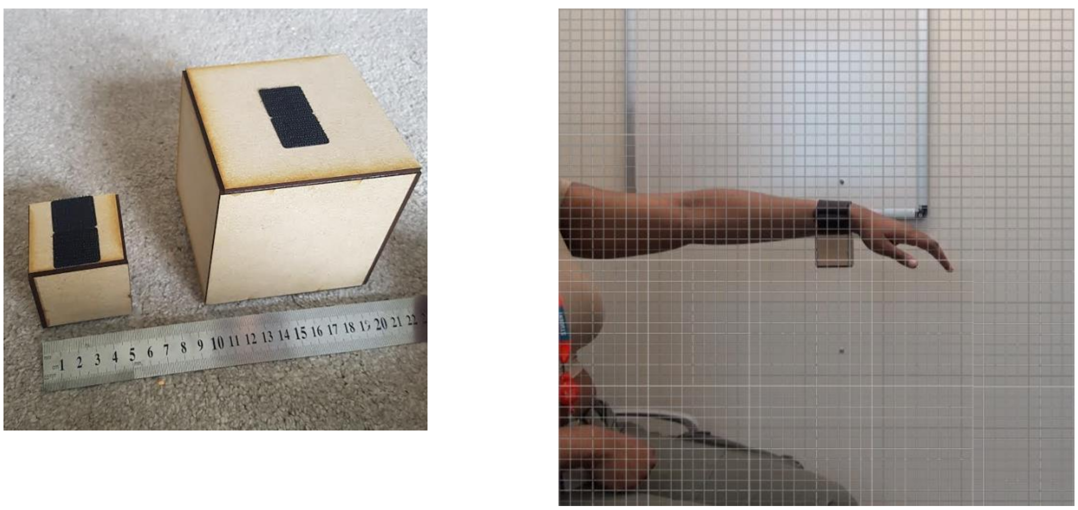

Figure 4. The stimuli consisted of 2 tagboard cubes, a small cube (5.1cm) and a large cube (10.2cm). Both cubes were identical in weight (150 grams), though were visually very different (in size).

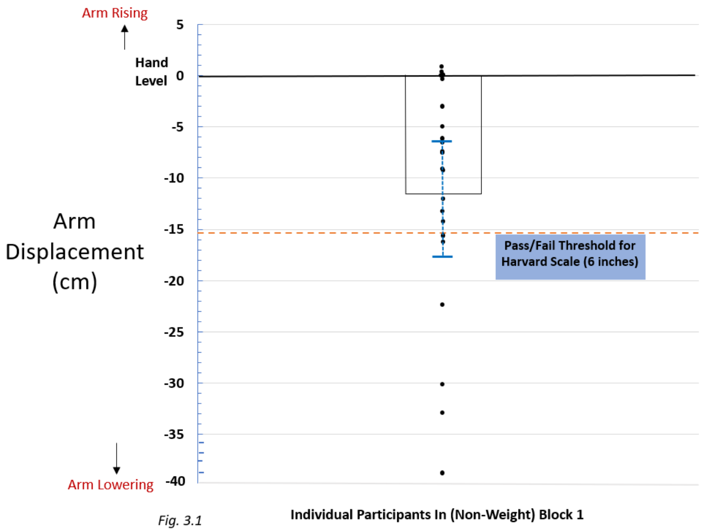

Figure 5. Bar graph showing the mean arm displacement of 11.8 cm for Block 1 (N=22). Error bar denotes standard deviation. Dots indicate arm displacement for individual participants.

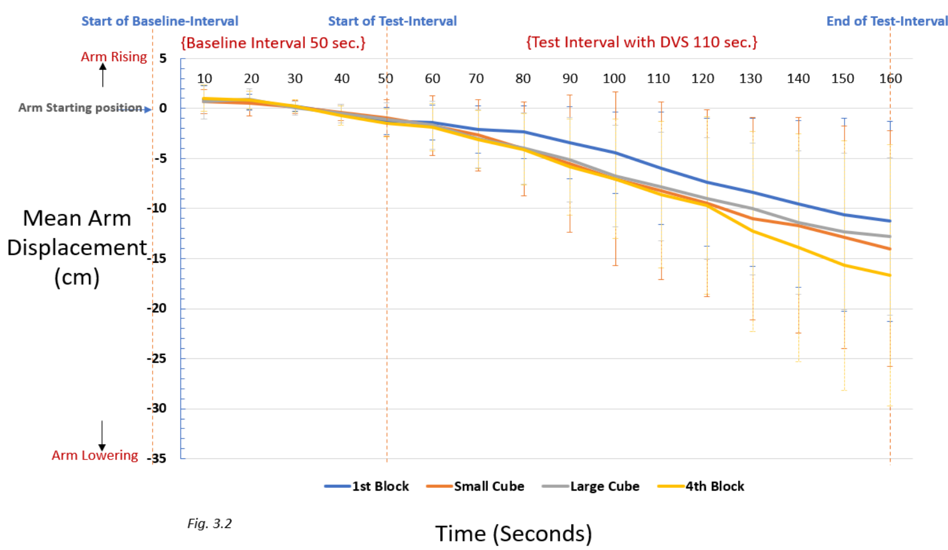

Figure 6. Mean arm-displacement (n=22) for the baseline and test-intervals ordered by the 4 experimental conditions. Error bars denote the standard deviations for Small-Cube and Large-Cube as well as for Control blocks 1 and 4 (no cube). Note how the arm position lowers for all 4 Blocks during the test-interval.

When a pair of objects of the same weight but of different size, are visually presented at the same time, the smaller object of the two feels heavier when lifted, a phenomenon known as the Size Weight Illusion (SWI). Nineteen of 22 participants reported that the smaller-cube felt heavier than the (equally heavy) larger-cube, or that the larger-cube, felt lighter than the smaller-cube t (21) = -3.5; p = .002, *d* = -.74 CI [-1.2, -.26]. thereby demonstrating the Size-Weight Illusion.

The central role of language, especially as it relates to Direct Verbal Suggestion has been considered. The finding that experientially congruent DVS in the 'hand-lowering task' results in congruent behaviour, has been demonstrated and objectively measured using video analysis (Figures 5; 6). In Experiment 11, attempts were made to manipulate participants' expectations prior to the commencement of the task and during the task. Prior vision did not appear to modulate proprioception and having an actual weight attached to the wrist, instead of an imagined weight, did not result in a greater degree of arm-lowering. The lack of effect of cube size is best explained in terms of a 'weight-dominant account'.

Experiments 12, 13 and 14 employ the same arm lowering / video analysis protocol for 3 different research questions. The aim of **Experiment 12** was to test the responsiveness of the upper limb during suggestions of heaviness and lightness (see also case study Exp. 9 above). In a counterbalanced, within-subjects design, 18 healthy participants listened to suggestions of either arm heaviness or arm lightness. Results show that suggestions of heaviness were associated with mean arm lowering (-13.4cm; $p<0.001$), while suggestions of lightness was accompanied by mean arm raising (+5.8cm; $p<0.034$). Heaviness suggestions were accompanied by a faster rate of movement (mean rate = -6.2cm/min) than lightness suggestions (mean rate = 2.7cm/min); $p<0.05$. Moreover, the HGSHS self-report for passing the threshold for arm lowering (≥-15cm) and arm levitation (≥15cm) were inconsistent with the actual observed responses captured by video.

Experiment 13 asks if the left arm is more suggestible than the right arm in the same individual. Eighteen participants (12 female) participated in the arm lowering protocol; mean age = 24.7, SD = 4.3 years; mean handedness score (EHI; Oldfield, 1971) was 508.3. A paired samples t-test indicated that there was no difference between the lowering of the arm between the left arm (M = -22.8, SD = 16.6 cm) and right arm (M = -18.8, SD = 15.0 cm); $t(17) = -1.43$, $p = 0.172$, $d = -336$, two-tailed). Video was used to track both the left and right arm during performance of Harvard Item 3 (Arm Lowering). Using standard Harvard subjective procedures, no difference was noted in pass rates for the left and right arms. Interestingly however, objective measures of the actual pass rates using video analysis confirmed that the pass rate for the left arm was greater than that for the right arm (Table 1).

Table 1. *Pass rates (> 15cm) for the left and right arms as measured by the Harvard Objective Response and by video recordings, with Chi-Square analyses (N=18).*

	Pass Rate (%)			
	Left Arm	**Right Arm**	**χ^2**	**p**
Harvard Objective	66.7	44.4	2.81	.094
Video	66.1	44.4	9.2	**.002**

Finally, **Experiment 14** asks if response to Direct Verbal Suggestion (DVS) delivered in 2 different voices results in different response. Eighteen healthy participants listened to the same audio scripts for arm lowering presented in two contrasting voices, a Natural Male voice, and a Synthetic Female voice, presented in counterbalanced order. The language of the audio was English (British). The Natural Male voice was recorded by a male actor. We used Adobe Audition 2021 (version 14.2.0.34) for noise reduction and the Text-To-Speech (TTS) tool in the video editing software Capcut (version 2.2.0) to generate a Synthetic Female voice version of the script. The empathetic female voice feature in Capcut was selected for generating the Synthetic Female voice. The content wording of the audio scripts for both conditions were identical. Audacity (version 3.3.3) was used to match the two audios so that the onset of each spoken phrase was time-matched, and the overall length of both audios were exactly five minutes and six seconds in duration, matching previous studies (Oakley et al., 2020). To measure participants' perception of both experimental voices, participants rated each voice on a 0 to 7 scale (McLean et. Al). Otherwise, the methodology was the same as Experiments 12 and 13 above, using the modified HGSHS:A procedures (subjective measure) to determine pass rate, where people estimate whether their arm lowering exceeds a threshold (≥ 15cm).

Participants rated the human male voice as more ‘socially present’ (p=0.001); ‘intelligent’ (p=0.003); ‘socially attractive’ (p=0.027); ‘natural’ (p=0.015) and older (p=<0.001) than the synthetic, female voice. Participants rated the male voice as influencing their arm movements more powerfully than the female synthetic b=voice (p=0.015). Participants rated the Natural Male voice as having a stronger effect on their Arm Lowering than the Synthetic Female voice (subjective measure). Significant Arm Lowering displacement was observed for both voice conditions. However, the objective video-recorded results, revealed no actual difference in arm lowering for the two voices; male voice (Mean = -16.9 cm, CI: [-23.9, -9.8]) and Female voice (Mean = -17.3 cm, CI: [-25.4, -9.3]); t(17) = -0.284, p = .780, Cohen’s d = -.067. Therefore, voice type influenced subjective ratings of how effective the voice was, but not objective (video) measurements. The divergence between subjective questionnaire responses and objective video analysis underscores the complex interplay between perception and reality in DVS.

In summary, in **Progress Report 3**, eight further experiments were conducted, building on previous research. Experiment 7 explored the impact of verbal suggestions on tickle and itch perception, demonstrating that machines could deliver precise tactile stimulations influenced by verbal suggestion. Experiment 8 utilized verbal suggestions with a warming procedure, affecting the explicit representation of the forearm but not the hand. Experiment 9 introduced a remote protocol for measuring the effects of verbal suggestion on arm movements. Experiment 10 revealed mismatches between self-report and video findings in hand lowering. Experiment 11 explored arm lowering responses to different weights and the Size-Weight Illusion, emphasizing the role of language in direct verbal suggestion (DVS). Experiments 12-14 investigated responsiveness to suggestions of heaviness and lightness, left vs. right arm suggestibility, and the influence of different voices on DVS. The findings highlighted the complex interplay between subjective perceptions and objective measurements in the context of DVS.

In conclusion, this research project involved the successful execution of 14 experiments, which encompassed a diverse range of studies, including a case study and a pilot investigation. This comprehensive approach allowed us to delve into the nuances of assessing the effects of verbal suggestion on body representations and somatosensory cortical processing in the brain. An integral aspect of our progress lies in the development of a novel protocol, specifically tailored for evaluating the impact of verbal suggestion. This innovation involved adapting the arm lowering (ideomotor) item in the Harvard Group Scale, as detailed by Shor and Orne in 1962. This enhancement not only contributed to the robustness of our methodology but also signifies a noteworthy advancement in the field.

Together, results from this series of experiments show that verbal suggestion procedures without a conditioning stimulus, can affect both implicit and explicit body representations. Verbal suggestion can influence laterality of sensory effects i.e., make one limb relative to the other more sensitive to touch. Stimulation was observed to habituate over time and repeated stimulation resulted in a decrease in sensitivity. Verbal suggestion moderated the extent to which these sensory effects decreased over time. This indicates that verbal suggestion has the capacity to gate the perception of touch, which has important clinical implications. For example, habituation to repetitive painful stimulation may help protect against the development of chronic pain states. Language is powerful and not only plays a key role in the construction of the self but can also influence somatosensory and bodily perception. Experiment 8, for example, stands as a particularly promising avenue, with the potential to chart a sensory-linguistic map of suggestibility for each body part, akin to Penfield's homunculus. Such a map could deepen our understanding of individual variations in suggestibility, paving the way for personalized approaches in various contexts.

One limitation encountered in psychology experiments examining tactile stimulation pertains to the inconsistency in stimulus delivery when presented by hand, leading to potential variations in each trial. To address this issue, we developed and designed two novel experimental devices. The first device is a manually operated apparatus designed to administer tactile stimuli to the back of the hand, either laterally or longitudinally, specifically tailored for a 2-point discrimination task. This innovation aims to enhance precision and standardization in stimulus delivery, mitigating potential confounding factors associated with manual administration. The second device constitutes a tickle machine, featuring a 2Hz electric motor positioned beneath a mouse pad. This machine ensures consistent and reliable tactile stimulation e.g., tickle to itch, to the palm of the hand. The incorporation of this device is intended to overcome the variability introduced by manual administration, providing a more controlled and replicable experimental environment for studying tactile perception.

Our commitment to fostering the next generation of scientists is evident in the training provided to 12 MSc students, 2 BSc students, and 2 Nuffield Placement students in experimental techniques. By imparting knowledge and hands-on experience, we have laid the foundation for their future contributions to the scientific community. In achieving these milestones, we have successfully met the specific aims of this project. We have not only advanced our understanding of the effects of verbal suggestion on body representations and cortical processing but have also uncovered individual differences in susceptibility to such suggestions. Moreover, by training and inspiring a cohort of budding scientists, we have set the stage for ongoing and future exploration in this exciting field. In these ways, the specific aims of this project, to assess the effects of verbal suggestion on body representations and somatosensory cortical processing in the brain; to assess individual differences in susceptibility to verbal suggestion targeted at body representation, and to provide opportunities for future scientists are reached.

Acknowledgements:

Special thanks to MSc Students Louis Taylor, Laraib Mirza, Laura Coronel Hernandez, Oluwatomi Arisa, Mailin Kullmann (Exp. 7); Shagana Gopalakrishnan (Exp.8); Mahnoor Mahmood (Exp.9); Anastasia Mattingley (Exp.10); Alistair Good (Exp.11); Nafisa Islam (Exp.12); Rachael West (Exp.13), and Liyuan Liu (Exp.14), to BSc Students Neila Zaara, and Anna Misztal, and lastly to Nuffield Research Placement post-primary school Students Sumayya Hakim and Zalanda Shinwarie.

This work was funded by Bial Foundation grant Nr. 198/16.