Vestibular stimulation does not modify the body schema

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Abstract

Studies have reported an altered body schema during caloric vestibular stimulation. Caloric stimulation involves artificially stimulating the horizontal semicircular canal by applying hot water or air to the ear canal. Others tried unsuccessfully to replicate the findings, and the absence of a mechanism explaining the observation renders further replication attempts necessary. In this study, we aimed to replicate the original study by Lopez et al. (2012) and tested whether the body schema is altered during either passive body movements or caloric vestibular stimulation. Participants (within-subject design, N = 40) reported their perceived size of the hand via a tablet during caloric, natural, and no vestibular stimulation. For natural vestibular stimulation, a motion platform was used to passively move the entire body in the upward / downward direction. Our results show that vestibular stimulation does not cause significant changes compared to the sham condition ($p = .59$) on the perceived width of the hand. At the same time, the difference in perceived hand length is significant ($p < .01$). This indicates that the connection between the vestibular organ and the body schema is more complex than previously believed. This study contributes to the ongoing discussion on the influence of vestibular input on the body schema and highlight the importance of replication studies in scientific research.

Keywords: vestibular stimulation, body schema, replication study, cognitive psychology

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1. Introduction

The concept of the body schema is central to our understanding of how we perceive and interact with the world around us. Ataria et al. (2021) defined the body schema as a representation in a sensorimotor format of bodily parameters essential for planning and controlling actions. Its role is both to describe these parameters and to guide or influence bodily movements. It acts as an efficient and flexible representation of our body in space (Macaluso and Maravita, 2010), integrating sensory input from multimodal sensory information, including vestibular stimulation, to adjust the mental representation of our own body (Haggard and Wolpert, 2005). Studies underscore the adaptability of the body schema by demonstrating its ability to transform our perception of our body's size to incorporate tools into our self-representation. This adaptability underscores the flexibility of the body schema and its capacity to integrate external objects into our body representation, as demonstrated by Maravita and Iriki (2004) and Cardinali et al. (2009). The adaptability of the body schema is not just limited to one's own body, as it also takes part in the perception of others. Through this, the body schema plays an important role in embodied social cognition (Haggard and Wolpert, 2005; Ferrè et al., 2014).

However, despite these advances in understanding the body schema's adaptability and its critical role in perception and action, the journey towards fully comprehending its complexities is far from over. The demonstrated adaptability of the body schema is evidenced by its integration of external objects into our bodily representation and its crucial role in both personal and social perception. This opens intriguing questions about the contributions of various sensory modalities to the body schema and the extent to which they provide a foundation for the sense of one's own body. In this context, Carruthers (2009) brings to light a critical perspective, arguing that the precise contributions of different modalities to the body schema remain difficult to understand. Moreover, he questions whether the body schema encompasses adequate mental resources to foster a robust sense of ownership over one's own body. This argument introduces a significant layer of complexity to our understanding, suggesting that our grasp of the body schema's integration and function is far from complete. If it is true that the body schema is not capable to create a sense of ownership on his own, it further opens the question which systems help the body schema out.

We construct an understanding of our own body in multiple ways, not only through the body schema. Another crucial part is the vestibular system, which significantly contributes to our sense of self-location (our position in space) and our first-person perspective (how we view the world around us). This system is, therefore, vital for experiencing changes in how we perceive our bodily self (Lopez et al., 2008; Ionta et al., 2011). The vestibular system's main job is to keep us oriented in space and ensure that our vision remains stable, helping us maintain balance, particularly during movement. It achieves this by detecting head accelerations through the vestibular end-organ, which sense both angular and linear accelerations. The central nervous system then uses this data to keep our gaze steady when we move our heads (Fife, 2010).

As both the body schema and the vestibular system interact with bodily self-consciousness, it makes sense to explore the different ways to influence the body schema through the vestibular system. One method of stimulating the vestibular system is natural movement and, among others, also caloric vestibular stimulation (CVS) as a more experimental approach. CVS involves the use of hot or cold air to alter the firing rate of the vestibular nerves, effectively stimulating the vestibular system (Black et al., 2016). It has been used in several studies (André et al., 2001; Schonherr and May, 2015; Schönherr and May, 2016) to manipulate the body experience.

Sedda et al. (2016) tested the sensory input of CVS to alter the perceived temperature of the participants' limbs. The results showed a drop in temperature in both arms after CVS. CVS was also used to increase the perceived length and width of the left hand during active-stimulation in comparison to the sham-condition (Lopez et al., 2012, 2018). These findings highlight the capabilities of the body schema and how we can induce and evaluate changes in its mental representation.

Contrary, (Karnath et al., 2019) reported no significant effect of vestibular stimulation on the internal representation of the physical dimensions of our body during CVS.

Due to the inconclusive literature, our aim is to replicate Lopez et al. (2012). Furthermore, we challenge the original statement by introducing a condition with natural vestibular stimulation by means of passive body acceleration.

If there is a connection between the vestibular organ and the body schema, both types of stimulation (natural and artificial) will lead to a change in perception of the left hand. In addition to the study of Lopez et al. (2012), we add new perspectives to the ongoing discussion about how our perception of our bodies is influenced by different types of stimuli, and we test to what extent the general statement of the original document holds up when we examine it using real-life conditions of balance and motion testing.

The experiment, analysis, and predicted outcomes were preregistered (osf.io/cnhsu).

2. Methods

2.1. Participants

To ensure comparability with the original study by Lopez et al. (2012), which utilized 17 participants (mean age 25; range 22–29 years; standard deviation = 2), we recruited 40 healthy participants (32 female; mean age 22.8; range 19–30 years; standard deviation = 2.2; all right-handed) from the University of Bern. The sample size of 40 participants surpasses the minimum number of participants required, as determined through a power analysis. The analysis, carried out with a power of 0.8, a mean effect size of 0.25 (estimated from the original work) and an alpha error probability of 0.05, indicated a minimum of 28 subjects needed for the test. We increased the sample size from 28 to 40 individuals to ensure that the number of participants beginning the experiment with active CVS or CVS-sham matches the number of participants reported in the study by Lopez et al. (2012). This expansion also enables the organization of participants into four equally sized groups for the order of conditions.

All participants were right-handed students who received credits for their participation. Additionally, participants were selected to be less than 1.70 meters in length to ensure that their hand size did not exceed the dimensions (25.65cm) of the available tablet (Lenovo Yoga Tab 3 10). The procedure was approved by the Ethics Committee of the Faculty of Human Sciences at the University of Bern, and written consent was obtained from all participants.

2.1.1. Caloric vestibular stimulation (CVS)

For the active CVS conditions, we closely replicated the methodology of the original study, using a constant air flow. Warm air (47 °C) was blown into the right ear (Airmatic II, Diatec), while cold air (20 °C) was blown into the left ear. To ensure precise temperature control, we used ICS AirCal (Diatec) for the left ear, as it is more effective in maintaining a consistent temperature of 20 ° C compared to Airmatic II.

Participants underwent 60 seconds of stimulation during this condition, followed by completing the task for 120 seconds, then receiving another 60 seconds of stimulation, and finally finishing the remaining tasks. During CVS, participants' nystagmus was confirmed using an eye-tracker (eVNG - BioMed 19-2008.22). Participants were instructed to relax their eyes, keep their gaze straight ahead, and refrain from closing their eyes during CVS stimulation.

2.1.2. Sham-Condition for CVS

Applying 37°C air to both ears is a common sham stimulus (Baguley et al., 2011; Preuss et al., 2014) and was also used in the original study. This ensured identical test conditions in the sham CVS setup, with the only distinction being the vestibular stimulation. The duration of the sham stimulation was equal to the active stimulation. Refer to Figure A.1a for an illustration of a participant with an eye-tracker and their hand positioned below the tablet. No nystagmus was observed during sham stimulation.

2.1.3. Platform

To provide a natural stimulation, we employed a Six-Degree-Of-Freedom Motion Platform (Moog 6DOF2000E). The motion platform was operated through PlatformCommander, an open-source software package designed to interface the motion platform. This software enables the creation of sinusoidal acceleration patterns, commonly utilized in the assessment of vestibular sensitivity (Ertl et al., 2022).

We concentrated on vertical oscillations to reduce potential interference with task-specific hand movements in the horizontal plane. The maximum vertical displacement achieved in these movements was 0.3 meters in both upward and downward directions. Each phase of the movements, upward or downward, was completed in a duration of 1.5 seconds, resulting in a total cycle time of 3 seconds for a complete upward and downward movement. Consequently, the frequency of these oscillations was 0.333 Hz. According to the findings of Fitze et al. (2024), this frequency surpasses the threshold necessary for the consistent perception of motion stimuli acting on the participants body.

During both active and sham condition, participants were blindfolded. To ensure the absence of residual visual input, the experimental room was dimmed while participants completed the task.

2.1.4. Platform-sham

To maintain consistency in auditory and positioning cues, we implemented a sham condition where participants sat on the platform without any movement. The platform was turned on during the sham condition and in standby condition, which is 0.3 meters lower than the center condition during movement. For reference, please see Figure A.1b, which depicts a participant blindfolded while sitting on the platform.

2.1.5. Localization task

Participants placed their left hand palm-down on a table in front of them. On top of the hand was a wooden board with the tablet on top. Velcro secured the participant's middle finger, preventing hand movement and ensuring a standardized position across participants. The task involved locating four anatomical landmarks on the left hand: the knuckle of the little finger, the knuckle of the index finger, the tip of the middle finger and the wrist (Figure A.2). The landmarks were explained to the participants in written form previous to the experiment, and we ensured that the participants understood the task.

During the experiment, audio cues were presented through the tablet and instructed which landmark to touch. To mitigate the impact of the platform's auditory noise, participants wore headphones to receive the audio cues. In the CVS conditions, participants heard the audio cues through the tablet's built-in speakers during the 120s intervals between the stimulation.

Our decision on how to order the different parts of our task was based on something missing in the methods of the study by Lopez et al. (2012). They did not describe the exact order for the localization task in combination with the stimulation. Initial pilot tests conducted under CVS showed that participants struggled to hear audio cues due to loud noise from the stimulation. This led us to modify our study's approach to ensure accurate data collection.

The instruction were given in German language. Participants responded by touching the tablet right above the requested landmark with their right index finger. The tablet registered the touched x/y-coordinates and confirmed the successful contact with a short sound. Each condition comprised 40 trials, with each of the four landmarks presented 10 times, in a randomized order. The inter-stimulus interval was 5 seconds.

In contrast to Lopez et al. (2012), we have consistently randomized the order of the landmarks throughout the conditions. We did this because we assume that it reduces the training effect.

2.1.6. Hand Dimensions

We measured the perceived length and width of participants hands by means of the Euclidean distance between two landmarks. Perceived length was defined as the distance between the wrist and the tip of the middle finger, while width was calculated as the distance between the knuckles of the index and pinkie fingers (Figure A.2).

2.1.7. Order of conditions

The 40 participants were divided into four groups of 10 individuals each, with each group assigned to a specific sequence of experimental conditions. In the first group, the order of conditions was active platform, platform-sham, active CVS, and CVS-sham. The second group followed the sequence active CVS, CVS-sham, active platform, and platform-sham. The third group undertook the order platform-sham, active platform, CVS-sham, and active CVS. Lastly, the fourth group underwent the conditions in the order CVS-sham, active CVS, platform-sham, and active platform.

2.1.8. Subjective reports

Following each condition, participants completed a German questionnaire adapted from Cox and Swinson (2002). Like Lopez et al. (2012), we selected only the questions related to body perception. Items included sensations of strangeness, numbness, detachment, dizziness, blurred near-far distinction, and perceived movement. Responses were rated on a scale from "Do not agree at all[0]" to "Completely agree[4]," with an additional "Yes[0]" or "No[1]" response for perceived movement. Participants were instructed to recall the moment of strongest stimulation for their answering.

2.2. Statistics

To evaluate the significance of our findings, we employed one-sided paired t-tests to estimate differences in the perceived width and length of hand size under different conditions. We went for one-sided tests based on our directional hypothesis, which anticipates findings consistent with those reported by Lopez et al. (2012). Specifically, we hypothesized that perceived hand width and length would be greater under active conditions compared to their respective sham conditions. When comparing both active conditions against each other and also the two sham conditions against each other, we used two-sided paired t-tests, because no significant differences between these conditions were assumed.

To account for the increased risk of Type I errors associated with multiple comparisons, we implemented the Bonferroni procedures. The Bonferroni correction, which is known for its conservative control of the family-wise error rate (FWER), reduces the likelihood of false positives (Cudeck and O'Dell, 1994; Cribbie, 2000) and is best suited when testing for pairwise comparisons with parametric data (Midway et al., 2020).

Contrary to the approach taken by Lopez et al. (2012), who used the t-test for their analysis of the questionnaire, we went for the Wilcoxon signed-rank test instead due to the ordinal nature of the scale and the comparison being limited to only two conditions.

The statistics for the data analysis in this study was also registered ahead of time (osf.io/cnhsu).

3. Results

3.1. Width

The mean and SD of the hand width as indicated by the participants was 11.23cm $\pm$ 3.59 for active CVS, 10.88cm $\pm$ 3.70 for CVS-sham, 11.02cm $\pm$ 3.53 for active platform, and 10.79cm $\pm$ 3.49 for platform-sham. The analyses showed no significant difference in hand width between active CVS and CVS-sham conditions (p = .36, $t = 1.81$, $df = 399$, one-sided paired t-test) or active platform and platform-sham conditions ($p = 1.00$, $t = 1.2$, $df = 399$, one-sided paired t-test). The difference between the active platform and the active CVS was ($p = 1.00$, $t = -0.99$, $df = 399$, paired two-sided t-test). An overall comparison of active vs. sham in both conditions also did not reveal significant changes ($p = 1.00$, $t = 0.66$, $df = 399$ two-sided paired t-test). The variation in the left hands' width between active CVS and CVS-sham conditions is presented in Figure A.3a, while the comparison of active platform and platform-sham is illustrated in Figure A.3b. The touches on the tablet under the CVS-sham condition are shown in Figure A.6a, while the touches for active stimulation in CVS are shown in Figure A.6b. The positions of the touches in platform-sham are seen in Figure A.7a, while the touches for the active stimulation in platform are shown in Figure A.7b. The overall change in hand perception in all conditions is seen in Figure A.8.

3.2. Length

The perceived mean length of the hand was 19.04cm $\pm$ 5.27 for active CVS, 19.31cm $\pm$ 5.23 for CVS-sham, 20.43cm $\pm$ 5.38 for active platform, and 19.73cm $\pm$ 5.18 for platform-sham. The analyses indicated no significant change in the perception of length between active CVS and CVS-sham conditions ($p = 1.00$, $t = -1.25$, $df = 399$, one-sided paired t-test), but between active platform and platform-sham conditions ($p<.01$, $t = 3.15$, $df = 399$, one-sided paired t-test) with an effect size of ($d = .13$). The difference between active platform and active CVS was also significant ($p<.01$, $t = 5.65$, $df = 399$, two-sided paired t-test) with an effect size of ($d = .26$). An overall comparison of active vs. sham within both conditions also showed significant changes ($p<.01$, $t = 4.41$, $df = 399$, two-sided paired t-test) with an effect size of ($d = .04$). Figure A.4a showcases the alteration in the left hands length when comparing active CVS to CVS-sham. Insights into the change in length of the left hand across active platform and platform-sham conditions are provided in Figure A.4b. The overall median percentage change for the left hand is captured in Figure A.5, highlighting the overall impact across conditions.

3.3. Questionnaire

The comparison of responses from the Cox and Swinson's questionnaire revealed a significant change in the answers from question "My body feels somehow strange or different" for active platform vs. platform-sham ($p<.01$, $V = 281$). The answers from question "My body feels numb" where different for active platform vs. platform-sham ($p = .01$, $V = 187$). "I have a feeling of detachment or separation from my own body" was different for active platform vs. platform-sham ($p = .02$, $V = 163.5$). The question "I feel dizziness" was answered differently for active CVS vs. CVS-sham ($p = .03$, $V = 209.5$) and active platform vs. platform-sham ($p<.01$, $V = 222$). "The distinction between near and far is blurred" was also different in active platform vs. platform-sham ($p<.01$, $V = 156$). The comparison of "Did you perceive any movement during the experiment?" was different for active platform vs. active CVS ($p<.01$, $V = 0$) and active platform vs. platform-sham ($p<.01$, $V = 0$). Detailed results of the statistical tests are provided in Table A.1 and Table A.2. Mean scores for different questionnaire items are presented in Table B.3.

4. Discussion

The primary objective of this study was to replicate and extend the findings of Lopez et al. (2012) regarding the effects of CVS and natural vestibular stimulation on the perceived hand size. Our results, based on a comprehensive dataset from 40 participants, did only reveal a significant alteration in perceived hand length, nor perceived hand width. This alteration took place in natural stimulation when active platform vs. platform-sham, active platform vs. CVS, and the overall comparison of active vs. sham condition was compared. It is noteworthy that the effect sizes of the significant results are only within the limits of a small effect size (Cohen, 1990). Consequently, it raises questions about the meaningful impact of the interventions tested on the perception of the hand. The participants maintained a consistent posture across all conditions. Therefore, the posture does not explain the observed significant difference between the active platform and active CVS conditions. This lack of consistence significant differences in perceived hand size between active and sham conditions challenges the original study's interpretation regarding the relation between vestibular stimulation and body schema. Or at least, it highlights the uncertainty regarding the significance of this relationship in everyday life. Our findings align more closely with those reported by Karnath et al. (2019). In their study, they enlisted healthy participants and asked them to adjust the placement of blocks within a 3D virtual reality scenario until the participants felt they could barely touch the blocks with their left or right hand or heel. They observed that participants did not experience any changes in the perceived size of their limbs during the experiment. This led them to conclude that the egocentric representation of our body's midline and the internal representation of our body's metric properties (such as size and shape of large body parts) are managed by different systems within human body representation.

While our findings did not align with the prior study's outcomes, it is important to consider various factors that could contribute to discrepancies between research outcomes. Variables such as the number of participants, their specific traits, and the methods used can all influence the outcomes of studies. Lopez et al. (2012) showed an effect size of $d = .49$ for the comparison of hand width in active CVS vs. CVS-sham conditions, while our study observed a significantly smaller effect size of $d = .01$ for the same comparison. Lopez et al. (2012) found an effect size of $d = .49$ in the comparison of lengths, our findings indicated a smaller and negative effect size of $d = -.05$. The effect sizes mentioned by Lopez et al. (2012) were obtained from the data shown in the study's graphs, since these values were not explicitly documented in the study's text. In our case, having a larger group of participants gave us the advantage of being better equipped to identify even minor effects. Since we had more than twice the number of subjects, our data should be more accurate. The significantly higher sampling size resulted in a better estimate of the effect size.

Differences in sample size, participant characteristics, and methodology could all play a role in shaping research results. In the context of our study, the larger sample size allows for increased statistical power to detect even subtle effects. However, it's worth noting that the intricacies of sensory and cognitive processes are complex and may vary between individuals.

Our questionnaire responses did have interesting results, showing a significant increase in the perception of movement during active platform stimulation compared to the CVS conditions. This could be, because of the clear movement, that participants felt during the active platform condition and the critical attitude towards CVS stimulation.

This study's outcomes raise intriguing questions about the specificity of vestibular effects on the body schema, particularly regarding hand dimensions. Future research endeavors could explore how different types of vestibular stimulation impact other dimensions of the body schema, including body posture, limb movement, and spatial cognition. Moreover, delving into the neurobiological mechanisms underlying the relationship between vestibular input and body perception could offer deeper insights into the intricate connections between sensory input and cognitive processes.

Replication studies, like the one undertaken in this research, fulfill a crucial role in advancing scientific knowledge by critically assessing the reliability of previously reported findings. Our results, which did not replicate the hand size perception alterations reported by Lopez et al. (2012), underscore the importance of replication research in refining our understanding of complex phenomena. This also emphasize the necessity for further research into the broader impact of vestibular stimulation on the body schema, as well as the mechanisms underlying these effects. Such research should explore a variety of stimulation methods to find out how diferent types of stimulation modify our bodily self-perception. One methods could include employing virtual reality to simulate movement through dynamic backgrounds, and therefore making participants perceive motion. Additionally, the scope of experimentation could be expanded beyond conventional uniaxial natural stimulation. Experiments could involve participants experiencing stimulation in more complex, real-world scenarios, such as while traveling on a train or bus, to investigate the influences of different environmental contexts on body schema.

In conclusion, this study contributes to the ongoing discourse surrounding the effects of vestibular input on the body schema by striving to replicate and extend prior findings. While our results did not substantiate the reported changes in hand size perception during vestibular stimulation, they underscore the significance of replication studies in scientific inquiry. Additional investigations are warranted to unveil the intricate relationship between vestibular stimulation and various aspects of the body schema, shedding new light on the interplay between sensory perception and cognitive processes.

5. Acknowledgement

6. Limitations

While this study has provided valuable insights into the perception of the own body, it is essential to acknowledge several limitations that may impact the interpretation and generalizability of the findings. The tablet utilized in the study was of an older model and presented limitations in terms of size. Future studies could benefit from employing a larger and more up-to-date tablet to ensure participants have ample space to interact with the task. This adjustment would alleviate any potential disruption that the participants' proximity to the tablet might have caused to their performance. A more diverse participant pool would bolster the external validity of our findings. Currently, the study predominantly included university students from the University of Bern within a narrow age range. Expanding the participant demographics to encompass a broader age range could provide a more comprehensive understanding of the phenomena under investigation. This is based on findings related to the late maturation of the body schema and the changes that are still visible during adolescence and young adulthood (Assaïante et al., 2014).

7. Conclusions

In summary, this study aimed to replicate and extend the findings of Lopez et al. (2012) regarding the effects of vestibular stimulation on the perception of body dimensions, specifically hand size. While the results did not replicate the reported changes in hand size perception during vestibular stimulation, they provide important insights into the complex relationship between sensory input and cognitive processes. The lack of significant differences in perceived hand size challenges previous findings, emphasizing the importance of replication studies in refining our understanding of complex phenomena. This study also underscores the need for further investigation into the broader impact of vestibular stimulation on the body schema and the underlying neurobiological mechanisms driving these effects. As the field of cognitive psychology continues to explore the interplay between sensory perception and cognition, replication studies remain crucial tools in advancing scientific knowledge and fostering a deeper understanding of the complexities of human perception.

Appendix A.

List of all the figures and tables

Table A.1
p- and V-value of the questions compared to CVS-condition, paired Wilcoxon-test

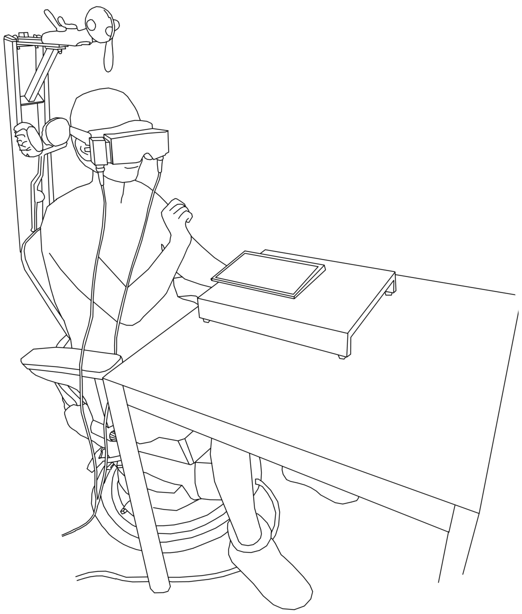
Question	Active CVS vs.	
	CSV-Sham	Active Platform
My body feels somehow strange or different	$p = .11$, $V = 161.5$	$p = .26$, $V = 83$
My body feels numb	$p = .69$, $V = 59$	$p = .64$, $V = 129$
I have a feeling of detachment or separation from my own body	$p = .07$, $V = 139$	$p = .29$, $V = 94.5$
I have a feeling of dizziness	$p = .03^*$, $V = 209.5$	$p = .78$, $V = 219$
The distinction between near and far is blurred	$p = .34$, $V = 77$	$p = .62$, $V = 82.5$
Did you perceive any movement during the experiment?	$p = .15$, $V = 18$	$p < .01^*$, $V = 0$

Appendix B. Supplementary Material

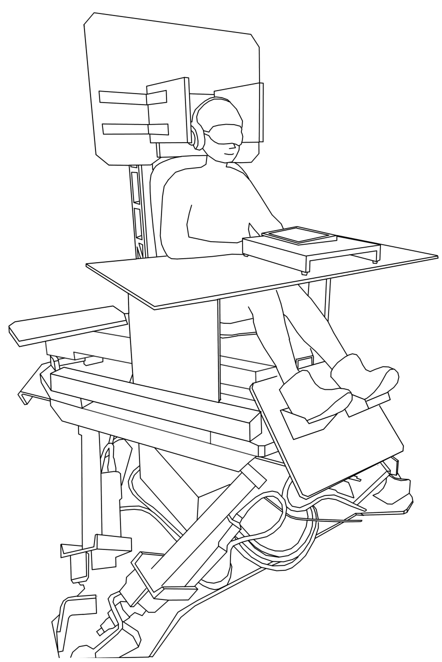
Table A.2
p- and V-value of the questions compared to platform-condition, paired Wilcoxon-test

Question	Active Platform vs.	
	Platform-Sham	Active CVS
My body feels somehow strange or different	p <.01*, V = 281	p = .26, V = 83
My body feels numb	p = .01*, V = 187	p = .64, V = 129
I have a feeling of detachment or separation from my own body	p = .02*, V = 163.5	p = .29, V = 94.5
I have a feeling of dizziness	p <.01*, V = 222	p = .79, V = 219
The distinction between near and far is blurred	p <.01*, V = 156	p = .62, V = 82.5
Did you perceive any movement during the experiment?	p <.01*, V = 0	p <.01*, V = 0

Figure A.1
Participants in both conditions



(a) Participant with eye-tracker and tablet in caloric stimulation



(b) Participant with blindfold and tablet in platform stimulation

Figure A.2
Anatomical landmarks on left hand with Euclidean distance

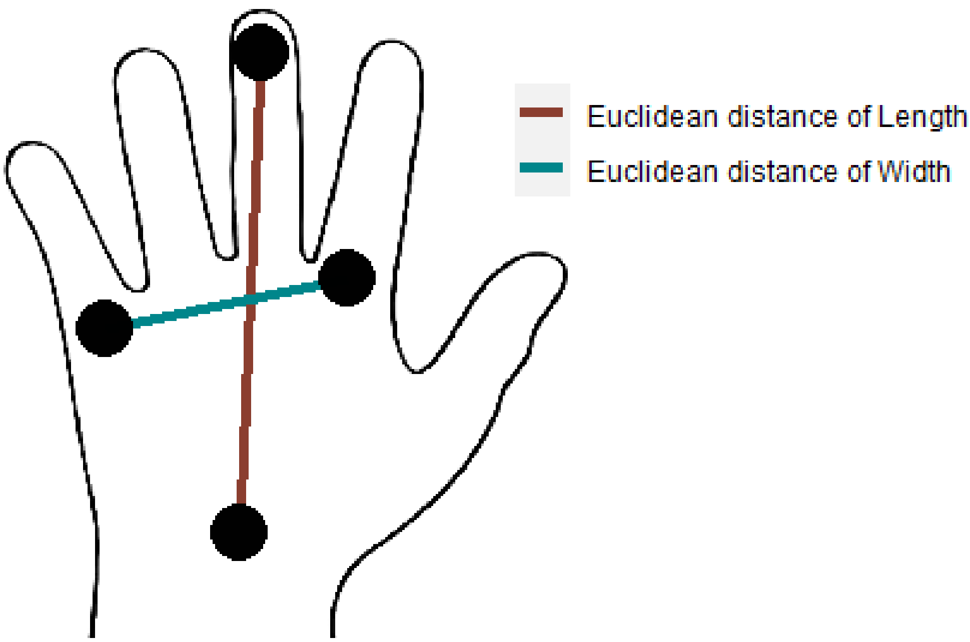
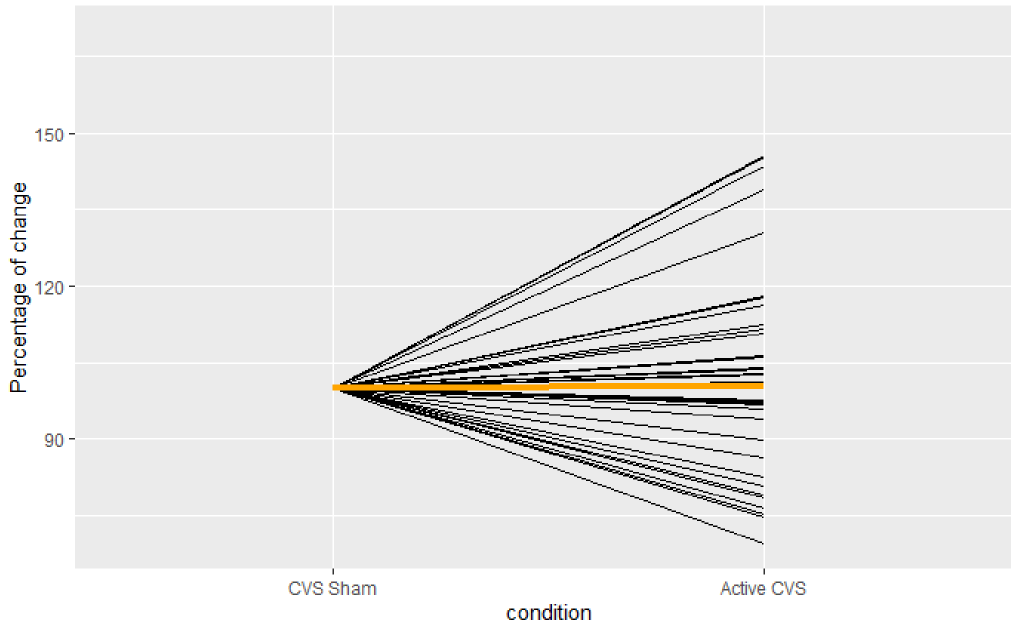
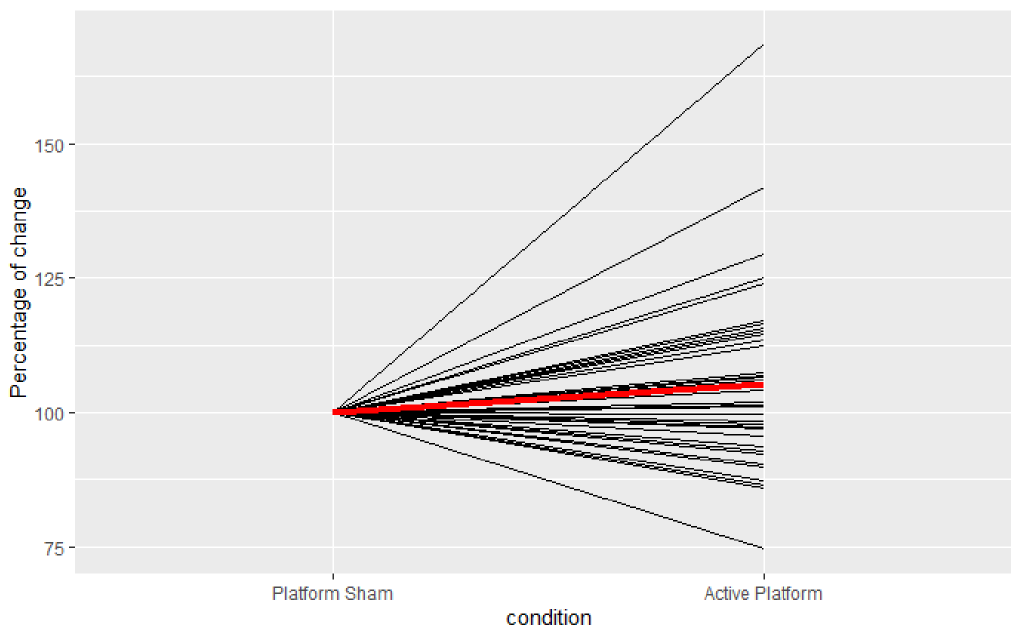


Figure A.3
Percentage of change in width



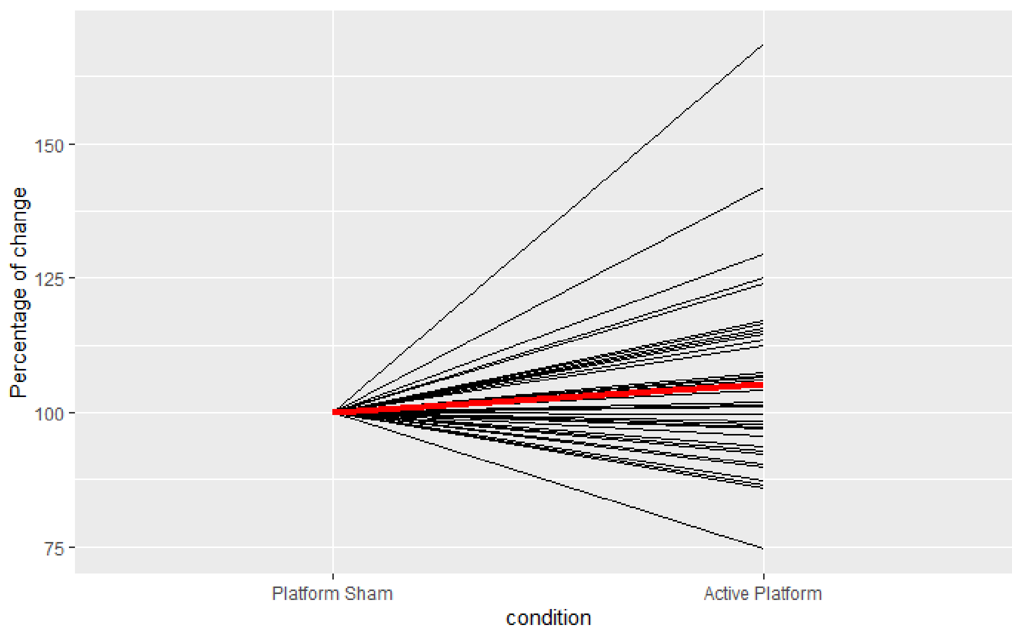
(a) Percentage of change in width in CVS



(b) Percentage of change in width in Platform

Figure A.4
Percentage of change in length

(a) Percentage of change in length in CVS



(b) Percentage of change in length in Platform

Figure A.5
Percentage of change overall

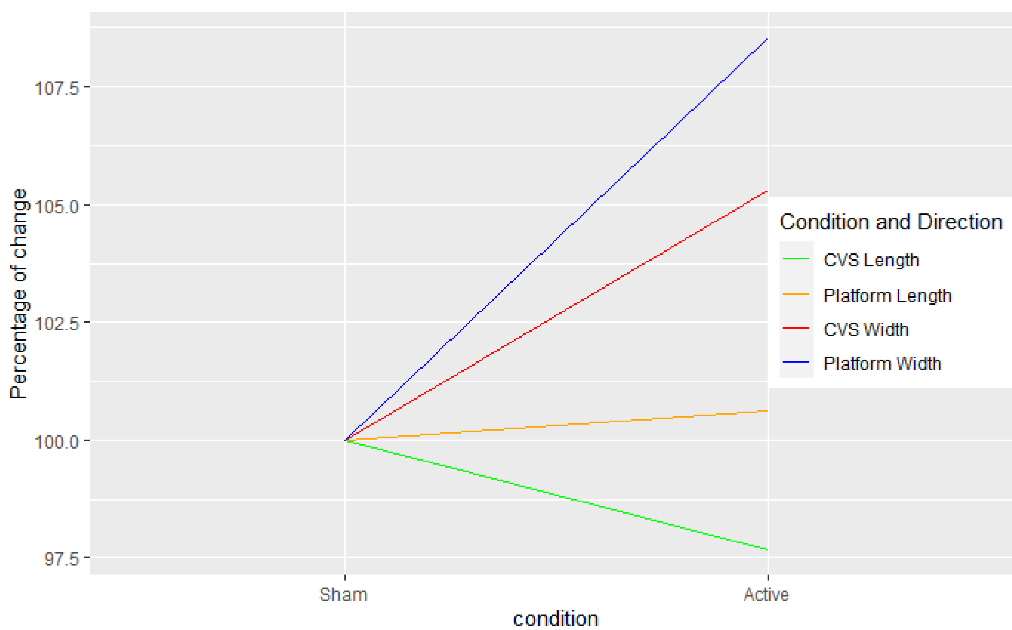
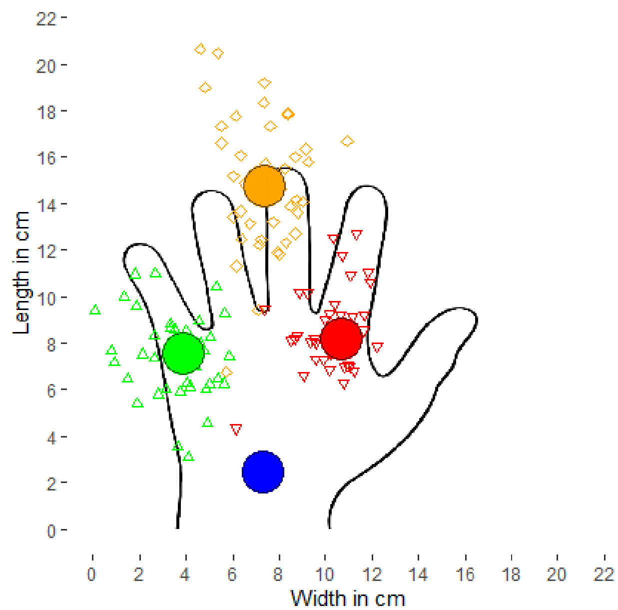
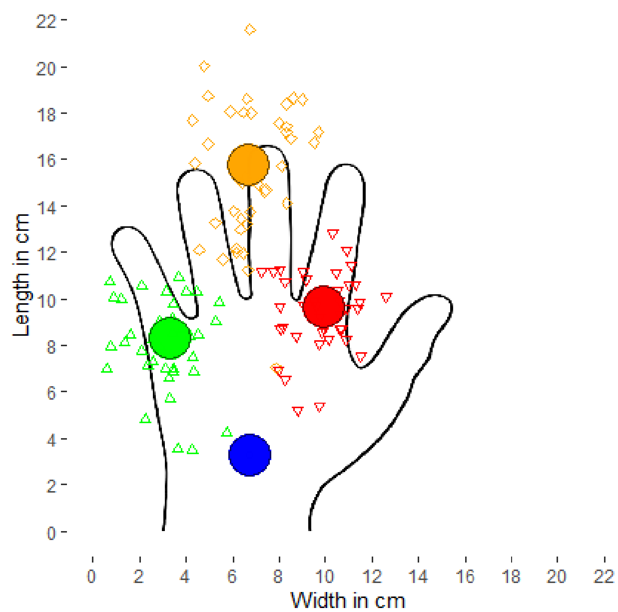


Figure A.6
Reported hand schema in CVS conditions

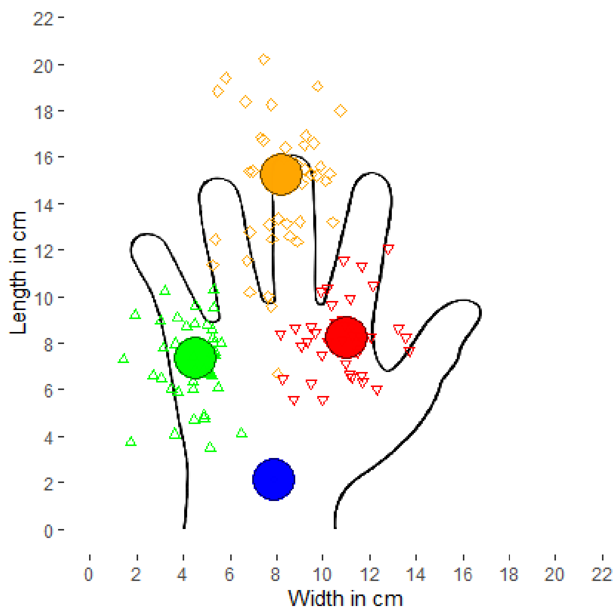


(a) Reported hand schema in CVS-sham

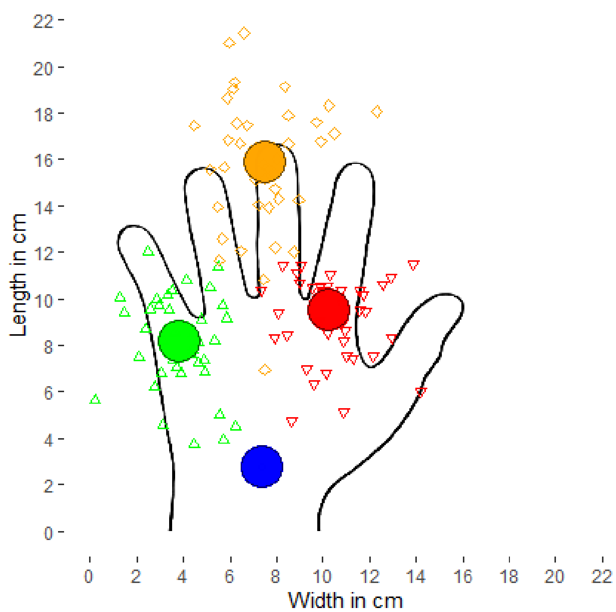


(b) Reported hand schema in active CVS

Figure A.7
Reported hand schema in platform conditions



(a) Reported hand schema in platform-sham



(b) Reported hand schema in active platform

Figure A.8
Reported hand schema in all conditions

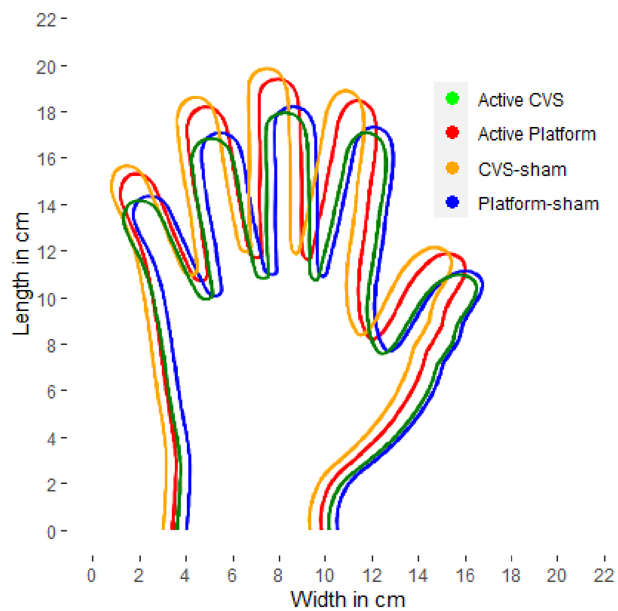


Figure B.9
Hand in wooden board

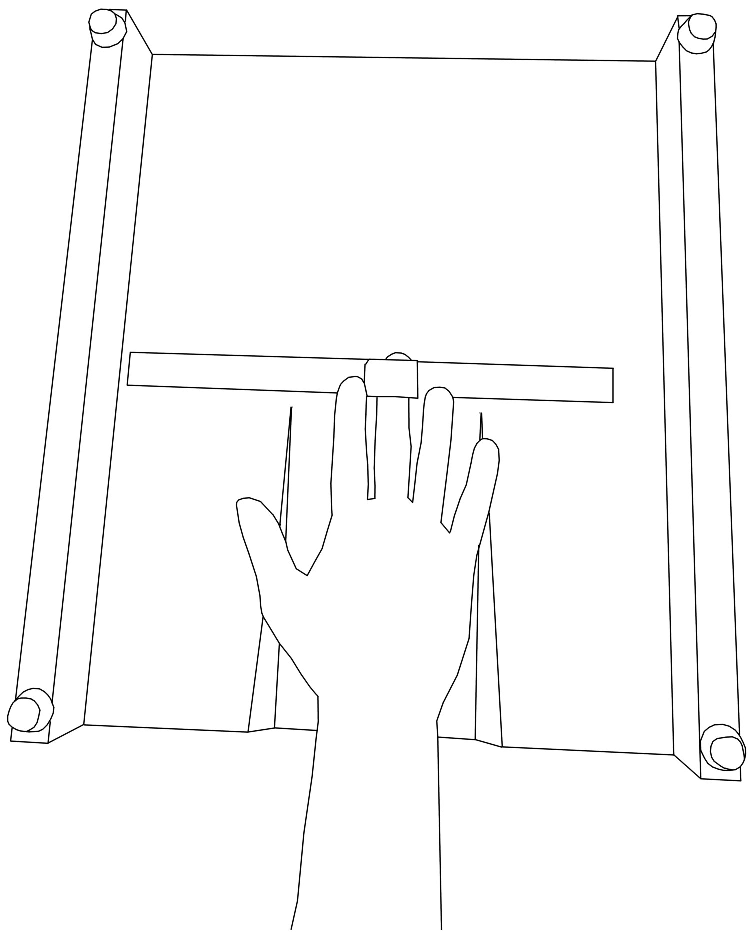


Table B.3
Mean of the questions

Question	active CVS	CVS-sham	active platform	platform-sham
My body feels somehow strange or different	1.60	1.28	1.38	0.73
My body feels numb	1.03	0.95	1.15	0.65
I have a feeling of detachment or separation from my own body	1.018	0.85	1.08	0.58
I have a feeling of dizziness	1.53	0.90	1.43	0.53
The distinction between near and far is blurred	1.5	1.325	1.38	0.93
Did you perceive any movement during the experiment?	0.8	0.93	0.05	1

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