Soma Design and Sensory Misalignment

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ABSTRACT
We report on a workshop bringing together researchers working in soma design and sensory misalignment. Creating experiences that make use of sensory misalignment has become increasingly common, often associated with virtual reality research. However, little attention has been paid to how to design such experiences. We argue that the practice of soma design is a relevant candidate method for designing misalignment experiences, since soma design brings with it concepts such as estrangement and disrupting the habitual as a path to design. We further argue that sensory misalignment may in turn extend soma design methods, adding methods for explicitly disrupting sensory perception using technology interventions. Finally, we draw on the findings of that workshop to discuss the ideas of: pluralism in experience; orchestration of overall experience; as well as the broader intersection of soma design and sensory misalignment approaches.

Author Keywords
Soma design; Sensory Misalignment; Bodily Sensation

CCS Concepts
•Human-centered computing → Interaction design process and methods;

INTRODUCTION
In recent years, and particularly associated with the resurgence of VR research in HCI, the topic of *sensory misalignment* has been gaining traction [26]. This is a practice where perceived information may subverted for a given sensory input, creating a subtle (or not so subtle) misalignment. This approach has been used in delivering the re- or mis- direction of, for example, walking [27] or haptics [22] and even simply for entertainment [37]. In such ways, sensory misalignment has been applied to create useful and engaging experiences. Sensory misalignments cover a broad range of senses, including visual, auditory, kinaesthetic, haptic and even smell or taste. Marshall et al. presented a framework for using digital stimulation to create sensory (mis)alignment, ranging from complete sensory alignment to extreme perceptible misalignment [26].

However, little attention has been paid to best-practice design methods for applying and exploring this approach. As *soma design* [16] brings ideas of estrangement [3] and disrupting the habitual [42], this method was seen as having the potential for new discoveries in sensory misalignment through somatic engagements. We consider whether soma design might be an appropriate way to deeply understand sensory misalignment, and reflect on whether the practice of sensory misalignment may in turn be a useful extension to the soma design method.

We present findings from a workshop organised between one research group with expertise in soma design, and another with expertise in sensory misalignment. As a common point of interest, we chose *balance* as the focus of the workshop, since both research groups were interested in it and as balance includes notions of perception, proprioception and thus offers rich ground for misalignment. We engaged in activities including bodily exercises common in soma design, and the Soma Design group brought some basic technology developed for exploring actuators close to the body and facilitate soma design research processes [43]. In turn, the Sensory Misalignment group brought a number of prototype systems, including a VR flying harness and a VR balance beam. While the workshop included groups exploring other aspects of balance, this paper presents detailed findings of the groups working with these two prototypes including descriptions of the soma explorations and personal reflections on individual experiences.

We synthesise this knowledge to discuss four key themes: 1) extending sensory misalignment – where we show that the application of a structured soma design approach helped uncover a wealth of previously unconsidered misalignments; 2) pluralism in experience – where we discuss how each individual experiences the effects of misalignment differently; 3) orchestrating the overall experience – where we discuss the idea of a *somatic trajectory* which describes the movement between alignment and misalignment to help consider an experience holistically; and 4) misalignment as a soma design method – where we suggest that sensory misalignment may serve as a tool within a wider palette of soma design methods to support embodied ideation, specifically estrangement ideation.

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The specific contributions of this paper are the suggestions that 1) soma design is an appropriate methodology to design sensory misalignment experiences; and 2) sensory misalignment is an appropriate technique to support soma design practice.

RELATED WORK

As this paper reports on a coming together of practitioners using the different approaches of soma design and sensory misalignment, here we focus in turn on each of those areas.

Soma Design

Richard Shusterman, a pragmatist philosophy scholar, created the somaesthetics project [32]. The concept itself combines the term *soma* with *aesthetics*. Soma refers to mind, body, emotion and social engagement as 'one', as we cannot separate them from one-another as has been done in dualistic accounts of the human condition [17]. When we respond to events in the world, we do so with our whole selves – bodily movements spur and are spurred by emotions, thoughts and social engagements and vice-versa in inseparable processes [31]. The second half, aesthetics, refers to how we engage with the world surrounding us. Shusterman argues that we can be sleepwalkers, shuffling through life without listening to our senses, without appreciating the qualities of our movements, without deepening our experiences and engagements with others. Or we can choose to train our senses to be more acutely aware of our surroundings, discerning the pleasures and displeasures, pains and potentials somatically. The latter is what he means by aesthetics – a process of deepened *aesthetic appreciation* of the world. A good life to Shusterman is one where we engage aesthetically, appreciating all the world offers through our senses and actions [33].

Following Shusterman's definition of somaesthetics, a *soma design* process is one where designers aim for an improved sensory appreciation through their lived, sentient, subjective, purposive bodies – both improving their own design skills and sensitivities, but also aiming to deliver somaesthetic designs to end-users. It relies on a first person perspective where designers filter design options through their own somaesthetically trained experience [17]. Höök defines it as: "a holistic approach to aesthetics in design" [16]. Khut argues that it is "a way to examine and improve on all connections between sensation, feeling, emotion, and subjective understanding and values" [20]. This is why soma design cannot be reduced to designing for the *body*, but according to Höök: "it has to do with movements and bodies, but addresses the whole self, body and mind, as one. In that sense, to me, soma design is relevant to any design process engaging with aesthetics." [16].

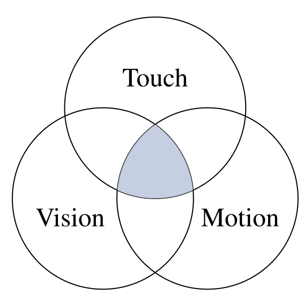
In the workshop described here, the aim was to engage interaction designers in the exploration of soma design – focusing on creative, form-giving engagements with digital (and other) materials. There are many soma-based design strategies aiming to improve designers' somaesthetic awareness, inspired by dance, theatre, body movement practices, and other aesthetic practices [30, 25, 20, 42, 15]. We can, e.g., slow down a movement in order to properly discern how it spurs emotions, thoughts, experiences or social responses [16]. Or we can make 'strange', disrupting the habitual ways we engage in movement or with one-another, helping us to 'see' both what is non-habitual and thereby also what is habitual. Soma design methods often rely on ways of introducing *change* and maintaining *interest* [19] so that designers can properly develop the design in all its details to achieve the sought experience [23]. Change refers here to the importance of subdividing experiences (be it bodily, emotional or social engagement) into specific areas or functions and engaging in activities shifting focus between areas to provide a nuanced perception of fine-grained experiences. The notion of interest deals with finding a way to sustain focus – preventing the mind from wandering.

Other soma design methods can not only improve on designers' aesthetic appreciation skills, but also engage with extracting the aesthetic potential and affordances of digital materials through touching, moving, giving form and experiencing [43].

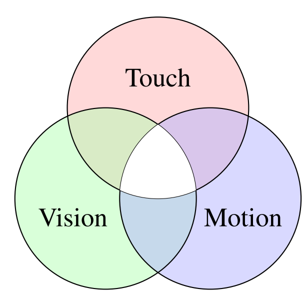
Sensory Misalignment

Marshall et al. [26] introduced the concept of sensory alignment as a property of interactive systems. This property refers to whether the sensory input that people experience in one sense whilst using a system is consistent with other sensory information they are receiving. Sensory misalignment has often been seen as a negative property of systems, for example in virtual reality, where experiencing visual motion that is inconsistent with physically experienced motion can in some conditions cause nausea [36]. However, Marshall et al. argue that there are in fact a range of purposes for which misalignment may be used to create new and potentially positive user experiences.

The key reason for exploring misalignment is that it expands the range of possible experiences we can build - as we see in figure 1, if we aim for complete consistency across senses, we are limited to the range of sensory experiences which can be produced in all senses, whereas misalignment frees us to explore other areas of the possible sensory stimulation space. Marshall et al. identify two key areas where misalignment has already shown promise, firstly, in addressing the limitations of current sensory stimulation technologies, and secondly, in creating new and exciting vertigo play experiences. These are described below:



(a) To achieve sensory alignment, stimulation in any sense must be consistent with other senses.



(b) Misalignment allows us to explore the full range of sensory stimulations possible with a technology.

Figure 1. Misalignment creates new possibilities for sensory stimulation

Addressing Limitations of technologies

An established use of deliberate misalignment between senses is seen in 'redirection' approaches, where the visual and kinaesthetic senses are subtly misaligned to create illusions which bypass the limitations of the technology – e.g. in redirected walking [27] the view of a user is gradually turned as they walk, this allows the simulation of walking long distances in virtual worlds even when the technology is only capable of working in a limited physical space. More recent approaches exploit knowledge of the user's attention to make more drastic changes without them noticing, e.g. by moving the view during saccades, when the eyes shift from side to side [35], or creating distractions in VR at moments when the view shifts [34]. Redirected touching approaches apply similar effects to warp relative position of hands and objects, enabling single objects to be mapped to multiple different ones [22], or warping touch of generic shapes to represent complex shapes [9].

Vertigo Play

The approaches described above make use of misalignments which are designed to be imperceptible to the user, either by being small and subtle, or by directing the user's attention away at moments when the sensory alignment is altered. Whilst it is known that excessive or careless use of sensory misalignment can create problems of sickness and disorientation, when used carefully as part of a design, extreme sensory misalignment can create exciting new experiences. These experiences may be seen as analogous to what game scholar Caillois refers to as 'vertigo play'[8], entertainments such as spinning fairground rides which push the boundaries of disorientation in exciting ways, aim to create exciting disorientation whilst minimizing risk of actual sickness. For example in Byrne et al's digital vertigo play experiences [6, 7], people's balance is manipulated so that their visual and inner-ear sense of balance are in conflict, which creates thrilling experiences as players battle to maintain their balance despite conflicting sensory signals. Tennent et al. use a similar approach in their 'visual kinaesthetic experiences' [38], where they manipulate motion in VR, creating exciting rides where the rider's physical motion is mapped to different movement in VR via an 'abstract machine' [37]. These approaches form a more extreme category of misalignment designs that Marshall et al. describe as deliberately perceptible, as they are openly done with users' knowledge.

WORKSHOP OVERVIEW

In a two-day workshop the two research teams participated in several exercises to explore the topic of "balance" and, more generally, sensory misalignment using soma design. All the authors participated in the workshop. Four participated in the Balance Beam group and two in the Flying Harness group. The first-person accounts presented later in the paper include reflections from all the authors.

Preparations before the workshop

Before the workshop, the Soma Design group explored balance (without technology) in Feldenkrais lessons and contact improvisation (see figure 3) to train our somaesthetic appreciation of what happens when you attempt to balance. We found that it was not so much about *holding your balance* but *being in balance* – a dynamic on-going negotiation process of giving weight and taking weight, always in relation to some reference point, such as the floor, someone else's shoulder or a wall to lean against. Key experiences we explored included relaxing into balance, trust in yourself and others, and daring to take risks. These insights were incorporated into the workshop structure, helping to determine which body exercises the group could do together. We also brought a series of small physical objects called Soma Bits many containing simple technology such as vibration motors that be combined with other technologies or shapes to form interactive units [43]. By placing combinations of actuators and shapes on different parts of the body, one can rapidly orchestrate interactive bodily experiences, aiming to explore the qualities of digital and physical materials on different parts of the body, e.g. by changing the intensity of the actuators. The Soma Bits were developed to address a difficulty experienced in past Soma Design processes: That of articulating sensations and experiences and maintaining these experiences throughout a design process. The Soma Bits enable designers to explore, from a bodily-oriented perspective, what a soma design experience might 'feel like' and to share that with others. The Soma Bits we brought included vibrators, heat elements and a coupling to generate sound from a muscle sensor.

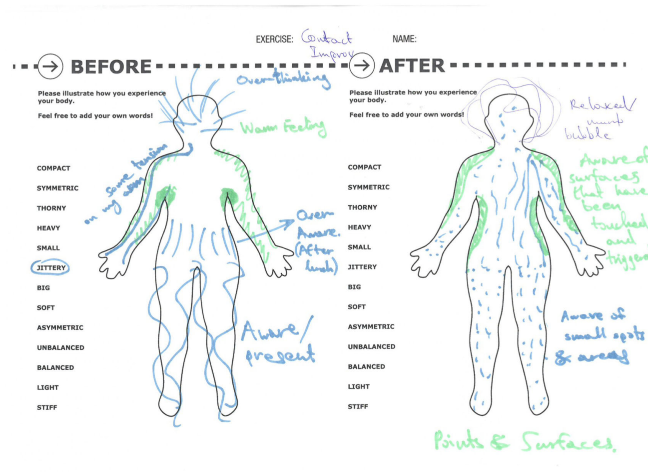


Figure 2. Example of a body map used in the workshop to document bodily experiences before and after each workshop activity

The Sensory Misalignment group brought technologies and proto-experiences prepared ahead of the workshop. These were: a) a flying harness to be used with VR to create a feeling of flying, b) a balance beam, again aimed to be used together with a VR application that would distort your vision to make it harder or easier to balance, c) a guitar enhanced with embedded codes of digital content from a previous project [5], and d) a project focused on 3D printed prosthetic limbs for dancers. In this paper we are focusing on the process and discoveries that emerged from the two first applications, as these are the most directly focused on balance.

At the workshop

Sixteen participants were split into four groups. Each worked with a different proto-experience (see above) though all four were related to balance. Before and after each bodily exercise we documented our experience in body maps [24] (see Figure

Figure 3. Contact improvisation exercise focused on exploring balance

3). After each exercise the group discussed their personal experiences, aiming to improve their somaesthetic appreciation of these experiences. The aim was to unpack the experiential qualities of balance to which each experience drew attention.

The workshop began with a 'body scan'. This is usually performed with closed eyes and involves a set of questions to focus one's attention to particular body parts. One facilitator led the body scan activity while the rest of the participants lay on mats on the floor. For most of the Sensory Misalignment group, this exercise was their first experience of somaesthetic appreciation. Next, a Feldenkrais exercise was moderated by a practitioner that we invited for this purpose. Feldenkrais is a typical bodily activity used in soma design [17] as it can help to sensitize oneself to one's body, turning inwards and reflecting on how it feels to perform movements extremely slowly. Moshe Feldenkrais [13], sought methods of extending our sense of being in the world by exploring different ways of performing habitual movements. One exercise we performed focused on how the torso balances on the bones of the pelvis when sitting on a chair: While sitting, participants made slow and subtle rotations of their upper bodies focusing attention on those bones. Each group then picked some of the Soma Bits, first exploring these without the prepared experiences, and then using them to rapidly consider how the experiences might be changed, disrupted or subverted with Soma Bits.

Day two began with reports and reflections from the work conducted by each group so far and another body scan exercise. The second body scan was to re-ground participants in their bodies before the actual design work would start, particularly in light of having just discussed the prototype experiences, it was necessary to restore a bodily focus to keep the design discussions tightly coupled to bodily experience. For the next activity, each group was given a BITalino biosensing platform [14]. The goal was to consider whether the externalisation of sensing, foregrounding invisible aspects of sensing, or explicitly sensing and presenting things one cannot reasonably perceive, such as skin conductance to detect arousal, or electromyography (EMG) to detect micro-muscle movements, could lead to innovations in bodily design. Next was a Contact Improvisation session (figure 3). Contact Improvisation is a form of improvised dancing that involves exploring one's body in relationship to others by using the fundamentals of sharing weight, touch, and movement awareness. The exercises focused on the dynamics between the participants who engaged in activities of feeling the weight of another person's arm or leg by holding it in one's hands, or by exploring leading and following movements, building on a non-verbal communication between two people. Lastly we returned to the proto-experiences now in the context of the shared balancing experiences highlighted by the Contact Improvisation. The workshop concluded with each group presenting their findings.

TWO EXAMPLE PROTO-EXPERIENCES

Each stage of the workshop was documented variously with body maps, personal notes, video recordings and photographs. We will now reflect in depth on two of the proto experiences. First the balance beam and then the flying harness.

Experience 1: Balance Beam

The first group worked on a virtual reality balance beam simulation (see Figure 4b). Before the workshop, the sensory misalignment group had prepared a physical balance beam made out of a scaffolding pole, overlaid with visuals of the same beam in VR. In the VR, subtle rotation of the visuals was used to enable the balance beam to be made more difficult – adding rotation as a participant's head moved further to the left or right of the beam. Additionally, a range of balance beams, from a narrow pole, to a 10cm wide plank were made available to allow tuning of the base balancing difficulty.

Balance Beam Soma Exploration

Participants showed varying levels of skill with balancing, with those more expert in the practice performing the act differently from those less skilled. One aspect of this related to gaze behaviour: the expert balancers tended to look straight forward, and 'feel' the position of their feet, making micro-adjustments as necessary, while less skilled balancers tended to look down at their feet. After observing both approaches, we applied muscle sensing to understand what was happening to people's muscles when they were in balance or falling off, and noticed that with data relating to the tension of calf muscles, it was possible to predict when a person was losing balance some time *before* they fell off. Next we considered how we might reasonably disrupt balance. Our initial prototype was geometric – tilting the visuals to disrupt the visual cues associated with balance, following the process established in Byrne et Al's 'AR Fighter' [7]. The soma focus of the workshop enabled us to consider other approaches we might take to balance disruption. Considering the bodily point of contact rather than the visuals, suggested that changing or adding things like texture, motion, vibration, heat, and shape might affect balance behaviour differently to geometric misalignment.

We explored stimulation of the user's feet by applying Soma Bits to the balance beam, with some interesting results, this further highlighted the differences in how people perform the act of balancing, for example, in the K's account below, one highly experienced balancer found themselves entirely unable to balance when vibration was applied to their foot, and fell off repeatedly, whilst the same effect made little difference to others. The skilled balancer was also less affected by the fact that the VR visuals did not include their feet or body than the other participants. More generally this suggests the fact that the skilled balancer, as with many skilled pursuits was performing the process in a different way — entering a flow state [10] in which they focus on the task of progressing to the other end of the beam, rather than focusing on the act of

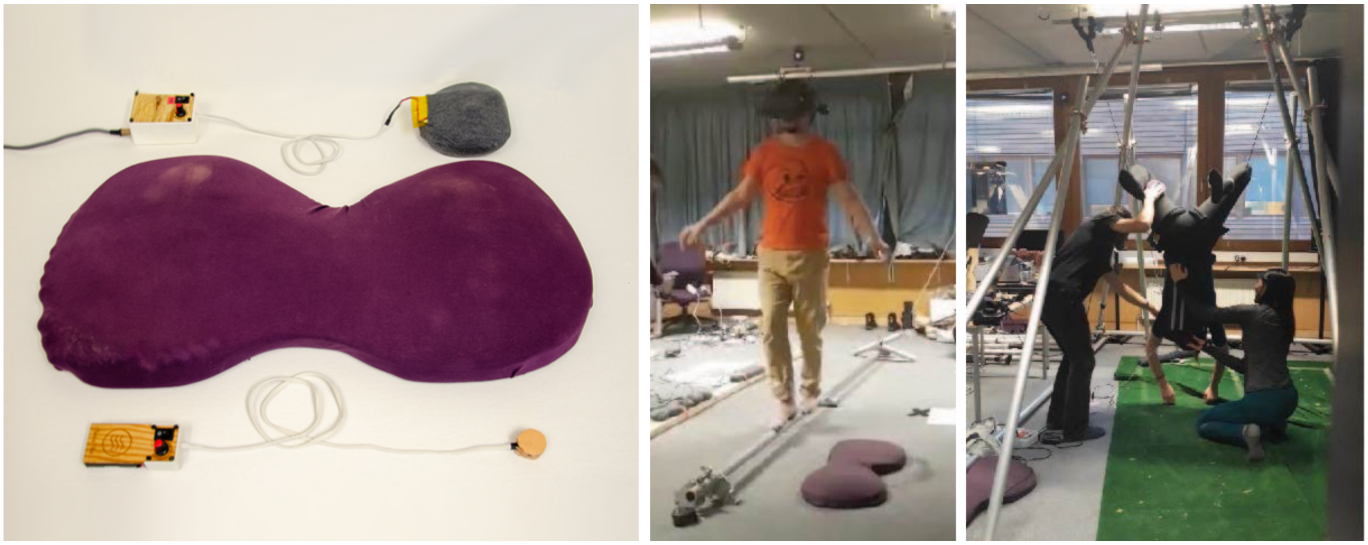


Figure 4. (left to right) a) Some Soma Bits that were used for exploring actuation on the body, b) tightrope prototype, c) flying harness prototype

balancing itself. The introduction of the Soma Bits made the ‘feeling’ of the act different, interrupting the flow state and bringing the balancer back to the immediate act of balancing. This suggests that such disruptions may be a way to equalise skill levels, to make an expert re-confront their process, or engage more deeply with the act rather than the goal.

We explored changing the texture, shape and flexibility of the beam, using different physical beams. This seemed less effective for disrupting the expert, and in some cases made it virtually impossible for the less skilled balancers to perform the task. We made these changes without altering the beam’s appearance in the virtual world, wondering if a mismatch between the visual of the beam and its physicality would affect the balancer, but as the expert balancer tended not to look at his feet, the changed visual cues appeared to make little difference, and the inexperienced balancers didn’t appear to be any worse for this change – the size and shape of the beam seemed to have a similar effect both in and out of VR.

When adding heat to the end of the balance beam the heat was envisioned as a‘reward’ – a nice feeling after successfully crossing the beam. This may not exactly be a sensory misalignment as there is no obvious reason for the heat to be there, or expectation that temperature would make a difference, unless the visual environment suggested some reason why temperature should be important. In general though this leads us to ask questions about what constitutes sensory misalignment, and whether it is more complex than simply adding additional sensory cues. While the heat was pleasant, it had little effect on the balancer’s ability, but it did have an effect on the overall satisfaction of the experience: When placed at the end of the beam, it created feelings of catharsis and accomplishment.

One further addition, which, like heat, isn’t exactly a sensory misalignment, but the introduction of new sensory input, was the inclusion of audio feedback captured from the activation of the balancer’s calf muscles. These audio cues provided indication that a user was going to lose their balance, but we were unable to determine whether this cue made the balancer more or less likely to actually fall off. Again, it might be necessary to consider why such audio might be there in context, and whether the visuals could be used to provide that reasoning.

We now present a series of first person accounts of participants’ observations and experiences of the balance beam. We suggest that these first person accounts help to clarify the ‘felt’ experience – something that is notoriously challenging to present on paper. We begin with the accounts of participants J and K, who reflect on a pivotal moment in the group’s exploration.

J’s Balance Beam Experience

I’ve been able to walk tightropes and balance beams for years, but when someone put the vibration on my foot, suddenly I was like a beginner again. It made me realise quite how important foot feel is to my balancing, in the same way hand feel is vital for hand-balancing.

K’s Balance Beam Experience

J had been working on the tightrope balancing project for quite a while. To properly understand what tightrope balancing would entail, he had done quite some tightrope training himself. In comparison to the rest of us in this team, he was really good at balancing – perhaps not on the level of a circus balance act but enough to impress the rest of us. In an early exploration, we decided to put a vibration bit on top of the beam to see what would happen. I happened to look at J’s face as he put the ball of his foot onto this vibrating bit. It was a facial expression of utter confusion. It was as if he could not believe what his senses were doing to him. As soon as his foot just touched the vibration, he lost his balance. He tried it over and over with the same result every time. Finally, he started to articulate his experience, making up theories for why it was so disturbing. He realised that balancing starts from the feet and that he had trained his body to balance based on this premise without necessarily understanding that himself.

The rest of us also tried balancing on the beam with and without the vibration bit attached to it. The effects were not as astonishing to us. My experience was that balance on the beam required a whole range of bodily adjustments, loosening up my whole body: bending my knees; making my upper body softer and more flexible; not waving around stiff outreached arms; and so on. The addition of vibration under my foot in fact helped more than disturbed me. My focus traveled towards the part of my body, my feet, where my balance originated.

Seeing J struggle to balance with the sensory additions later led to a longer discussion on sensory misalignment beyond using VR and visual distortions. We agreed that involving (and disturbing or stimulating) other senses could make for other, interesting sensory misalignments. Next we consider the experience of participant P which reflects on P's own balancing and in particular the effects that the VR implementation and the body exercises had on that process.

P's Balance Beam Experience

I have limited experience as a tight rope walker, but I do have fairly good balance. Prior to the workshop I'd spent some time practicing walking on the beam and was able to cross it fairly competently. However once I was in the VR, I became acutely aware of how much I look down at my feet when standing on the beam. Since in the VR one's feet are not visible, I found myself having to re-learn an already partially learned skill using different sensory inputs – in short I had to 'feel' the beam rather than observe my position. While I'm sure this was a subconscious part of the process anyway, it became much more of a conscious process for me, perhaps as a consequence of having had my attunement to my body 'heightened' by the various exercises – e.g. the Feldenkrais. I found the enforcement of not looking at my feet without removing the visual cues for the position of the beam, as would happen if blindfolded, while initially making me significantly less proficient, quickly improved my ability to balance both in and out of VR. The inclusion of the visual misalignment definitely threw me off – suggesting I'm very reliant on visual cues.

For me, the addition of the vibrating Soma Bits was less impactful to my ability to balance, perhaps because I had less experience with the beam as-is, and as mentioned was still relying more on visual cues, I found the sensory interruptions less problematic than my expert colleague. I did however, especially after the Contact Improvisation, find myself thinking extensively about bodies, and beginning to envision the tightrope being represented as a body and what that would mean in terms of delivering an interesting sensory experience for both the walker and the walkee.

P's experience suggested that the soma design process – not just the application of Soma Bits, but the bodily exercises in the workshop, and the deliberately introspective nature of the method had an effect on their relationship with their body and balance. It further shows how the soma practices were helping ideate new experiences. Next we discuss the experience of participant C who focuses on the application of the biosensing and the effect it had on both his balance and his bodily perception.

C's Balance Beam Experience

On day two, we focused on sensing exploration by attaching an EMG sensor onto one of my outer calf muscle. While I balanced on the tightrope with the EMG sensor attached to my calf, the rest of the team watched the screen showing the real-time plot of the EMG signal. We cycled through different calf muscle until we found the one most distinct. After some time one of the team member could sort of predict by saying "And now you will soon fall off...". As discouraging as it sounds, it made me focus on my lower leg and foot. The setup with the EMG and visualisation didn't really provide more insight as there was this disconnect between the perception of my leg and the data that someone else interpreted for me.

In a second session, we redirected the sensory data to music software that mapped the intensity level of the EMG onto the pitch of a sine wave. While balancing on the beam, everybody could hear the changes of my contracting calf muscle. This changed the perception of my balancing act. I could focus much better on this muscle and link it to the balancing as I could experience it in real time. It did not make me perform better but more aware on what is involved. I believe it would need more involvement of other muscles that move my feet to "hear" (and in turn "feel") the actual balancing act on a beam.

Balance Beam Summary

In the balance beam experience we tried a number of different sensory misalignments, from the purely visual to the inclusion of brand new sensory inputs. We saw the difference these misalignments had on different skill levels of balancers, demonstrating how a change in perception might disrupt flow. We also saw how the body activities shaped, and helped to deepen our perception of our bodily relationship with balance. We looked at the externalisation of sensing using EMG, and noted how while this didn't necessarily affect ability, it did change participants' perception of their own bodily activity. Finally we saw how the soma exercises encouraged the ideation of new or extended experiences.

Experience 2: Flying Harness

The second example concerns a flying proto-experience. This system was built by the sensory misalignment group for testing flying (that is human flying – like a superhero) applications in VR environments. The flying harness depicted in Figure 4c, is a triangular scaffold structure with a crossbar and cables hanging which can be attached to a harness similar to those used on stage to support one person at a time. The person wearing the harness is slightly suspended from the floor in a vertical position. When wearing the flying harness and the VR headset, a user appears to be able to fly like a superhero, for example from one rooftop of a building to another. The flyer can perform movements such as turning their body upside-down (180 degrees) or twisting their body forwards or backwards (90 degrees). The system enables two distinct bodily flight modalities in VR: one in which the subject extends his/her arm(s) forward to move in the pointing direction (nicknamed Superman) and one in which the subject places his/her hands behind the hips, creating propulsion from the hands at the back of the body (nicknamed Iron Man). The Superman position requires significant core strength to maintain, but is perhaps more intuitive, while the Iron Man position is more comfortable but slightly less instantly familiar for new users.

Flying Harness Soma exploration

The group first reflected on how it feels to be suspended from this construction. Since the harness has to be tightly fastened around one's waist, belly and thighs for safety, the first sensation evoked was a feeling of discomfort and slight pain. The straps of the harness felt almost like 'cutting' into one's flesh under one's clothes as these few points of contact support one's entire bodyweight. Often the hips were very 'present', as those contact points relied on the hips to support the flyer's weight. Apart from the waist that is tightly held into place, the rest of the body can move freely in space, without restrictions. This means one can perform movements that are quite different to movements one is used to performing on the floor or while standing. Being suspended felt nice for a short period as the whole body could be stretched, but it was observed to be tiresome and uncomfortable to be suspended extended periods. One flyer reported on a body map, a feeling of tension in their head from trying different movements and twists of the body while suspended. When performing more 'extreme' movements such as turning upside down, flyers observed that the body felt briefly rested, shifting from having legs stretched towards the floor, to allow them to rest for a while upwards. Another flyer reflected in their body map that being suspended evoked a 'heavy' feeling throughout the body, which was evenly distributed, but that the arms felt rested and the upper part of the body was quote: *"conscious warm"*.

The group next picked some Soma Shapes (Soma Bits created in different shapes), heat and vibration bits and tried these with the flying harness. They tested what sensory experiences can be evoked in a flyer when heat or vibration was placed on different parts of the body. They wanted to focus on sensory experiences that can be evoked while suspended they mainly focused on the fact that 'the body was suspended' rather than on 'being in a VR environment', so to focus this, the group used a cloth to simply blindfold the flyer. Each group member, one after the other, was suspended and blindfolded, while another placed different Soma Bits on different areas of the flyer's body. The fact that only one harness was available, stressed the role dynamics of the experience. While having only one person in the harness at a time might appear to be limiting, not having the possibility to transition quickly from one role to another actually forced the participants to give themselves the time and space to try out several things. Moreover, while jumping into the unknown desensitising experience was daunting, being the center of an experience felt invigorating, thought-provoking and inviting to explore. The choice of actuation, shape and area of the body was decided between the person manipulating the bits and the third person – who was documenting the process through photo, video and field notes. Although decisions were sometimes communicated, the element of surprise was a fundamental part of the experience. The flyer was guided, but could always rely on asking for breaks or even stopping the exploration if it felt too overwhelming. Examples of our explorations included placing a heat pad on the back side of the left knee of a flyer, while she was leaning her body forward and keeping it horizontal; or placing one of the Soma Bits with vibration actuators on the flyer's chest.

One discovery emerged when vibration Soma Bits were placed in different places along the flyer's back. This vibration, in combination with being suspended and blindfolded, created an unexpected sensory confusion – a sensation of spinning around oneself, but without actually doing so. This vibration was tried while the flyer was vertical (legs down) and also when they were swinging their body back and forth, or while performing rotations. The sensation of spinning around yourself was the same in all these instances, and all group members reported in their body maps that vibration applied on the back caused this effect. This stimulated sensory misalignment calls to mind Byrne et al.'s work artificially stimulating the inner ear in [6]. The metaphor used to describe how the effect spread differed between participants though, for instance reporting a sensation of a flow, articulated as "*an animal crawling on your back*".

The second day led to a change in the perceived experience from the vibration bits on the back. Immediately following the Contact Improvisation exercise, the group found their bodies were more relaxed and the spinning effect was less intense, as there were quote: "*points and surfaces of the body that have been stimulated due to the Contact Improv exercises*" (phrase taken from one participant's reporting on a body map).

A second area explored by the group was a sensory misalignment suggesting expansion. Following on from the effects of the vibrations, the group examined how it feels to support the movements of the flyer with different physical surfaces placed around the person. The group explored how various Soma Shapes, which have different dimensions, thicknesses and affordances can support movements and create additional reference points, when placed on the back, the feet or the chest. As seen in Figure 4c, the group explored different ways of supporting the movements of the flyer with different Soma Shapes, while that flyer freely performed a range of movements, including rotation or bending parts of the body or the whole body. When one of the big shapes was placed on the back, the flyer felt that the shape was much bigger than it actually was. One person reflected on his body sheet that as well as feeling the shape on his back much bigger than it actually was, his back also felt more extended. Other articulations of this effect suggested that physical shapes placed on the back felt like a person was touching their back with their body, or that the shape was extending round their body or hugging them.

This last finding prompted a reflection on the Soma Bits themselves. Following the observation that different shapes had different affordances, their role in highlighting contrasts was noted. This could be exemplified with the surface-to-surface navigation reported from the use of rigid Soma Bit surfaces placed on feet and hands after blindfolded disorientation, or the feeling of being held thanks to an elastic Soma Bit after losing control and tipping over, both accounts that cannot be disentangled from surface properties. These sensations, i.e. appreciating the affordances of the shapes, would not have been possible without engaging in misalignment or disorientation that brought such evocative contrasts.

We now again present a series of first person accounts of participants' observations and experiences of the flying harness. We begin with V's account.

V's Flying Harness Experience
On the second workshop day our group tried different Soma Bits on the flying harness. At some point it was my turn to be suspended and blindfolded and to reflect on my experience. I felt relaxed being suspended, as gravity was pulling my whole body down to earth, and I started performing movements in space, without knowing what the other members of my group would decide to do (i.e. which shapes and actuators they would pick and where they would place them on my body). My colleagues placed a vibration Soma Bit on my back, and when it came in contact with my spine I felt the vibrating patterns spreading along my spine, as if the person holding the actuator was moving it up and down- but without actually doing so. The most interesting, and at the same time confusing experience, was the illusion that the vibration applied on my back created. I felt spinning around myself and slightly dizzy. My sense of balance was totally distorted and confused and I tried to stay completely still to limit this sensation. For a while I did not know whether I was actually moving slightly back and forth, trying to divert my attention from feeling like I was spinning; or whether I was standing completely still.

M's Flying Harness Experience
The Soma Design approach and the contrasts it brought, let me look at balance while moving away from a goal to be achieved with my body. As good or bad as it can feel, misalignment grows beyond the VR scope. When voluntarily jumping to the void of being swung and blindfolded, one thinks there is no surprise to come. However, when my colleagues applied vibration on my neck, I lost a hold on where I was. When approaching my back with a soft firm surface, unexisting arms seem to grab me softly.

Flying Harness Summary
The flying harness exploration elected to focus on sensations created by senses other than the visual. The decision to do this was invaluable, as will be picked up in the discussion, as much sensory misalignment research is concerned directly with visual misalignment.

The group found that the application of vibration Soma Bits to the back led to a sensation of spinning, though after the Contact Improvisation exercise, the body felt more relaxed and the spinning effect was less pronounced. Additionally the physical shapes that were used for supporting a person's movements felt bigger than they actually were, and some also evoked a feeling of being embraced when applied on the back.

DISCUSSION
We aimed to open up the sensory misalignment design space using a somaesthetic grounding. We asked ourselves what sensory misalignment might add to soma design practices?

Extending Sensory Misalignment
In the two design groups we have described here, we started from applying visual misalignment to alter our ability to balance. But we know that balance is a multi-sensory experience, being affected by a combination of vestibular senses, vision, proprioception and touch [11]. Previous work has demonstrated that both vision [7] and inner ear signals [6] can be digitally stimulated to produce incorrect signals which affect people's ability to balance – this is an effect that has been shown in research relating to reducing sickness caused by vestibular conflict [41]. With our use of vibration for the balance beam prototype, we found that targeted noise can disrupt aspects of our sense of balance. This is not an example of sensory misalignment as much as demonstrating how an active disruption of senses (as opposed to physically misaligning sensory signals) can also be used to alter people's balance.

This stands in contrast to current examples of sensory misalignment mainly focused around geometrical misalignment [26] – i.e. moving things in different directions or positions. Balancing on the beam was distorted by the addition of vibration to the ball of the foot, leading us to the discovery that sensory misalignment might go beyond geometrical misalignment. Our work here suggests that sensory misalignment could be expanded to consider stimulation that differs in other ways. There seems to be a whole scale from sensory alignment to adding noise; removal of a sense (as in being blindfolded); all the way to a "proper" sensory misalignment. Deliberately introducing one of these appears to allow for the possibility of interrupting flow, and subsequently forcing users to reconfront and reconsider the act of balancing at a bodily level. The structured soma design exploration allowed us to discover a whole range of possible interactions, in turn allowing for many different experiences of balancing.

Furthermore, our soma experience suggests that the specific senses people rely on differ greatly between individuals based on differences such as their previous experience of balance activities. This in turn also offers opportunities to arrange for many different forms of misalignment.

Pluralism in experience
These individual differences in how we balance leads us to our second discussion: how to share experiences despite our individual differences.

Soma designers often emphasise the need for a deep first person experience, arguing that a subjective, sentient self is not only allowed into the design room, but required [17]. Perhaps contrary to what one might assume, a first person design engagement does not mean lack of insight into or empathy with what others might experience. As it turns out, when we work together, sharing our experiences, a pluralist position [2] on somatic experience is unavoidable. As this workshop showed, when performing bodily exercises together and engaging/touching/feeling the design materials, one cannot avoid acknowledging what different subjectivities bring to the table. All sorts of differences, such as body height or size, pains and aches, and visual, auditory, or haptic sensitivity, will keep popping up in design discussions. But the discussion will not revolve solely around the surface of bodily differences. Deeper somatic differences will be on the table – emotions, attitudes, and beliefs, thought processes, a sense of the other and of the self and how this changes with the joint experience.

At our workshop, given the focus on balance, these differences very much came to the forefront. For the balance beam, it became clear that people with different skill levels in the same task use different sensory stimuli to achieve success. In the flying harness, depending on what bodily exercise took place right before being suspended, people were more prone to experience the "spinning effect". Both the bodily skills on the balance beam, and immediately prior activities on the flying harness are examples of how we need to care for the specific"somas" when we do design work. By doing the same bodily exercises together participants developed a fundamental somatic understanding enabling a deeper conversation and allowing us to reflect on and at least attempt to understand the other. These pluralist accounts of experience are in turn key to considering how systems might explore and take advantage of differences, for example considering how to 'teach' transitions or how to intensify or decrease certain effects.

Orchestrating the overall experience

Beyond figuring out how to create sensory misalignments, the workshop allowed us to address the aesthetics of the *overall orchestrated experience* unfolding over time, e.g.: arranging stimuli for creating alignment as well as misalignment, going back and forth between the two; helping our imagined users to progress from struggling with balance to a catharsis experience when succeeding; finding bodily ways of shifting from novice behaviour to learning how to balance; easing into the effect of spinning by first engaging with a relaxation exercise; and so on. This orchestrated whole will provide for (depending on the aims of the design) thrilling/uncomfortable/calming/exciting experiences for (different) end-users.

An orchestrated experience consists of many different threads, or as framed by Benford and colleagues: different trajectories [4]. These trajectories need to come together into a whole. Note that an orchestrated soma experience is not the same as a strong narrative – even if narratives may well contribute to the soma experience. By exploring our somatic reactions and how one can transition into the next, we create what we might frame as a *somatic trajectory*. We can, for example, ease users into an experience through sensitising engagements; we can purposefully misalign senses through technology and then later align them again to create for a somatic sense of catharsis; and so on. For example, with the balance beam we made the first part of the beam more difficult, and then progressively easier, finally adding heat towards the end of the beam to create a sense of relief, aiming to create a trajectory towards a somatic catharsis experience. The somatic trajectory therefore goes beyond solely stimulating our language-oriented, story-craving selves, to instead touch our whole sensory selves.

Misalignment as a soma design method

The experience of working consciously with misalignments and in general uncomfortable experiences as a path to design was intriguing to the Soma Design group. We found that some of what we had prepared for the workshop (such as the choice of Feldenkrais lesson, the Contact Improvisation session, and our insights on how balance is enacted) failed to account for what it would mean to *disturb* those experiences in an explicit sensorial sense. As a designer you may first need to somatically understand what balance entails in order to also understand when it fails in an *interesting* manner – potentially leading to a thrilling experience. After introducing body works relating to how to *keep* balance, we could have prepared for a range of distortions to help defamiliarise the sense of balance.

Defamiliarisation is a documented soma design method, explored in various forms [3, 42, 29]. The overarching idea is by doing something familiar in a strange way, the experience of the strange helps elucidate what is involved in the familiar. As a creative practice, it helps us shift our somatic understanding from what we may already know, and is deeply ingrained into our habits, into a state of being open to again feeling and articulating not only the familiar but also what novel experiences we might be interested in designing for.

A range of such embodied ideation methods through "making strange" is described by Wilde and colleagues [42]. In short, they divide the phases of such methods into: *disrupt, destabilise, emerge* and *embody*. For each, conscious choices have to be made, such as what will be disrupted? And what norms or habits will that disruption destabilise? The most difficult step is to properly feel and be able to articulate what emerges, and what idea, quality, or feeling does the process give tangible or visible form to – what does it embody?

Balancing is something we all do every day, walking, sitting, standing. To really understand what is involved in our balancing habits, we need to disrupt them. But engaging randomly in some disruption might not destabilise the core of what we are searching for. In the soma workshop described above, the participants from the Soma Design group had to take on and properly understand, not only intellectually, but viscerally, somatically, through a first person felt engagement, what a sensory misalignment disturbing balance might entail. Beyond discovering a possible misalignment, it had to be those particular misalignments that the Sensory Misalignment group would find relevant to their design aims. It required a feeling for what forms of disruptions also encompass a sensory misalignment that can, when put to good use, embody a thrilling experience.

We did indeed discover instances of misalignments of senses pertaining to balance, as discussed in the accounts of the flying harness and balance beam explorations above. For example The VR rotation of vision on the balance beam, dramatically disrupts one's ability to perform a simple balancing task. As the effect is increased balancing even without the beam becomes challenging - making the everyday task of walking progressively more difficult, and certainly strange. The body works at the workshop (Feldenkrais, Contact Improvisation and body scans) helped tune our aesthetic appreciation of balance generally – both of our own bodily sense of balance, but also adding elements of social interaction as we were leaning on one-another, trusting others to hold us as we swayed. But the most important 'disruptions' happened once we introduced technology into our experiences (the semi-finished technology that the Sensory Misalignment group had provided – in particular VR), together with the Soma Bits the Soma Design group had brought). Actively looking for and somaesthetically experiencing sensory misalignments through combining simple technology bits formed a basis for a different ilk of estrangement. It allowed us to come closer to the affordances of (digital and other) technologies than most other embodied ideation methods. Instead of solely feeling and understanding a particular “idea, quality or feeling" [ibid] we came closer towards forming a full orchestrated experience and making it take shape in a prototype scaffolding that idea, that quality of feeling, with digital and other technologies.

We found that deliberately introducing and feeling potential sensory (mis)alignments through technology has something to bring to the growing plethora of soma design methods. It resonates strongly with the ideas of estrangement and embodied ideation methods. Consciously bringing specific technologies that may distort our senses helps deconstruct the habitual, finding the unexpected, designing for both what is already familiar to us, as well as that which is unfamiliar – but most of all it brings soma design one step closer to properly engaging with technologies and their somaesthetic affordances.

The problem of shifting from reading or talking about an experience to actually somaesthetically experiencing it is one of the core topics of the whole somaesthetic project according to Shusterman [32]. It is also extensively discussed by Höök, who writes about soma design: “this will not be a theory that can be understood solely through an analytical engagement [..]. Instead, soma design must also, by necessity, be a pragmatic study of methodologies to improve our functioning and a practical study in which we test those pragmatic methods on ourselves to render experience and design concrete.”

While we consider this workshop a success, it was not without tensions and failures. We were reminded of how difficult it is to isolate, communicate and ‘preserve’ a fleeting experience that we found intriguing. While the experience can be ‘clear in our minds’ in the moment, crafting the full design requires revisiting that experience over and over to make all the details of a design come together to scaffold it. That in turn requires somehow ‘saving’ the experience in a form that the design team can share and to which they can repeatedly return.

CONCLUSIONS

In a workshop focusing on designing for balance, we set out to see what mutual benefits we could gain by using soma design methods in an explicit engagement with sensory misalignment. While the focus of this particular workshop was on letting soma Design meet sensory Misalignment in the context of designing for balance, our workshop experiences have broader implications for interaction design research.

First, we would like to point out that this meeting between two design studios led to a much deeper understanding of the other group’s ethos, aesthetic concerns and research concerns. While we had been reading one-another’s papers for years, it was not until we designed together that the true underlying “aesthetic axioms” [28] of the other group came to the foreground and could be understood on a deeper level.

Second, the results from this workshop have implications beyond designing for balance, or using misalignment as an estrangement method. Soma Design is a broad design framework that has already been used for domains such as design engaging with female health [1]; mental health; body awareness [25, 30, 18]; performance art [30, 40, 12]; home appliances [39]; and biofeedback pain regulation [21]. Through extending the Soma Design methods with misalignment provocations, we can engage more heavily with the fast, thrilling and uncomfortable application domains. Likewise, we found that designing for sensory misalignment through a heavy engagement with soma design-inspired first person felt experiences contributed to both designerly imaginations and a better grounding for misalignment design. The fusion of these two frameworks is not without tensions or theoretical clashes, but the workshop showed us a path forward benefiting both.

Soma design methods contributed to opening the design space in a slightly different manner, addressing more of our senses. Our findings included discovering (sometimes quite unexpectedly) that disturbing other senses by using vibration, heat or sound, had strong effects on balance. Some of these ‘disturbances’ lead to sensory misalignments, others did not explicitly misalign one sense against another but instead provided stimuli that tapped right into the balancing act. The soma design experience brought insights on the pluralism of human experience. This in turn allowed us to imagine different sensory interactions for different users. Finally, the soma design emphasis on designing for the whole – for the overall orchestrated experience, how it starts, grows, and ends – contributed to imagining an overall somatic trajectory to our design ideas.

These insights were enabled through the deep and structured engagement, where we aimed at increasing our own aesthetic appreciations of balance, refining the relationship between somatic concepts such as *being in balance*, *relaxing into balance* or *trust*, relating them to sensory misalignments through technology that could disrupt or aid users’ experience of balance.

Second, sensory misalignment adds to the growing plethora of estrangement ideation methods. It is an inherently ‘disruptive’ practice – changing the sensory inputs to disrupt before we even get round to perceiving, or even breaking the relationship between different sensory perceptions and thus encouraging us to re-examine an experience.

Used in combination then, sensory misalignment can disrupt a bodily experience and motivate us to understand it, while soma design provides the necessary tools to create that understanding. Conversely, soma design can help us create engaging sensory misalignment experiences by providing a method to deconstruct and examine our bodily perceptions and better understand which senses and sensations might be misaligned and the effects of those misalignments.

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