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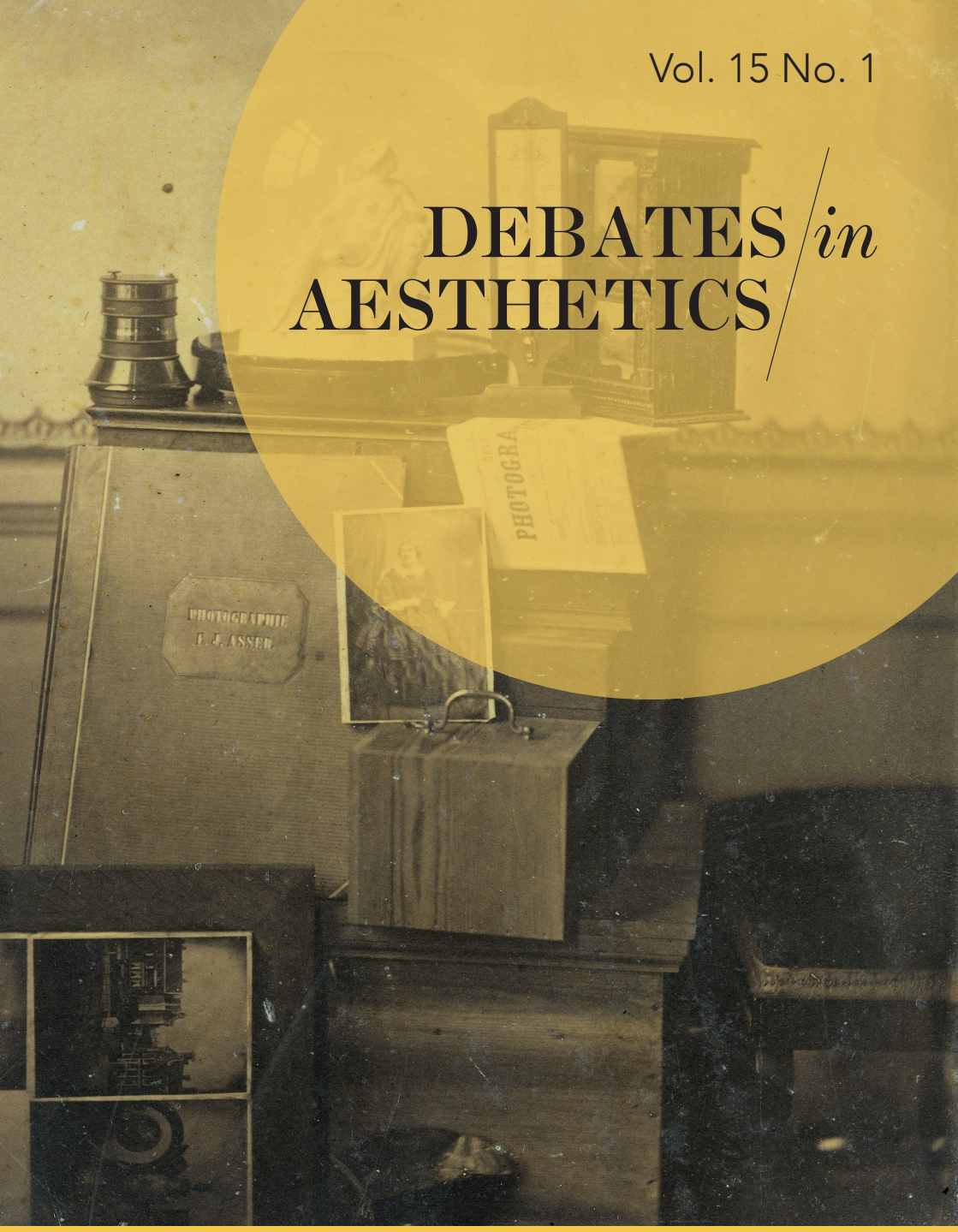

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SENSORY AUGMENTATION AND THE TACTILE SUBLIME

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This paper responds to recent developments in the field of sensory augmentation by analysing several technological devices that augment the sensory apparatus using the tactile sense. First, I will define the term sensory augmentation, as the use of technological modification to enhance the sensory apparatus, and elaborate on the preconditions for successful tactile sensory augmentation. These are the adaptability of the brain to unfamiliar sensory input and the specific qualities of the skin lending themselves to be used for the perception of additional sensory information. Two devices, Moon Ribas' Seismic Sense and David Eagleman's VEST*, will then be discussed as potential facilitators of aesthetic experiences in virtue of the tactile sensory augmentation that these devices allow. I will connect the experiences afforded by these devices to the Kantian categories of the mathematical and the dynamical sublime, and to existing accounts of tactile sublimity. Essentially, the objects these devices make sensible, earthquakes for the Seismic Sense and digital information for the* VEST*, produce pleasurable feelings of potential danger, awe, and respect. The subsequent acclimation to this new way of sensing and the aim to comprehend its sensed object are then discussed as possible objections to the interpretation of these experiences as sublime, and as aesthetic in general. To exemplify these issues and concretise my thesis of tactile sensory augmentation as a trigger of the sublime, I will outline an experiment to use the* VEST *as an aid for faster decision making on the stock market.*

Introduction

From the figure of the cyborg, an ambiguous merger of flesh and technology[1], to the recent innovations in the field of virtual and augmented reality,[2] the technological mediation of our embodied experience of the world elicits constant debate about its potential, implication, and value. In addition, phenomena such as wearables or body modifications pose interesting questions to the field of aesthetics. Virtual reality goggles or smart glasses, for example, transform, denaturalise, and deconstruct the way we sensually experience the world. Such devices challenge the very basis of aesthetic experience. In this paper, I want to examine how technological modification of the senses can alter or facilitate aesthetic experiences. I will discuss two devices that exploit our tactile sense (the registration of pressure on the skin).[3] The first, Seismic Sense, is a vibrating ankle bracelet, invented by the artist Moon Ribas.[4] The second, the Versatile Extra-Sensory Transducer (VEST), is a vibratory device worn as a VEST developed by neuroscientist David Eagleman.[5] The ankle brace-

1 On the concept of cyborgism see Grenville (2001) and Kirkup (2010).

2 For an overview on augmented reality technologies, see Dey *et al*. (2018); a review of literature on virtual reality can be found in Berntsen *et al*. (2016).

3 Our tactile sense is thus a subcategory of the sense of touch, which includes tactile, haptic, proprioceptive, kinaesthetic, vestibular, and cutaneous sensations. For an overview and definition of these different 'senses of touch' see Paterson 2007, IX.

4 Even on Ribas' own various web presences, there is conflicting information on the Seismic Sense. On the project's website (ThoughtWorks Arts 2016), it is described as a wearable, an exteriorly worn device, and illustrated with a picture of it worn on Moon Ribas' ankle. Later, it is described as an implant into Ribas' arm, however. On another webpage co-founded by Ribas, (Cyborg Arts 2019) the Seismic Sense is described as an implant in the artist's feet. Since the function of the Seismic Sense is not affected by these differences, I will address it as an ankle bracelet, which, as a wearable, seems its potentially most popular form. Interestingly, Ribas also uses her device as a prop in various performances, whose choreography depends on the seismic activity felt by her. Here, the sensorally augmented artist functions as a medium for the creative power of 'nature' itself. For a summary of Ribas' artistic activities and strategies, see her TED-Talk in Munich in 2014 (TEDx Talks, 2015).

5 This, too, has been presented in a TED-Talk, in Vancouver in March 2015 (TEDx Talks, 2015a).

let makes earthquakes perceptible at a distance, by vibrating whenever there is an earthquake happening somewhere in the world. The device is connected to an online seismograph, causing the vibrations to vary in strength according to the earthquake's magnitude (Boukhris and Almiron 2017, 203). The VEST is equipped with small vibratory sensors on its back which can be controlled via Bluetooth. Depending on the programming, the VEST can receive and automatically transduce different kinds of digital information into vibratory patterns. This way, digital information, such as data from the stock market, can be translated into tactile sensations. I will argue that both facilitate the aesthetic experience of the sublime. In other words the experiences afforded by these devices can be understood in terms of the Kantian dynamical and mathematical sublime.

In Section One, I will explain what sensory augmentation is and how it works. Important here are the premises of brain plasticity (its functional and structural changeability) and the possibility of tactile sensory augmentation. In Section Two, I discuss the two aforementioned devices, which are able to transduce abstract information into immediately felt tactile sensations. Section Three develops an understanding of the experience afforded by the devices using the Kantian categories of the dynamical and the mathematical sublime. Section Four examines a potential worry: how can we render sensory augmentation devices as sublime, when their aim for sensual comprehension of abstract phenomena stands contrary to the sublime as an aesthetic of failed comprehension? To further explore this worry, in Section Five I discuss a particular example of sensory augmentation technology facilitating an experience of the sublime, namely the use of the VEST in stock trading experiments. This will lead me to the conclusion that the sublime experiences manifested with these devices are only possible during the early stages of use before the inevitable normalisation of the tactile sensations, although the desired effect of sensual comprehension is open to question.

1 Sensory Augmentation and Neuroplasticity

One way of understanding sensory augmentation is an alteration of the way we sensually experience the world. On this understanding a mirror which relocates the sense of vision, or a white cane which extends the tactile sense, or even temporary sensory alterations such as hallucinogenic drugs can be seen as sensory augmentations. This ambiguity necessitates a distinction between four related concepts of sensory alteration for the purpose of this essay, a distinction which roughly follows four definitions proposed by Jamie Ward and Thomas Wright (2014, 9-10):[6]

> a) Sensory Restoration – repairing a damaged sense modality with, for example, prescription lenses or cochlear implants
>
> b) Sensory Extrapolation[7] – increasing the range of perception of an existing sense modality, with devices such as night vision goggles or microscopes
>
> c) Sensory Substitution – replacing a certain sense by translating sensory stimuli of one modality into information for another modality, for example braille
>
> d) Sensory Augmentation – using technology to make something formerly imperceptible known to the sensory apparatus, such as x-ray radiography
>
> (Ward and Wright 2014, 9-10)

Although the line of distinction between (c) and (d) is rather thin, it is important to separate them to account for the different underlying

6 The authors distinguish between 'compensatory prostheses', which corresponds to my definition of a) 'within-sense referral devices', which expands b) onto relocations of the sensor with mirrors etc.; 'between-sense referral devices', which, as the authors state, is largely synonymous with sensory substitution; and 'novel-sense referral devices', which corresponds to my usage of the term sensory augmentation.

7 The term 'sensory extrapolation' is borrowed from Humphreys (2004, 4).

motivations. Whilst sensory substitution (c) – and also sensory restoration (a) for that matter – simulates the sensing of another modality, restores previous sensory abilities, or establishes normative sensory abilities for differently abled people, sensory augmentation (d) accesses information which lies completely outside the human sensory realm.[8] Particularly, sensory augmentation (d) does not understand the substituting sensory modality as a mere compensation for the substituted modality, but embraces the specific way of each modality to sense the world. The tactile augmentations discussed here are therefore no mere substitutions for vision, but augmentations in their own right. However, sensory augmentation and substitution are inevitably linked. The attempt to augment the sensory apparatus was only made possible by innovations in the field of sensory substitution. The same device can often be used to both substitute and augment a sensory modality, as the history of tactile sensory substitution shows. Therefore, although my main interest is sensory augmentation (d), it is so closely connected to sensory substitution that a prior discussion is required.

Crucial for the development of sensory substitution and augmentation devices was the research by neuroscientist Paul Bach-y-Rita, starting in the late 1960s. His experiments made two important discoveries: (1) the ability of the brain to interpret new sensory stimuli, and (2) the affordance of the skin. Bach-y-Rita developed a method for Tactile-Visual-Sensory-Substitution (TVSS). This enabled blind people to perceive objects at a distance using their tactile sense. In Bach-y-Rita's original setup, an array of vibratory solenoid plates was mounted to a dentist's chair and connected to a camera (1969).[9] The blind participants controlled a camera to scan various items placed on a table in front of them. The camera image was then transduced into vibratory responses,

8 For an ideological and technological critique of sensory restoration as a reproduction of ableism, see Campbell (2009, 79-96).

9 For a more recent review of the progressings in the field of sensory substitution using different sensory modalities, see Bach-y-Rita and Kercel (2003).

corresponding to the image in intensity and position on the array. By interpreting the vibrations on their backs, the participants were able to discriminate between the objects placed in front of the camera.

In comparison with previous technological inventions which can be seen as TVSS-devices, such as the white cane or the braille writing system, Bach-y-Rita's setup works without directly or indirectly touching the object and performs a greater range of functions than identifying obstacles or reading text – it makes possible the simultaneous perception of several objects, including non-haptic features such as their shadows, their potential movement, and their spatial relation (Bach-y-Rita *et al.* 1969, 963-4).

The participants in this experiment reported a fast process of adaptation, as they learnt this new means of perception. With time, users became less aware of the tactile stimulation itself and instead began to perceive the objects directly, i.e., without being conscious of the technological mediation facilitating the sensual experience (Bach-y-Rita *et al.* 1969, 964; Bach-y-Rita 2004, 86). The experiment demonstrates two factors which are essential for the success of sensory augmentation devices discussed in the next section: neuroplasticity and the affordance of the skin for additional sensory input. Neuroplasticity denotes the theory that the connections between neurons in the brain are not fixed but get established and consolidated by frequent use. (Hebb 1949, 62; Bach-y-Rita 1967). According to neuroplasticity the brain can transform its anatomical or functional structure according to changing requirements, i.e., it is malleable. Bach-y-Rita's experiments with sensory substitution demonstrate this. After an initial learning phase, the brain is able to interpret new sensory stimuli. This ability, which is necessary for successful sensory substitution, also enables sensory augmentation. Instead of transducing the sensory information of one modality into another, information that is completely alien to the sensory apparatus is translated into tactile stimuli and is perceived directly.

Another finding of Bach-y-Rita's experiment is the potential of the skin to process additional sensory input. Unlike the eyes or the ears, the skin is not permanently occupied with discriminating unfamiliar sensory information. At least on the back, most passive stimulations on the skin are processed unconsciously – if we do not concentrate on it, the sensations of the air or of clothes touching our skin go largely unnoticed. Although subliminal sensations occur within all sense modalities, the threshold for the skin on the back to consciously perceive sensory stimuli is comparatively high (Weinstein 1968). Therefore, it offers a large, typically underutilised area for additional sensory information in the form of vibrations. Although the tongue or the fingertips have far more sensory receptors, Bach-y-Rita's original experiment has shown that the sensibility of the skin of the back is effective enough to discriminate the sensations of four hundred vibratory rods on an array. Keeping these discoveries in mind – (1) the ability of the brain to interpret new sensory stimuli, and (2) the affordance of the skin, especially on the back, for sensory augmentation – I would now like to introduce two technical devices, both of which have popularised sensory augmentation using the tactile sense.

2 Tactile Sensory Augmentation Devices

In this section, I will introduce two devices which engage with the findings of Bach-y-Rita's research to transit from sensory substitution to sensory augmentation: the Seismic Sense and the VEST.

In 2013, the artist and co-founder of the Cyborg Foundation Moon Ribas started wearing a vibratory ankle bracelet with a wireless connection to the US government web service for earthquake data (Boukhris and Almiron 2017, 203). Whenever it receives information about an earthquake happening somewhere in the world, the ankle bracelet vibrates. The vibration's strength matches the earthquake's magnitude on the Richter scale. Ribas thus carries a tactile augmentation which functions as a 'Seismic Sense'. In an interview from 2016, the artist stressed the

feeling of closeness this device facilitates, when she described the effect of a particularly strong earthquake: "It felt very weird, like I was there [...] I feel connected to the people who suffer through an earthquake." (Quito 2016). The Seismic Sense thus combines an affective quality ("I feel connected") and sensual immediacy ("like I was there") with the safe distance to the actual object of perception, the earthquake.

The second example of sensory augmentation is a TVSS-device developed by the team of neuroscientist David Eagleman. This device is called the VEST (Versatile Extra-Sensory Transducer). It functions as a portable and flexible version of Bach-y-Rita's dentist chair, which I discussed in Section One.[10] The VEST has several vibratory motors on its back which are controlled by an implemented microcontroller. With a specifically designed interface – a smartphone app, for example – information is compressed and sent to the microcontroller via Bluetooth. Here, the information is transduced into vibratory patterns, which can be felt as tactile sensations on the back. If a working interface to compress the incoming information is provided, any kind of information can be transduced into tactile sensations. Given the plasticity of the brain, it is possible that information will eventually be perceived directly as an additional sense.

The VEST still remains in a highly experimental state with no established ways of usage. There are, however, many contexts it could be introduced to. The VEST could be connected to a camera, for instance, through which the user scans their surroundings and transduces the appearance of objects into tactile sensations on the back. However, we can imagine many other ways to apply the VEST. It could be used to ease navigation in space by vibrating when the user has to turn to a certain

10 Bach-y-Rita himself developed several portable applications of his TVSS system, including an array of tactile stimulators grid worn as a belt on the abdomen and a small array placed on the tongue, connected to a camera mounted within spectacles. See: Paterson (2016, 168-170); Chirimuuta and Paterson (2015, 416); Renier and Volder (2013, 855).

direction, for example; to get direct bodily feedback whilst controlling complex machinery; as a notification system for upcoming appointments or social media activities; to notify the user of changes of internal bodily states they might otherwise be unaware of (e.g. ovulation or hypoglycaemia); or it could increase synaesthetic experience, enhancing, for example, the enjoyment of music. When sitting in a concert hall, the VEST could be connected to microphones and, depending on the chosen programming, vibrate according to the music's volume or timbre, or the different vibrators on the VEST could match different instruments. Or when going on a run, the VEST could warn against dehydration, give feedback on the heart rate or keep the wearer on a pre-programmed path by vibrating on crossways. Again, theoretically, the relayed information via the VEST could be of any kind as long as it is translatable into vibrations via Bluetooth. These two devices suggest that the brain adapts itself to new sensory stimuli, particularly to those utilising the skin, which is a sensory medium without many interfering conscious stimuli. In addition, the tactile sensations seem to be able to produce feelings of immediacy and closeness. These feelings are important for the next section of this paper, in which I will argue for the Seismic Sense and the VEST as facilitators of sublime experiences – the latter not in a certain area of application, but its general incentive to make abstract information tactilely sensible. While the association of the Seismic Sense with the sublime might seem obvious, given the preoccupation of both with natural phenomena, the relationship between abstract information and the sublime will require some elaboration.

3 The Tactile Sublime

I will first briefly discuss the sublime as conceptualised by Immanuel Kant and describe existing accounts of a tactile sublime. I will then relate the sublime to the devices introduced in the previous section.

In the *Critique of Judgement,* Kant develops two distinct categories of sublime experiences (1987, 101 §24). On the one hand, the dynamical

sublime describes the merely theoretical fear triggered by overwhelming or threatening phenomena in nature, such as thunderclouds or waterfalls. To experience the dynamical sublime in nature, the subject has to reassure herself that the danger imposed by nature is not harming them, yet re-enact the fear it would cause as a form of amazement.[11] On the other hand, the mathematical sublime describes the incapability of human imagination to comprehend magnitudes in the same way that mathematical concepts can frame them. Magnitude is a relative term, denoting objects which are large beyond comparison, or 'in comparison with which everything else is small.' (Kant 1987, 106 §25). Their totality exceeds imaginative abilities and curbs the urge for aesthetic comprehension (Kant (1987, 97-8 §23). Similar to the dynamical sublime, this failure of the aesthetic faculty entails a certain threat for the subject, a momentary questioning of his sovereignty. It opens up 'an abyss in which the imagination is afraid to lose itself.' (Kant 1987, 115 §27) The momentary trembling, facing a danger or the limits of aesthetic comprehension, arouses a feeling which is 'not so much a positive pleasure as rather admiration and respect.' (Kant 1987, 98 §23 and 114 § 27)

Kant's account of the sublime is based solely on the sense of vision. Yet, recent work by Alan McNee and less directly by Carolyn Korsmeyer explore the possibility of a tactile sublime (McNee 2015; Korsmeyer 2014 and 2016). In his work on 19th-century mountaineering as a multisensory aesthetic experience, McNee coined the term 'haptic sublime', which is, unlike the ocularcentric,[12] distanced aesthetic theory by Kant based on

11 '[…] any spectator who beholds massive mountains climbing skyward, deep gorges with raging streams in them, wastelands lying in deep shadow and inviting melancholy meditation, and so on is indeed seized by amazement bordering on terror, by horror and a sacred thrill; but, since he knows he is safe, this is not actual fear: it is merely our attempt to incur it with our imagination, in order that we may feel that very power's might and connect the mental agitation this arouses with the mind's state of rest' (Kant 1987, 129 §24).

12 I borrow the term 'ocularcentrism' from Martin Jay (1988).

the proximity of tactile encounter.[13] According to McNee, it is the sensually experienced closeness to the mountains which evokes sublime feelings in the touching subject: the sensations of climbing a mountain, feeling the tension in the whole body, its slow movement in the scenery, the exhilarating feeling of danger, and the contact of the skin to the rock or ice wall all come together to make the mountaineer aware of their bodily presence while simultaneously inducing a feeling of transcendence. McNee stresses that the sublimity of mountaineering cannot only be attributed to the overwhelming nature of mountains, but to the human urge to conquer them: 'The sublime [...] is to some extent an aesthetic of mastery, of overcoming a threat or difficulty.' (2014, 15) This threat is, unlike the Kantian dynamical sublime, not theoretical but real; it intensifies the threat for human sovereignty and the accompanying feeling of respect (McNee 2014, 15-7).

In Korsmeyer's writing on genuineness and the sense of touch, the category of the sublime is repeatedly implied, when she references David Lowenthal's notion of the 'shiver of contact' David Hume on the sublimity of cross-temporal contact (Korsmeyer 2016, 219) and the tactile encounter of ruins (Korsmeyer 2014, 434). In touching something genuinely old, the touching subject is directly confronted with a temporal scale far beyond the human lifespan. Touch, in this case, establishes the perceptual link necessary for an aesthetic experience and elicits the feeling of respect.

Both these models of tactile sublimity replace the distance necessary for experiencing the Kantian dynamical sublime with a moment of physical contact. Ribas' seismic device, then, can be understood as a reconciliation of this tactile sublimity with the distanced dynamical sublime. The Seismic Sense conforms to the dynamical sublime firstly because earthquakes as the given object of perception are a traditional

13 McNee uses the term 'haptic' instead of 'tactile' to account for the synaesthetic experience of mountaineering, including proprioceptive and kinaesthetic sensations (2014, 14).

trigger of sublime experiences. For example, in his treatise on the dynamical sublime, Kant discusses natural phenomena such as 'tempests, storms, earthquakes.' (1987,122 §28) Secondly, the Seismic Sense elicits a sense of possible danger while maintaining a safe distance. It is exactly this combination of danger and distance that makes the Seismic Sense eligible for the aesthetic category of the sublime. In the accounts of McNee and Korsmeyer, the sublime experience is brought about by physical presence. In the case of the Seismic Sense, the physical presence becomes telepresence, which denotes 'the presentation of perceptual information that claims to correspond to a remote physical reality' (Goldberg 1998, 33). The ankle bracelet as a device able to facilitate telepresence reconciles the tactile sublime and the Kantian dynamical sublime: it establishes an immediate contact with the destructive powers of nature but secures a safe distance, which enables the feeling of respect while emphasising the subject's independence.

The Vest, on the other hand, responds to the mathematical sublime. This is because it establishes a perceptual link with phenomena across multiple spatio-temporal dimensions, questioning human sovereignty. Specifically, in this case, the overwhelming phenomenon is the sheer amount of information gathered in the 'information society'.

The post-industrial paradigm of the information society has been, among others, postulated by Theodore Roszak. In his book The Cult of Information, Roszak analyses the impact of a 1948 paper on communication theory by Claude Shannon. In this paper, Shannon proposes a new definition of information, not as a carrier of meaning, but as a 'purely quantitative measure of communicative exchanges' (Roszak 1986, 11) which is independent from both sender and receiver. Information gains value on its own and effectively reduces human agency and sovereignty. Roszak argues that this new definition of information prefigures the paradigm of the information society, as a society organised in decentralised global networks, in which humans become mere

participants (1986, 15–16).[14] Information itself, organising and controlling human interaction, becomes a sublime phenomenon – something that is increasingly hard to grasp in its totality and is less and less subordinate to human command.

This relation of information and sublimity has in recent years been further popularised by 'developments across a range of technologies, from digital sensors, computer networks, data storage, cluster computer systems and cloud computing facilities' (Bryant *et al* 2008, 2-3 in McCosker and Wilken 2014, 156), developments that have led to the algorithmic aggregation of information in nearly every aspect of life. This is subsumed under the term 'big data', which denotes amounts of data that are too big to be intelligible by humans. Moreover, due to the logic of total data accumulation, which lead to the phenomenon of big data, humans themselves became profitable sources of information. This logic increases the subjugation denoted in Shannon's model of information. Thus, the concept of big data as a relative magnitude, the challenge it poses for human sovereignty and the problem of representability or comprehension lead back to the mathematical sublime. The Vest not only allows users to experience phenomena such as big data sensually, but makes this experience a potentially aesthetic one, as a feeling of the sublime.

Although the category of the sublime was originally used in relation to predominantly visually experienced phenomena, the work of McNee and Korsmeyer have paved the way for an understanding of a tactilely experienced sublime. The physical presence, which is essential to both accounts of tactile sublimity, is, in the devices discussed here, transformed into telepresence. While the Seismic Sense refers to the traditionally sublime phenomenon of earthquakes, the Vest is able to make digital information sensible through vibrations, facilitating an equal feeling of sublimity.

14 See also Poster (1994, 173).

Yet, framing tactile devices as sublime facilitators poses a problem. The VEST proposes an alternative way of knowing, an immediate, sensual form of comprehension. If, however, the VEST is able to aptly comprehend big data for its user, a conflict with my interpretation of the feelings it produces as sublime would arise. In the following section, I will explore this conflict between the VEST's aim for comprehension and my interpretation of it as aesthetic facilitator further. Observing a process of normalisation in the sensual experience afforded by the VEST, which reinforces the aim for comprehension, I will argue that sublime experiences are only possible in the early stages of the use of such devices.

4 Sensual Comprehension and Normalisation

The relationship between sensual comprehension of abstract information and the sublime has been discussed in detail for the topic of data visualisation.[15] I will relate this discussion to the given case of tactile sensory augmentation devices, with regard to Bach-y-Rita's experiments, as well as existing work on somaesthetics – the aesthetic experience of one's own body.

For the case of data visualisation, Lev Manovich argues that visualisation is indeed anti-sublime, since it attempts to represent overwhelming masses of data in perceptible, and what are frequently referred to as 'beautiful', graphs (Manovich 2002, 8). Anthony McCosker and Rowan Wilken, on the other hand, plea for data visualisation as a trigger of sublime experiences in its own right, which rather 'reinforces the sense of 'unknowability' that has become associated with sublime experiences of phenomena connected with 'big data'' (2014, 156).

For the case of the VEST, I will take the view of McCosker and Wilken. The VEST primarily establishes a sensual relationship with the represented object, a sublime anticipation. Similar to imaginatively encoun-

15 See Manovich (2002); Jevbratt (2004); Stalbaum (2006); Sack (2011); McCosker and Wilken (2014).

tering centuries of history with a single touch, the venerating gesture Korsmeyer sees in the tactile encounter of ruins, I propose that the vibrations of the VEST can produce a feeling of respect for the excessive amounts of information channelled through it. In the beginning, when the vibrations seem erratic and incomprehensible, the wearer of the VEST might feel overwhelmed by the constant stream of data, and the sheer vastness of the informational world they are now exposed to. Here, the 'urge for mastery' (McNee) is paired with the 'sense of unknowability' (McCosker and Wilken).

It was reported that the participants of Bach-y-Rita's original experiment became accustomed to the vibrations and with time came to perceive objects directly. This indicates that the initial sublime 'shiver of contact' may weaken. This process of normalisation is the exact reversal of what Richard Shusterman and Sherri Irvin describe as a criterion for somaesthetics — the unusual attention one has to give to bodily sensations to perceive them aesthetically (Shusterman 1997; Irvin 2008). Due to the malleability of the brain, the user of the VEST will give less and less attention to the sensation itself, and start to feel them as a direct manifestation of the data the VEST has been connected with. Following this line of thought, neuroplasticity hinders aesthetic experience: the tactile devices discussed here start out as facilitating sublime aesthetic experiences, which, with increasing normalisation, eventually fade into ordinary sensory perception. The aesthetic appreciation of ordinary objects thus requires a sense of unfamiliarity and an unusual attention to the sensual experience itself, both of which are challenged by constant exposure.

I will end my paper by exemplifying this tension between the category of the sublime and the process of normalisation with a particularly remarkable experiment performed with the VEST. This experiment, aiming for a tactile sensing of the fluctuations of the stock market, combines the characteristics of the mathematical and the dynamical

sublime and, notwithstanding that this aesthetic effect might dissipate after repeated use, illustrates the device's processing of big data.

5 Sensing the Stock Market

In a separate experiment carried out by Eagleman's team, the VEST was linked to data from the stock market.[16] The stock market is an electronic network of shareholders, which has been described by economists such as Shiller or Kahnemann as behaving like a herd, yet without any common or higher purpose.[17] The fluctuations in the stock market, which the buying and selling of stocks produce, are in their entirety mostly erratic, unforeseeable, and in times of crisis highly destructive for the economy. In this context, the VEST is promoted as a novel approach to the stock market. It promises an intuitive, visceral understanding of the market fluctuations and a considerable advantage in the virtual trade of buying and selling stocks, in which only the fastest and most knowledgeable participants profit.[18] Eagleman explains the rationale as follows:

> We stream 5 seconds of real-time data from the internet to a person wearing the VEST. Then two buttons appear on a screen, and the person has to make choice. A second later they get a smiley face or frowny face telling them whether their choice was the right one. The person has no idea that what they're feeling is real-time stock market data, and that the buttons represent buy or sell decisions. [...] Eventually we'll tell the participants what is really going on, and we are interested to know what the expe-

16 David Eagleman reports on the ongoing experiments in a TED-talk in Vancouver, March 2015 (TEDx Talks, 2015a). A scientific publication of the results is yet to be published.

17 See, for example, Shiller (2005), Tversky and Kahneman (1974), and Brunnermeier (2001).

18 Research has shown that traders with a highly developed sense of interoception, a visceral feeling for the internal state in the body, are significantly more successful at high-frequency-trading. See Kandasamy *et al* (2016).

> rience will be like for a person who wears this stock market VEST for long time. Are they suddenly going to feel a tightening in their stomach and think, "Oh gosh, the oil price is about to crash"? (Eagleman in Thomson 2015, 27)

In this setup, the VEST enables its wearer to adapt to the rapid fluctuations of the stock market and to integrate its, at times, devastating instabilities directly into the sensory apparatus. In particular, the VEST offers a new way to interpret the constant, overwhelming and often hardly intelligible flow of information in real-time, and to sensually experience the devastations caused by ruptures in the stock prices. This way, the tactile sensing of the stock market responds to the mathematical as well as the dynamical sublime.

Eagleman does not try to conceal the fact that the experiment is highly speculative and might not provide a substitute or even a supplement for traditional stock market analysis. However, the erratic vibrations indicating changes on the incomprehensible scale of the world economy will eventually cease to produce sublime experiences and dissipate into ordinary tactile sensations that the wearer of the VEST will get accustomed to – whether they can make sense out of them or not.

6 Conclusion

In this article, I discussed two tactile sensory augmentation devices and their potential for aesthetic experiences, in particular experience of the sublime. Following Jamie Ward and Thomas Wright, 'sensory augmentation' has been defined as a way to exploit an existing sense modality in order to make something that was formerly imperceptible known to the sensory apparatus (Ward & Wright 2014, 9-10). Consequently, I have proposed that this is distinct from sensory restoration, extrapolation and substitution.

I have suggested that sensory substitution is the precursor for sensory augmentation, given that the sensory substitution experiments by Bach-

y-Rita have demonstrated that the plasticity of the brain and the affordance of the skin for sensory substitution are key to successful tactile sensory augmentations. The devices I have examined, in this paper, make use of these preconditions to enable new aesthetic experiences of the world — earthquakes in the case of the Seismic Sense and digital information in the case of the VEST. Moreover, I have demonstrated that these experiences fit the Kantian concept of the dynamical and mathematical sublime. I have singled out the problem of comprehension as a possible objection to my account. The sublime, as an aesthetic of failed comprehension, stands contrary to a possible motivation of the VEST, which is to comprehend phenomena, such as big data, tactilely. I have argued that instead of a feeling of comprehension, the VEST produces a feeling of unknowability, which triggers the sublime. An aesthetic feeling such as the sublime, however, requires that attention be given to the sensation, which will probably fade with constant use of tactile sensory augmentation devices. The facilitation of sublime experiences is therefore an effect confined to the initial stage of the usage of such devices. In order to concretise this issue and the abstract feature of the VEST to give a sublime sense of overwhelming amounts of data, I have examined an experiment to make stock data tactilely sensible. The lack of intelligibility of stock market fluctuations, and the possible danger caused by them culminates in a feeling of mathematical as well as dynamical sublimity.

This example illustrates that the Kantian sublime not only offers a way to conceptualise recent technological innovations and the social fabric they are weaved into, but also an entry point for the field of aesthetics to engage with the technological augmentation of the senses.

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