Title: careful whispers: when sounds feel like a touch

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Abstract:

There are anatomical and functional links between auditory and somatosensory processing. In this paper we suggest that these links form the basis for the popular internet phenomenon where people enjoy a sense of touch from auditory (and often audio-visual) stimuli.

Keywords: audio-visual elicited somatosensation (AVES), autonomous sensory meridian response (ASMR), auditory processing, somatosensation

Over the last decade, there has been a great increase in online content created with the specific aim of causing the audience to experience a pleasant sense of touch, also called a 'tingling' sensation, often around the scalp, neck, shoulders and back [1]. It is not the case that all sounds elicit such sensations: these tend to be quiet sounds such as whispered speech, non-verbal sounds such as finger tapping or crinkling, and personal attention roleplays, such as the sounds of a haircut [1]: they are typically recorded in a way that makes the sounds seem proximal to the listener. People who are sensitive to these experiences often find them to be relaxing, and they have become even more popular under the global COVID-19 pandemic – in September 2020 searches for videos which played such sounds were the third most common on YouTube (https://theconversation.com/asmr-what-we-know-so-far-about-this-unique-brain-phenomenon-and-what-we-dont-135106). The term 'ASMR' is frequently used to describe these experiences, which stands for autonomous sensory meridian response, but these words are not accurate descriptions of the sensory experience, nor of the manner in which it is elicited, so we will not be using it further.

So far – so what? There are lots of popular kinds of content being created for YouTube, they cannot all be of scientific interest. We wish to argue, however, that this audio-visual elicitation of somatosensation (AVES) is an intriguing demonstration of a perceptual illusion that results from links between auditory and somatosensory processing. Further exploration of AVES may well be an important way of determining some of the function's relationships between sound, space and touch.

Auditory processing is influenced by somatosensory input from the cochlear nucleus and the ascending auditory pathway, up to the cortex [2] (figure 1.). Indeed, the processing of some aspects of sounds in the ascending auditory pathway *requires* information from the somatosensory system (e.g., about head orientation). At the cortex, there are anatomical links between auditory fields and somatosensation (figure 1.). The functional consequences of these links have been seen in several studies: in studies of non-human primates, caudal-medial auditory fields respond to touch as well as sound and receive inputs from somatosensory fields [3]. An fMRI study in humans showed that hearing a sandpaper 'rubbing' sound and feeling the texture of sandpaper with the fingertips leads to spatially overlapping cortical activation in caudal auditory areas, extending up into somatosensory cortex [4].

A recent computational model of cortical auditory processes [5] suggested that caudal and rostral auditory fields could be broadly distinguished in their responses to sensory input. The neural properties of caudal fields are associated with short response latencies, onset responses, and somatosensory input. These were associated functionally with guiding sound production, processing sounds as actions and sound-related spatial computations. In contrast, the rostral neural properties of auditory fields are associated with long response latencies, sustained responses and visual input, with functional links to recognition processes, connections to semantic networks and multiple auditory streams. We propose that the caudal fields, with their links to both spatial processing and somatosensory processing may be critical links in the perception of AVES.

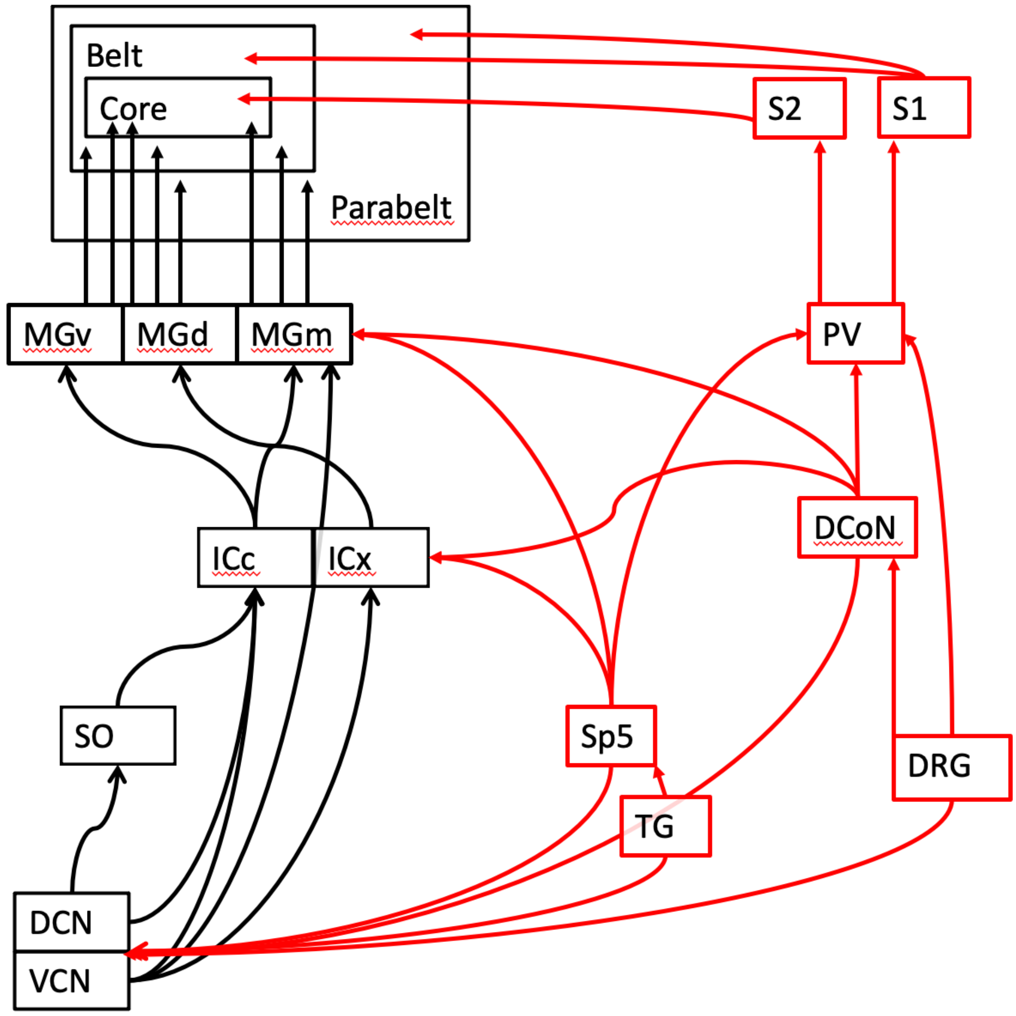
In acoustic terms, sounds with a lower spectral centre of gravity, or a 'darker' timbre – that is, where there is a dominance of low frequencies in the spectral shape of a sound - are more likely to lead to AVES sensations [6] which is consistent with previous findings on preferences for stimuli with a lower pitch [7]. This cannot be the whole story however: whispered speech has a weak pitch, and the plosives and fricatives which are popular in AVES recordings are often somewhat higher in their spectral centre of gravity. Furthermore, there is a suggestion of a spatial element – people creating these films for YouTube typically make sounds very close to the microphones, and popular use of binaural microphones suggests that AVES may require the sounds to not be simply proximal, but close to the listener's ears and head [6]. Finally, there is a key role for interpersonal features, such as the use of emotive language and 'semantic dialogues' wherein social interactions occur, including direct personal attention [8] – for example, the sound of a haircut, where the AVES listener is the recipient of the haircut. These roles for proximity and personal attention, combined with sounds that would actually be hard to hear if they were occurring at a distance, suggests that AVES is strongly associated with sounds that could be *occurring close to* the experiencer, and resulting from behaviour *directed at* the experiencer. This seems to be how visual information enhances AVES responses, with a strong link to attentional and performative elements of the content.

In terms of neural activation, some fMRI studies have been carried out, although one could speculate how the intensely acoustically noisy fMRI environment might interact with AVES experiences. A wide range of activations are associated with stimuli designed to elicit an AVES somatosensory response, involving sensation, emotion, attention, and reward networks: in addition, activation in posterior auditory fields has been reported [9]. This is consistent with a role for caudal auditory areas in AVES experiences. We suggest that a systematic exploration of the acoustic and visual factors that lead to AVES experiences may be able to expand upon these findings, and test more explicitly the roles of different auditory visual and somatosensory functional connections.

Is AVES an illusion, or is it a form of synaesthesia? Is it related to other forms of sensory experience associated with sound, like musical 'chills', or sounds that 'put your teeth on edge' or vision – for example experiencing the sensations of touch from viewing someone else being touched [11]? Also, there are clear individual differences in the AVES experience – with evidence suggesting that people who are more prone to AVES sensations are more open to experiences, more empathetic and likely to get engaged in immersive experiences [10] and display specific autonomic responses during AVES sensations, including reduced heart rate and heightened skin conductance [12]. More work is needed. However, we strongly suspect that AVES will prove to be a very important illustration of the links between sound, space and somatosensation. When we hear a sound, it means something has happened, and when we hear sounds that seem close to our ears, are gentle, and result from actions and attention that seem to be directed at us, this may prime somatosensory responses. And the experience may be pleasant and relaxing precisely because, away from the internet, in the 'real world' such situations would normally occur in a trusting, intimate and affectionate way.

Figure legend

This figure shows the integration of ascending somatosensory pathways (in red) into ascending auditory pathways (in black). The dorsal and ventral cochlear nuclei (DCN, VCN) receive ascending somatosensory inputs from trigeminal ganglia (TG), spinal trigeminal nuclei (Sp5), dorsal root ganglia (DRG) and dorsal column nuclei (DCoN) via the marginal cell area of the VCN. There are also separate inputs to the central and external nuclei of the inferior colliculi (ICC, ICX), and the auditory thalamic nuclei. Finally there are projections from primary (S1) and secondary (S2) somatosensory cortex to core, belt and parabelt auditory fields. [superior olivary complex = SOC, dorsal nucleus of medial geniculate body = MGd, medial nucleus of medial geniculate body = MGm, ventral nucleus of medial geniculate body = MGv, posterior ventral nucleus of thalamus = PV).



Belt
Core
Parabelt
S2
S1
MGv
MGd
MGm
PV
DCoN
ICc
ICx
SO
Sp5
DRG
TG
DCN
VCN

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