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ABSTRACT

Autonomous Sensory Meridian Response (ASMR) is a perceptual condition in which specific visual and auditory stimuli consistently trigger tingling sensations on the scalp and neck, sometimes spreading to the back and limbs. These triggering stimuli are often social, almost intimate, in nature (e.g., hearing whispering, or watching someone brush her hair), and often elicit a calm and positive emotional state. Surprisingly, despite its prevalence in the general population, no published study has examined the neural underpinnings of ASMR. In the current study, the default mode network (DMN) of 11 individuals with ASMR was contrasted to that of 11 matched controls. The results indicated that the DMN of individuals with ASMR showed significantly less functional connectivity than that of controls. The DMN of individuals with ASMR also demonstrated increased connectivity between regions in the occipital, frontal, and temporal cortices, suggesting that ASMR was associated with a blending of multiple resting-state networks. This atypical functional connectivity likely influences the unique sensory-emotional experiences associated with ASMR.

Autonomous Sensory Meridian Response (ASMR) is a controversial condition in which specific visual and auditory stimuli trigger tingling sensations on the scalp, neck, and back. These "tingles" are typically accompanied by positive emotions as well as a feeling of deep relaxation (Barratt & Davis, 2015). What makes ASMR distinct from other uncommon sensory experiences such as frisson (tingling sensations, or "chills", associated with hearing music) is that ASMR triggers are quite reliable, with the same videos or sounds consistently eliciting tingles and relaxation in the same individual. Even more intriguing is the nature of the sensory triggers themselves; these stimuli are generally social, almost intimate, in nature. A recent survey study of over 450 individuals with ASMR found that whispering, close-up attention, and viewing slow movements such as hair brushing elicited tingles in over half of respondents (Barratt & Davis, 2015). ASMR has also been linked with repetitive movements and sounds (e.g., finger tapping) and alternating binaural auditory stimuli. Recently, online communities with over 100,000 subscribers have developed to share videos specifically created to elicit ASMR tingles (e.g., http://www.reddit. com/r/asmr/). Surprisingly, despite its fascinating phenomenology and apparent prevalence in the general population, there are no published scientific studies investigating the neural substrates underlying ASMR. The current study addresses this issue by examining the functional connectivity of a prominent resting-state network – the default mode network (DMN) (Raichle et al., 2001) – to determine if the brains of individuals with ASMR differ from those of matched control participants.

The DMN consists of the medial prefrontal cortex, medial temporal gyri, bilateral inferior parietal cortices, precuneus and posterior cingulate gyrus (Buckner, Andrews-Hanna, & Schacter, 2008; Raichle, 2015). In the absence of cognitive or environmental stimulation, the firing rates of neurons in these structures tend to covary, suggesting that these regions are functionally connected. Activity in the DMN is thought to represent self-relevant thoughts and attention toward the internal milieu rather than to external stimuli (Greicius, Krasnow, Reiss, & Menon, 2003). However, the integrity of the DMN is compromised in some neurological and neurodevelopmental conditions (e.g., Bluhm et al., 2007;

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Author contributions
SDS and JK designed the experiment. SDS, JK, and BF conducted the experiment, analyzed the data, and wrote the manuscript.

Greicius, Srivastava, Reiss, & Menon, 2004; Kennedy & Courchesne, 2008). This reduced functional connectivity may reflect structural abnormalities of brain regions, atypical densities of white-matter pathways connecting DMN structures, and/or a functional reorganization caused by changes in the firing rates of one or more structures within the network (Chen, Wang, Zhu, Tan, & Zhong, 2015; Luo et al., 2011). Reduced DMN connectivity may therefore serve as a biomarker for atypical neural functioning. Given that individuals with ASMR experience auditory-tactile and auditory-emotional associations that are atypical of the general population, we hypothesized that this group – like other groups with altered perceptual experiences (Alderson-Day, McCarthy-Jones, & Fernyhough, 2015; Jardri, Thomas, Delmaire, Delion, & Pins, 2013) – would show weaker connectivity between regions of the DMN than would matched control participants.

In the current study, we also hypothesized that ASMR would be associated with increased DMN activity in sensory cortices, perhaps including brain regions not typically associated with the DMN. If the DMN of these individuals included additional functional connectivity between sensory regions in the temporal (audition), parietal (somatosensation), and occipital (vision) cortices, it could suggest an increased openness to unusual sensory experiences. Such group differences would provide an intriguing initial glimpse into the neural architecture underlying ASMR.

Methods

Participants

Eleven participants (five males) with ASMR between the ages of 18 and 37 were recruited via word-of-mouth and social media posts from the Winnipeg, Manitoba community. All participants self-identified as having ASMR; these responses were confirmed by having participants view youtube.com videos designed to elicit ASMR responses while in the presence of one of the authors.

Although the current study did not assess brain activity during an ASMR experience, it is worth noting the characteristics of the ASMR tingles typically experienced by our participants. To that end, ASMR participants also completed a checklist that asked them to identify the different types of stimuli that trigger their ASMR experiences, as well as the characteristics of these responses. All participants reported being triggered by whispering. Nine of the 11 participants (81.8%) also reported experiencing tingles after hearing tapping or scratching sounds. A similar proportion of the

participants responded to simulations of socially intimate encounters (e.g., videos of simulated haircuts or scalp checks). Importantly, the participants reported that the same video or audio stimuli consistently elicit ASMR tingles. The average intensity rating for ASMR experiences was 4 (SD = 0.77) on a 5-point Likert scale, with 5 representing an extremely intense sensory experience. However, most participants indicated that they could dampen the intensity of the experience if they wished, an ability that distinguishes ASMR from similar conditions such as synesthesia. Ten of the 11 participants reported that the intensity of their ASMR tingles was larger when the actors in the videos addressed the viewer directly rather than depicting a scene from a third-person perspective. In contrast to the homogeneous intensity ratings, the onset times showed some variability. The average onset time for ASMR tingles was 59.54 s (SD = 80 s), with a range from 0 (i.e., immediate response) to 90 s.

Eleven sex- and age-matched control participants (age range 18–40 years) were recruited from the University of Winnipeg student population. All control participants viewed two videos shown to elicit ASMR to confirm that they did not experience tingling sensations. No participants had any history of psychiatric or neurological illness.

Ethical approval was obtained from the University of Winnipeg's Human Research Ethics Board and the University of Manitoba's Bannatyne Human Research Ethics Board. All participants gave written informed consent and completed magnetic resonance safety screening prior to scanning. Participants received $50 remuneration.

fMRI scanning parameters

Scanning was conducted using a 3-T Siemens scanner at the Winnipeg Regional Health Authority MRI Clinic. One hundred seventy-six T1-weighted (magnetization-prepared rapid gradient-echo, or MP-RAGE) images were collected. The scanner parameters for the anatomic MRI were as follows: TR = 1900 ms per volume, TE = 16 ms, with 256 mm × 256 mm resolution, and 0 mm between slices. The voxel size was 1.000 mm × 0.977 mm × 0.977 mm.

The resting-state functional MRI run was 7 min in duration and consisted of 140 volumes. Each volume consisted of 40 slices and was sampled transversely using a conventional whole-brain echo-planar imaging sequence with the following parameters: TR = 3000 ms per volume, TE = 75 ms, 3.75 mm × 3.75 mm resolution and a slice thickness of 3 mm and field of view (FOV) of 240 mm × 240 mm. Participants were asked to close their eyes but remain awake (i.e., to rest) for the
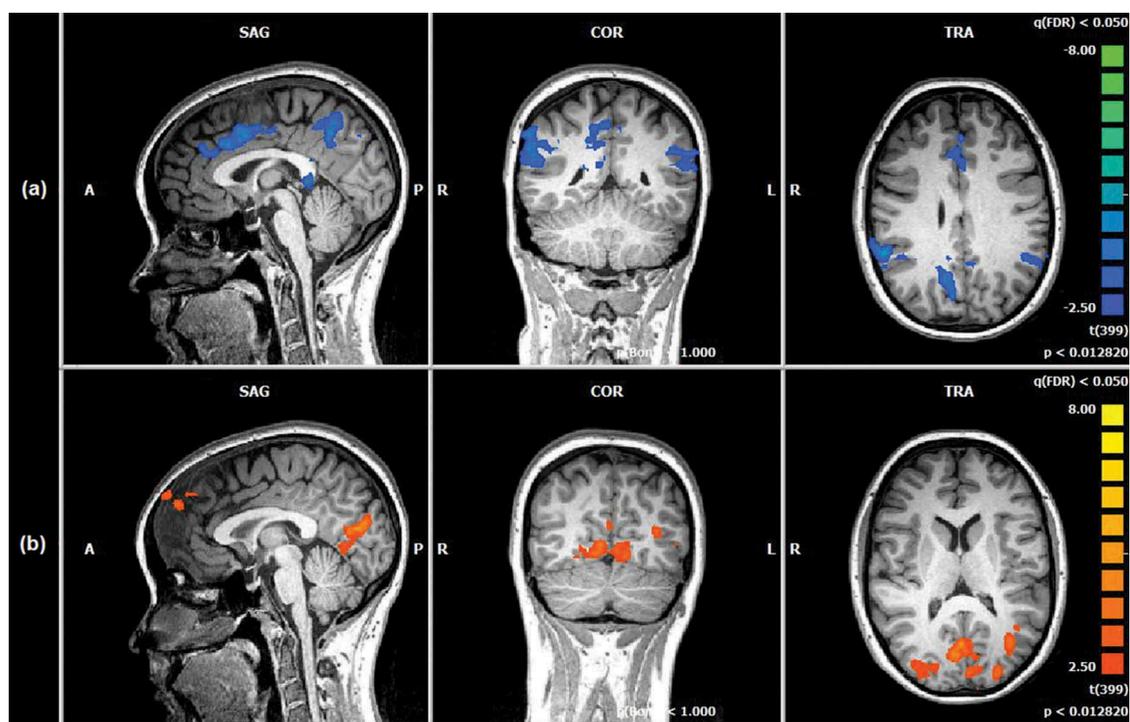
Figure 1. A comparison of functional connectivity in the default mode networks of individuals with ASMR and matched controls (minimum cluster size = 20 voxels; $p < 0.013$, false discovery rate (FDR) corrected for multiple comparisons). (a) Brain regions in which individuals with ASMR show *less* functional connectivity are depicted with blue voxels. (b) Brain regions in which individuals with ASMR show *greater* functional connectivity are depicted with orange voxels.

duration of the scan. No stimuli were presented during this time.

fMRI processing

Data were preprocessed and analyzed using BrainVoyager QX 2.8.4 (Brain Innovation, Inc., Maastricht, The Netherlands). Anatomical scans were manually transformed to Talairach space. Functional data were corrected for 3D motion and slice scan time and temporal filtering was performed. They were then co-registered and linked to the corresponding Talairach brains.

Each participant's resting-state data were subjected to an independent components analysis (ICA; Hyvärinen & Oja, 2000) to determine which areas of the brain showed correlated fluctuations in neural activity. This analysis identified 20 individual components for each participant. A self-organizing grouped ICA analysis (Esposito et al., 2005) was then performed with all 22 participants. As with the individual analyses, 20 components were produced. A 2-factor mixed-effects analysis of covariance (RX-ANCOVA) was performed with the within-subjects factor being the 20 fixed levels (20 components) and the between-subjects factor being the two group levels (ASMR vs. Control). The DMN

was visually identified as being the fifth component. From this ANCOVA table, the weights were set to zero for all but the DMN component in all subjects and the subjects were weighted in opposition representing Group (ASMR vs. Control). This analysis produced a *t*-map (*t*-threshold of 2.5 corresponding to $p < 0.013$, FDR corrected to $q < 0.050$; cluster threshold set to 20 voxels) that allowed us to compare the degree of functional connectivity in the DMNs of these two groups (depicted in Figure 1). The functional connectivity clusters were converted to volumes of interest; these yielded Talairach coordinates for the peak voxels, probability values, and number of active voxels (see Table 1). Talairach-daemon software (http://www.talairach.org/daemon.html) was used to identify the anatomical structures associated with each set of Talairach coordinates.

Results

The results indicated that the DMN of individuals with ASMR showed significantly less connectivity than that of controls (Figure 1(a)). Reduced connectivity was found between the right superior and middle temporal gyri, precuneus, superior frontal gyrus, and posterior cingulate, as well as the left superior temporal gyrus,

Table 1. Contrasting the functional connectivity of brain regions in the DMN of ASMR participants and matched controls.

Region	Brodmann area	Talairach coordinates (x, y, z)	t Value	Voxels
Controls > ASMR				
Superior temporal gyrus (R)	BA 22	62, 13, 0	−4.259	1055
Superior temporal gyrus (R)	BA 22	56, −53, 18	−6.295	8513
Superior temporal gyrus (L)	BA 22	−64, −56, 15	−4.595	2830
Middle temporal gyrus (R)	BA 39	41, −62, 21	−5.458	610
Precuneus (R)	BA 19	38, −74, 39	−4.806	655
Precuneus (R)	BA 31	5, −68, 27	−5.274	7682
Superior frontal gyrus (R)	BA 8	23, 22, 45	−5.987	579
Posterior cingulate (R)	BA 29	5, −41, 9	−5.041	1683
Medial frontal gyrus (L)	BA 32	−4, 10, 45	−5.309	4915
Thalamus (L)	Medial dorsal nucleus	−10, −17, 12	−4.138	633
Region	**Brodmann area**	**Talairach coordinates (x, y, z)**	**t value**	**Voxels**
ASMR > Controls				
Middle occipital gyrus (R)	BA 18	29, −83, 6	4.869	5991
Cuneus (R)	BA 18	2, −77, 15	5.638	20100
Superior frontal gyrus (L)	BA 9	−4, 61, 39	4.671	1707
Superior frontal gyrus (L)	BA 6	−10, 16, 69	4.389	639
Middle frontal gyrus (L)	BA 6	−31, 7, 51	4.441	1428
Middle temporal gyrus (L)	BA 21	−70, −38, −15	4.038	941

ASMR: Autonomous sensory meridian response.

medial frontal gyrus, and medial dorsal thalamus (see Table 1).

Individuals with ASMR also showed *greater* DMN functional connectivity than controls in some regions of the cortex (Figure 1(b)). This connectivity occurred between the left superior and middle frontal gyri, the left middle temporal gyrus, the right precuneus, and the right middle occipital gyrus (see Table 1). These regions are typically part of executive control and visual resting-state networks (Raichle, 2015).

Discussion

The reduced connectivity between the frontal lobes and sensory and attentional regions in the precuneus and parietal cortex has been linked with reduced attentional control and inhibition in patient populations (Lin, Tseng, Lai, Matsuo, & Gau, 2015); it is possible that ASMR reflects a reduced ability to inhibit sensory-emotional experiences that are suppressed in most individuals. The decreased connectivity of the thalamus is also relevant to the multimodal experiences in ASMR. There are two published cases of individuals developing synesthesia – a blending of the senses (Cytowic, 1993; Ramachandran & Hubbard, 2003) – after suffering a thalamic infarct (Ro et al., 2007; Schweizer et al., 2013). In one of these cases, the patient developed anomalous sensory-emotional associations (Schweizer et al., 2013). Atypical thalamic connectivity may therefore lead to the tingling and emotional responses that occur in ASMR.

It is possible that ASMR involves a blending of multiple resting-state networks. This hypothesis is consistent with experimental studies demonstrating that undifferentiated networks may be associated with atypical perceptions and conscious experiences (Alderson-Day et al., 2015; Roseman, Leech, Feilding, Nutt, & Carhart-Harris, 2014). It is important to note, however, that the current results do not indicate that ASMR is a psychopathology. In fact, the opposite may be true. Some individuals – including many of the ASMR participants in our study – use ASMR videos as a way of relaxing as well as to cope with stress and depression (Barratt & Davis, 2015).

It is also worth stressing that the group differences in DMN activity are statistical differences, not *necessarily* biological ones. Additional studies examining group differences in the volume and thickness of gray matter regions (e.g., voxel-based morphometry and cortical thickness analyses) and the density of white-matter pathways (e.g., diffusion tensor imaging) are necessary to fully characterize the neuroanatomical differences associated with ASMR. Functional neuroimaging investigations of individuals during an ASMR experience would also be helpful, although the loud noise of an MRI scanner and the scalp electrodes used in EEG studies may interfere with the responses of some participants. The DMN differences identified in the current research should inform the hypotheses in such studies by providing potential regions of interest for further investigation.

Although the current study did not find evidence that specific characteristics of ASMR (e.g., specific triggers) were linked with unique DMN activity, future studies with a much larger sample size may allow researchers to link individual differences in the heterogeneous ASMR phenomenology to differences in the activity of different resting-state networks. As such, this

initial study of the neural substrates of ASMR will hopefully serve as a catalyst for future investigations of this intriguing condition.

Disclosure statement

No potential conflict of interest was reported by the authors.

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