



## Full Length Article

## Functional connectivity associated with five different categories of Autonomous Sensory Meridian Response (ASMR) triggers

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## ABSTRACT

Autonomous sensory meridian response (ASMR) is a sensory-emotional phenomenon in which specific sensory stimuli (“ASMR triggers”) reliably elicit feelings of relaxation and tingling sensations on the head, neck, and shoulders. However, there are individual differences in which stimuli elicit ASMR and in the intensity of these responses. In the current research, we used resting-state fMRI to examine the functional connectivity associated with these differences. Fifteen individuals with self-reported ASMR completed the ASMR Checklist, which measures sensitivity to different ASMR triggers, and a resting-state fMRI scan. Checklist scores were entered as covariates to determine whether the functional connectivity of eight resting-state networks differed as a function of participants’ sensitivity to five categories of triggers. The results indicated unique patterns of functional connectivity associated with sensitivity to each ASMR trigger category. Sensitivity to two trigger categories was positively correlated with the dorsal attention network, suggesting that ASMR may involve atypical attentional processing.

## 1. Introduction

Autonomous Sensory Meridian Response (ASMR) is a sensory-emotional experience in which specific sensory stimuli elicit tingling sensations in the scalp and neck, often spreading to the back and limbs; these “tingles” typically co-occur with a subjective feelings of relaxation and positive affect (Barratt & Davis, 2015). These tingling sensations can last several minutes, are often predictable, and are a positive experience for most individuals (Barratt, Spence, & Davis, 2017; Fredborg, Clark, & Smith, 2017; Poerio, Blakey, Hostler, & Veltri, 2018). A particularly intriguing characteristic of ASMR is the nature of the stimuli that trigger the responses (i.e., “ASMR triggers”). These stimuli typically involve repetitive sounds (e.g., tapping noises), whispering, and/or viewing socially intimate acts (e.g., watching someone brush their hair or apply make-up; Barratt et al., 2017). However, not all individuals with ASMR experience tingling sensations in response to the same stimuli. Although some ASMR triggers such as whispering elicit tingling sensations in a majority of individuals with ASMR, many other triggers are less common (Barratt & Davis, 2015). Additionally, the intensity of ASMR often varies across triggers for the same individual (Fredborg et al., 2017), suggesting that ASMR responses to different classes of stimuli (e.g., whispers vs. repetitive sounds) may be generated by slightly different combinations of neural activity. The goal of the current research was to use resting-state functional magnetic resonance imaging (fMRI) to examine these differences within the ASMR population by investigating whether the “baseline” brain activity of individuals with ASMR is related to their sensitivity to different types of ASMR triggers.

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Resting-state fMRI measures fluctuations in the activity of neurons across different neural regions while the individual being scanned is *not* attending to a stimulus or performing a cognitive task (i.e., when the individual is “at rest”). Numerous studies have demonstrated that the activity of groups of neurons in disparate brain regions tend to fluctuate together, producing correlated patterns of neural activity that suggest these regions function as networks (e.g., Biswal, Yetkin, Haughton, Hyde, 1995; Damoiseaux, Rombouts, Barkhof, Scheltens, & Stam, 2006; De Luca, Beckmann, De Stefano, Matthews, & Smith, 2006; Friston, 2011; Raichle, 2015). The quantification of these relationships—which can be analyzed in a region-to-region or voxel-to-voxel manner—is known as functional connectivity.

Previous resting-state fMRI studies of ASMR used an independent-components-analysis (ICA) technique to identify patterns of functional connectivity that distinguished between individuals with ASMR and matched control participants (Smith, Fredborg, & Kornelsen, 2017, 2019a). The first fMRI study to examine ASMR (Smith et al., 2017) focused on the default mode network (DMN), a resting-state network consisting of the medial prefrontal cortex (mPFC), posterior inferior parietal lobule, angular gyrus, posterior cingulate cortex, and precuneus (Buckner, Andrews-Hanna, & Schacter, 2008; Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001). This network has been associated with several functions including episodic memory (Sestieri, Corbetta, Romani, & Shulman, 2011), representations of the self (Andrews-Hanna, 2012), and mind-wandering (Gusnard & Raichle, 2001; Spreng, Mar, & Kim, 2009). Smith et al. (2017) reported that the DMN of ASMR participants demonstrated weaker functional connectivity than the DMN of matched control participants. This network also appeared to include neural structures not typically associated with the DMN, leading to the speculation that ASMR was associated with a blending of resting-state networks. This hypothesis was supported by a subsequent study showing that individuals with ASMR demonstrated weaker functional connectivity than controls in a number of networks (Smith et al., 2019a). These included the salience network (SN), which is involved in determining the importance of sensory stimuli to a given situation and determining whether attentional and memory resources should be allocated to responding to that stimulus (Seeley, Menon, Schatzberg, Keller, Glover, Kenna, et al., 2007; Menon, 2015); the central executive network (CEN), a frontoparietal network involved in response inhibition, attentional set shifting, working memory, and emotional regulation (Chen, Meng, Hu, Cui, Ding, Kang, et al., 2016; Gagnepain, Hulbert, & Anderson, 2017; Sridharan, Levitin, & Menon, 2008); as well as visual (VIS) and sensorimotor (SMN) networks. *Post hoc* analyses of the data noted that an additional component of the ICA included strong functional connectivity in some brain areas typically associated with the DMN and CEN; however, this relationship was present only in ASMR participants, again suggesting that the resting-state networks of this group are more fractionated than those of control participants (Smith et al., 2019a).

Although these studies provided insights into the differences between individuals with and without ASMR, less is known about the neural mechanisms underlying the heterogeneity *within* the ASMR population. This topic is worth investigating given that several previous studies have noted that most individuals with ASMR appear to respond to several classes of triggers with varying self-reported intensities (Barratt & Davis, 2015, Barratt et al., 2017; Fredborg, Clark, & Smith, 2017, 2018). Identifying the neural substrates associated with this heterogeneity would provide a window into the atypical conscious experiences of this group. One potential research strategy for addressing this question would be to quantify the intensity of ASMR participants’ tingles in response to different triggers and to use these numbers as covariates in examinations of resting-state networks. The results of these analyses would indicate which regions of the brain show increased or reduced functional connectivity with a given network as a function of the intensity of an individual’s response to a specific class of ASMR triggers. These data would be a natural extension of the previous resting-state fMRI studies comparing ASMR and non-ASMR populations.

In the current research, ASMR participants’ sensitivity to different ASMR triggers was quantified by using the ASMR Checklist (Fredborg et al., 2017). This questionnaire asks individuals with ASMR the degree to which different stimuli elicit tingling responses. A principal components analysis of responses to the 14 items made by a sample of 284 individuals with ASMR found that the items loaded into five different ASMR trigger types: (1) Watching individuals interact with objects, (2) Watching individuals perform a socially intimate act, (3) Soft repetitive sounds, (4) Viewing simulated social interactions, and (5) hearing whispering or chewing sounds (Fredborg et al., 2017; a complete list of the items is listed in Table 1). By taking participants’ average response to the questions related to each of these five categories, it is possible to obtain a numerical representation of their sensitivity to different types of ASMR triggers. These data can then be entered as covariates for ICA-based functional connectivity analyses to provide us with information about the relationship between functional connectivity and sensitivity to different ASMR trigger types. Given that previous studies have reported decreased functional connectivity in individuals who experience ASMR, we hypothesized that increased sensitivity to specific triggers would be linked with reduced functional connectivity in the medial prefrontal cortex and precuneus (see Smith et al., 2017) and in sensory regions associated with that specific trigger type (e.g., motor regions for individuals responsive to triggers depicting touching).

## 2. Methods

### 2.1. Participants

Fifteen individuals with self-reported ASMR (7 males) between the ages of 18 and 37 ( $M_{age} = 22.33$ ;  $SD_{age} = 4.78$ ) were recruited from the Winnipeg, Manitoba, Canada community via social media posts and word-of-mouth. The presence of ASMR was confirmed by having participants view two popular YouTube.com videos that had been created to elicit ASMR responses; all ASMR participants confirmed that these videos elicited tingling sensations. This confirmation process was completed in the presence of one of the investigators. Each participant confirmed that he or she consistently experienced ASMR in response to the same categories of triggers.

None of the participants had a history of psychiatric or neurological illness. Ethics approval was obtained from the University of

**Table 1**  
Participants' Self-Reported Responses to Five Trigger Types Assessed by the ASMR Checklist.

Watching	Average Intensity Rating (Standard Deviation)
Watching others paint	2.40 (1.99)
Watching others draw	2.43 (2.17)
Watching others open a package	2.00 (1.88)
Watching others cook	1.08 (1.38)
<b>Touching</b>	
Watching someone touch another person's hair	2.73 (1.75)
Watching someone touch their own hair	1.60 (1.50)
Watching others apply makeup and/or nail polish to themselves	2.13 (1.60)
Watching others apply makeup and/or nail polish to another person	2.00 (1.71)
<b>Gentle Repetitive Sounds ("Repetitive Sounds")</b>	
Tapping sounds	2.88 (1.45)
Scratching sounds	2.88 (1.86)
<b>Simulations</b>	
Dentist simulation	1.00 (1.52)
Haircut simulation	3.19 (1.94)
<b>Soft, Oral Sounds ("Mouth Sounds")</b>	
Chewing sounds	1.13 (1.63)
Whispering	4.38 (1.20)

Manitoba's Bannatyne Human Research Ethics Board and the University of Winnipeg's Human Research Ethics Board. All participants provided written informed consent and completed MR safety screening before entering the MRI suite. All participants received \$50 CDN remuneration.

## 2.2. ASMR Checklist

The ASMR Checklist (Fredborg et al., 2017) consists of a list of 14 common ASMR-triggering stimuli, such as whispering. These stimuli were selected based on the results of a previous survey study of individuals with ASMR (Barratt & Davis, 2015) as well as an examination of common themes found in ASMR-eliciting videos on YouTube.com. For each item on this checklist, participants are asked to indicate the intensity of their ASMR tingles in response to each trigger (on a 0–6 Likert-type scale). Previous research with the ASMR Checklist has noted that it has high internal consistency, with a Cronbach's alpha of 0.81 (Fredborg et al., 2017).

A principal components analysis of data from a previous study (Fredborg et al., 2017) found that the 14 ASMR triggers in this checklist can be grouped into five categories: "Watching" ("Watching others paint," "Watching others draw," "Watching others open a package," and "Watching others cook"), "Touching" ("Watching someone touch another person's hair," "Watching someone touch their own hair," "Watching others apply makeup and/or nail polish to themselves," and "Watching others apply makeup and/or nail polish to another person"), soft, repeated sounds ("Tapping sounds," and "Scratching sounds") which were given the label "Repetitive Sounds", "Simulations" ("Dentist simulation" and "Haircut simulation"), and soft, oral sounds ("Chewing sounds" and "Whispering") which were given the label "Mouth Sounds". Moreover, a subsequent study from our laboratory has analyzed the ASMR Checklist data using a confirmatory factor analysis ( $N = 82$ ) which confirmed these same five categories (Wiebe, Fredborg, & Smith, 2020; manuscript under review). It was therefore possible to average participants' scores for the items related to each principal component in order to produce five ASMR Intensity Scores. In the current study, these intensity scores were entered as covariates to examine how functional connectivity varied as a function of participants' sensitivity to different ASMR triggers.

## 2.3. Procedure

Imaging began with a 3D high-resolution anatomical MRI scan of the brain. This structural MRI took eight minutes to complete. Following this, participants underwent a 7-minute resting-state functional MRI scan. During this scan, participants were instructed to remain still with their eyes closed. Upon completion of the fMRI session, participants were asked to complete the ASMR Checklist (Fredborg et al., 2017).

## 2.4. Data acquisition

Data were acquired using a 3-Tesla Siemens TRIO MRI scanner (Siemens, Erlanger, Germany). For the anatomical scan, high-resolution T1-weighted gradient-echo images were acquired using a magnetization-prepared rapid-gradient-echo (MP-RAGE) sequence with the following parameters: slice thickness = 1 mm; interslice gap = 0 mm; TR = 1900 ms; TE = 2.2 ms; in-plane resolution =  $0.94 \times 0.94$ ; matrix =  $256 \times 256$ ; and field of view = 24 cm.

Functional MRI data acquisition consisted of a 7-minute (140 vol) scan using a whole-brain echo-planar imaging (EPI) sequence with the following parameters: slice thickness = 3 mm; interslice gap = 0 mm; TR = 3000 ms; TE = 30 ms; flip angle =  $90^\circ$ ;

matrix =  $64 \times 64$ ; and field of view = 24 cm.

### 2.5. Data analysis

Resting state functional connectivity was assessed using the CONN toolbox Version 18b (Whitfield-Gabrieli & Nieto-Castanon, 2012) to preprocess and analyze the functional imaging data. The functional data were functionally realigned and unwarped, translated by centering to (0,0,0) coordinates, slice time corrected, segmented into gray matter, white matter, and cerebrospinal fluid, normalized to the Montreal Neurological Institute (MNI) template, and smoothed using an 8 mm Gaussian kernel. Structural data were translated by centering to (0,0,0) coordinates, segmented into gray matter, white matter, and cerebrospinal fluid, and normalized to the MNI template. Outlier detection was run using the Artifact Detection Tool (ART toolbox; [http://www.nitrc.org/projects/artifact\\_detect/](http://www.nitrc.org/projects/artifact_detect/)). During the de-noising processes, white matter, cerebrospinal fluid, and outliers detected by the ART toolbox were entered into the linear regression as confounding effects. Subject motion correction was performed via realignment parameters entered in the linear regression of confounding effects (1st-order derivatives, no polynomial expansion). Linear detrending was performed, and the default band-pass filter of [0.008–0.09] Hz was applied.

An ICA was run with a FastICA for estimation of independent spatial components and GICA3 back-projection for individual subject level spatial map estimation. Dimensionality reduction was set to 64 and number of components set to 20 (the identical number of components as were used in our previous between-subjects study with the same ASMR participants; Smith et al., 2019a). The correlational spatial match-to-template approach was used in CONN to identify within each component the brain resting state networks for the cerebellar (CER), default mode (DMN), sensorimotor (SMN), frontoparietal (FP), dorsal attention (DAN), salience (SN), language (LAN), and visual (VIS) networks. ICA results were displayed at  $p < 0.001$  uncorrected and a cluster-wise threshold of  $p < 0.05$ , FDR-corrected. Scores for each of the five trigger categories were entered as second-level covariates and between-subjects contrasts were run for the ICA components matched to the DAN, DMN, FP, SMN, SN, and VIS.

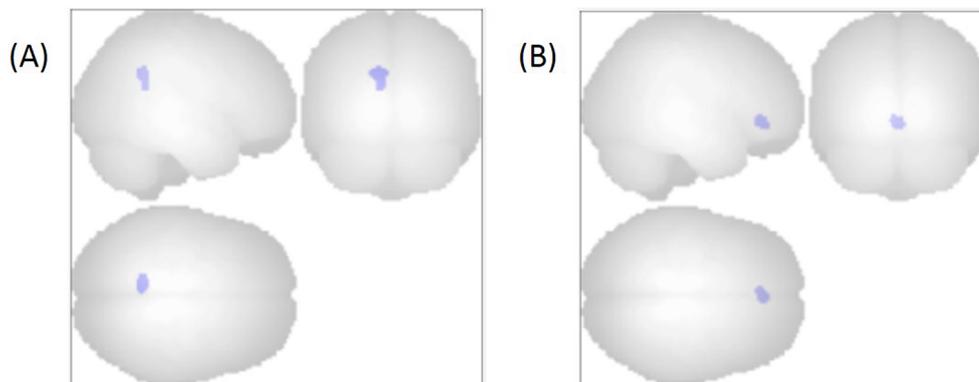
### 3. Results

The average intensity ratings for each item on the ASMR Checklist are presented in Table 1. These data indicate that whispering was by far the most common and most intense ASMR trigger for our participants, with tapping noises being the second most common trigger. Note that these averages include participants who entered ‘0’ for these items. The large standard deviations indicate that there was a large amount of variability in intensity ratings; this result was ideal for the current investigation into individual differences in sensitivities to different ASMR triggers.

The ICA-based examination of our resting-state fMRI data allowed us to determine how individual differences in sensitivity to five types of ASMR triggers were related to the functional connectivity of the brain’s resting-state networks. Importantly, these data depict brain areas whose activity correlated with the activity of a given network. It is therefore possible that brain regions that are not typically associated with a given network may show functional connectivity with that network (e.g., the activity of a prefrontal region might correlate with the activity of the visual network).

Individual differences in *Watching* scores were related to the activity of two networks (see Fig. 1 and Table 2). One cluster of voxels in the posterior cingulate gyrus and precuneus were negatively correlated with the functional connectivity of the SN. The functional connectivity of the VIS was negatively correlated with the activity of a cluster of medial frontal voxels including the anterior cingulate cortex, paracingulate gyrus, and medial prefrontal cortex. These regions are typically recruited into the anterior portion of the DMN (Buckner et al., 2008).

*Touching* scores were also associated with the functional connectivity of two resting-state networks (see Fig. 2 and Table 3). Four different clusters were negatively correlated with the DMN; three of these overlapped with areas typically associated with this

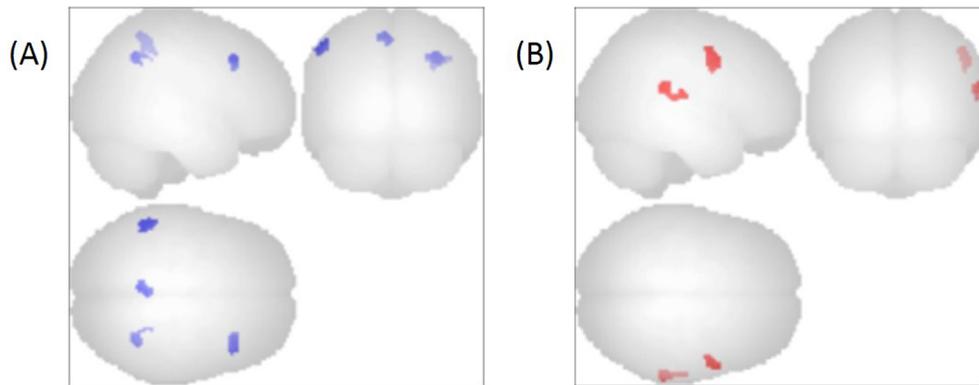


**Fig. 1.** Functional connectivity covaried with individual differences in *Watching* scores on the ASMR Checklist. Displayed in sagittal, coronal, and axial views, the clusters of voxels with *Watching* scores negatively correlated within the components spatially matched to the (A) salience and (B) visual networks are shown.

**Table 2**  
Clusters of Activity that were Associated with Individual Differences in *Watching*-Related ASMR Triggers.

Hemisphere	Region	Structure	MNI Coordinates				Cluster size	<i>T</i>	<i>p</i>
			BA	X	Y	Z			
<b>Salience Network</b>									
Left	Parietal	Posterior Cingulate Cortex	23	-10	-50	28	143	-7.38	0.000005
<b>Visual Network</b>									
Bilateral	Frontal	Anterior Cingulate Cortex	32	-2	38	-6	100	-6.26	0.000029

<sup>a</sup>Abbreviations: Brodmann area (BA), False Discovery Rate corrected *p*-value (*p*).



**Fig. 2.** Functional connectivity covaried with individual differences in *Touching* scores. Displayed in sagittal, coronal, and axial views, the clusters of voxels with *Touching* scores negatively correlated within the component spatially matched to the (A) default mode and (B) positively correlated within the dorsal attention networks are shown.

**Table 3**  
Clusters of Activity that were Associated with Individual Differences in *Touching*-Related ASMR Triggers.

Hemisphere	Region	Structure	MNI Coordinates				Cluster size	<i>t</i>	<i>p</i>
			BA	X	Y	Z			
<b>Default Mode Network</b>									
Right	Frontal	Middle Frontal Gyrus	8	34	22	40	105	-5.99	0.000045
Left	Parietal	Supramarginal Gyrus	40	-56	-46	52	95	-6.14	0.000035
Right	Parietal	Angular Gyrus	39	36	-54	40	87	-6.02	0.000043
Left	Parietal	Precuneus	7	-6	-50	60	81	-7.45	0.000005
<b>Dorsal Attention Network</b>									
Right	Frontal	Precentral Gyrus	6	56	0	38	136	8.73	0.000001
Right	Parietal	Supramarginal Gyrus	22	68	-38	20	114	7.95	0.000002

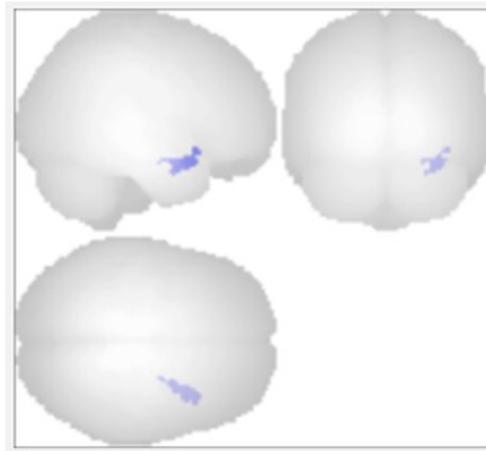
<sup>a</sup>Abbreviations: Brodmann area (BA), False Discovery Rate corrected *p*-value (*p*).

network. One cluster included voxels in the precuneus, while the other two clusters included the supramarginal and angular gyri in the left and right hemispheres. One cluster that was outside of typical DMN boundaries was located in the right middle frontal gyrus. An examination of the DAN component found that the functional connectivity of two right-lateralized clusters was positively correlated with this network. One cluster consisted of voxels in the supramarginal gyrus, planum temporale, and superior temporal gyrus, while other was comprised of voxels exclusively in the right precentral gyrus, a region typically associated with the SMN.

Scores on the items related to sensitivity to *Repetitive Sounds* were only associated with the functional connectivity of the DMN (see Fig. 3 and Table 4). One cluster of voxels located primarily in the right temporal pole, but extending into the amygdala and posterior orbitofrontal cortex, was negatively correlated with the functional connectivity of this network.

Individual differences in *Simulations* scores were negatively correlated with clusters in the FP network and the SMN (see Fig. 4 and Table 5). Two of the clusters included regions that overlapped with the FP network, one located in the left superior frontal gyrus and the other in the left lateral occipital cortex. The third cluster of voxels that was negatively correlated with the functional connectivity of the FP extended across the left postcentral gyrus, supramarginal gyrus, and superior parietal lobule. Interestingly, this cluster partially overlapped with a cluster that was negatively correlated with the SMN. This cluster included voxels in both the left precentral and postcentral gyri.

Finally, scores on the *Mouth Sounds* items of the ASMR Checklist were correlated with the functional connectivity of three resting-



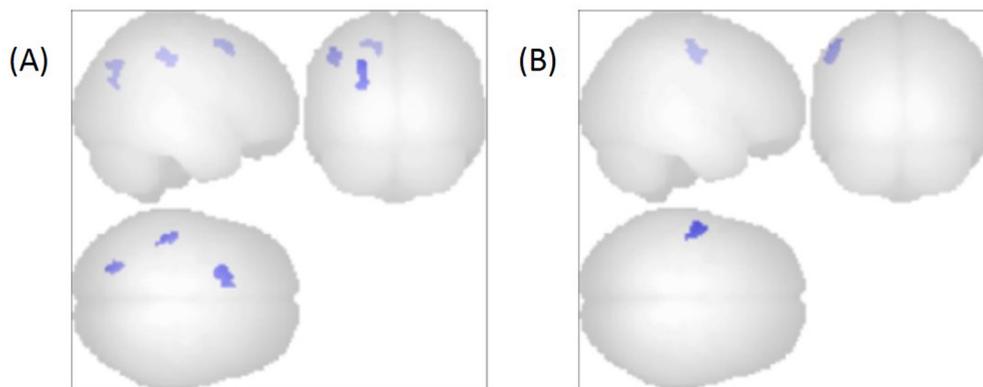
**Fig. 3.** Functional connectivity covaried with individual differences in *Repetitive Sounds* scores. Displayed in sagittal, coronal, and axial views, the cluster of voxels with *Repetitive Sounds* scores negatively correlated within the component spatially matched to the default mode network are shown.

**Table 4**

Clusters of Activity that were Associated with Individual Differences in *Repetitive Sounds*-Related ASMR Triggers.

Hemisphere	Region	Structure	MNI Coordinates				Cluster size	<i>t</i>	<i>p</i>
			BA	X	Y	Z			
<b>Default Mode Network</b>									
Right	Temporal	Temporal Pole	38	36	12	-24	135	-7.29	0.000006

<sup>a</sup>Abbreviations: Brodmann area (BA), False Discovery Rate corrected *p*-value (*p*).



**Fig. 4.** Functional connectivity covaried with individual differences in *Simulations* scores. Displayed in sagittal, coronal, and axial views, the clusters of voxels with *Simulations* scores negatively correlated within the components spatially matched to the (A) frontoparietal and (B) sensorimotor networks are shown.

state networks (see Fig. 5 and Table 6). These scores were positively correlated with the activity of one cluster of voxels in the DAN. This cluster included voxels in the left occipital pole and left lateral occipital cortex. Two clusters of voxels in the FP covaried as a function of *Mouth Sounds* scores. A positive cluster included voxels in the left parietal operculum, left planum temporale, and left insula, whereas a negative cluster included voxels in the right inferior temporal and fusiform gyri. Two clusters of voxels were also detected in the analysis of the SMN component. A positively correlated cluster encompassed typical SMN regions including the right precentral and posterior cingulate gyri. A negatively correlated cluster consisted of voxels in the left lateral occipital cortex, a region typically associated with visual functions.

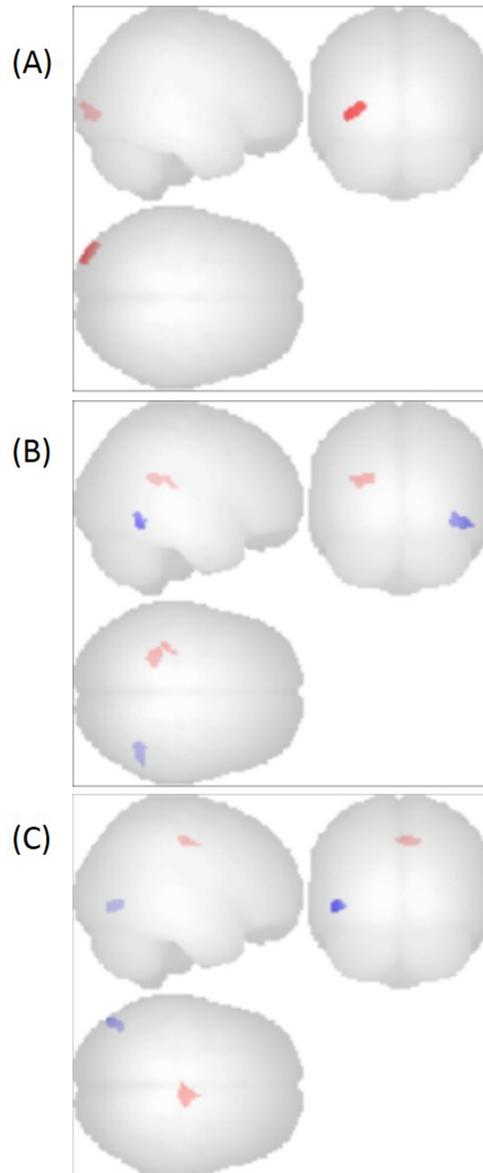
#### 4. Discussion

The data from the current study suggest that heterogeneity in ASMR trigger sensitivity has a neurobiological underpinning. Individual differences in the sensitivity to five categories of ASMR triggers were correlated with the activity of different groups of

**Table 5**Clusters of Activity that were Associated with Individual Differences in *Simulations-Related ASMR Triggers*.

Hemisphere	Region	Structure	MNI Coordinates				Cluster size	<i>t</i>	<i>p</i>
			BA	X	Y	Z			
<b>Frontoparietal Network</b>									
Left	Occipital	Lateral Occipital Cortex	7	-24	-72	36	148	-7.78	0.000003
Left	Frontal	Superior Frontal Gyrus	8	-12	16	52	119	-6.64	0.000016
Left	Parietal	Postcentral Gyrus	40	-50	-26	44	97	-6.36	0.000025
<b>Sensorimotor Network</b>									
Left	Parietal	Postcentral Gyrus	1	-52	-16	52	167	-6.21	0.000032

<sup>a</sup>Abbreviations: Brodmann area (BA), False Discovery Rate corrected *p*-value (*p*).



**Fig. 5.** Functional connectivity covaried with individual differences in *Mouth Sounds* scores. Displayed in sagittal, coronal, and axial views, the clusters of voxels with *Mouth Sounds* scores (A) positively correlated within the component spatially matched to the dorsal attention, and both positively and negatively correlated within the component spatially matched to the (B) frontoparietal and (C) sensorimotor networks are shown.

**Table 6**Clusters of Activity that were Associated with Individual Differences in *Mouth Sounds*-Related ASMR Triggers.

Hemisphere	Region	Structure	MNI Coordinates				Cluster size	<i>t</i>	<i>p</i>
			BA	X	Y	Z			
<b>Dorsal Attention Network</b>									
Left	Occipital	Occipital Pole	18	-34	-96	0	131	9.90	0.000001
<b>Frontoparietal Network</b>									
Left	Parietal	Parietal Operculum	40	-26	-42	18	128	8.85	0.000002
Right	Temporal	Inferior Temporal Gyrus	37	42	-56	-14	95	-6.59	0.000039
<b>Sensorimotor Network</b>									
Right	Frontal	Midcingulate Gyrus	24	8	-18	44	112	9.41	0.000001
Left	Occipital	Lateral Occipital Cortex	19	-48	-72	-4	90	-6.39	0.000051

<sup>a</sup>Abbreviations: Brodmann area (BA), False Discovery Rate corrected *p*-value (*p*).

brain structures. However, before discussing the potential implications of these data and comparing them to task-based studies of ASMR, it is important to note two limitations of functional connectivity analyses. First, because participants were not performing a cognitive or attentional task during the collection of these resting-state data, we cannot state that activity in a given brain region (e.g., supplementary motor area) is definitely related to a specific function (e.g., the planning of movements). To do so would be a “reverse inference” fallacy (Poldrack, 2006). Second, it is not possible—based on our study design—to say whether changes in functional connectivity lead to differences in ASMR sensitivity or that different ASMR sensitivities lead to changes in functional connectivity; the causal direction cannot be identified. Therefore, in this Discussion section, we will note patterns in the data that could serve as a catalyst for future behavioral or task-based neuroimaging studies.

Previous research has indicated that ASMR is associated with reduced functional connectivity in several resting-state networks (Smith et al., 2019a). Of the 21 significant differences found in our previous research comparing ASMR and control participants, 16 reflected weaker functional connectivity in individuals with ASMR. This tendency for ASMR to be associated with reduced functional connectivity was borne out, to some extent, in the current data as well. Specifically, there was a general trend in which greater sensitivity to a specific trigger was associated with weaker functional connectivity (see Tables 7 and 8). For example, analyses found negative correlations between *Watching* scores and activity in brain areas related to visual perception and attention. Specifically, the VIS was negatively correlated with activity in a region of the anterior cingulate gyrus (Brodmann area 32) typically associated with attentional functions (e.g., Testo et al., 2019). More posterior regions of the cingulate, which are also part of the DMN and are active during attentional control tasks (e.g., Yamashita et al., 2019), were negatively correlated with the SN. If ASMR is related to weaker functional connectivity, these data would suggest that within the ASMR population, sensitivity to specific ASMR triggers is also related to reduced functional connectivity in brain areas related to the perception of those triggers—even though participants were not viewing any ASMR-related stimuli during the resting-state fMRI scan.

The resting-state data related to sensitivity to *Repetitive Sounds* were consistent with this hypothesis. Here, the DMN was negatively correlated with activity in the right temporal pole, a brain area that is involved with emotional contagion (Sturm et al., 2013). This cluster of activity extended into the right amygdala, a region associated with the detection of dynamic emotional stimuli (Baeken et al., 2014), and the posterior orbitofrontal cortex, a region involved in response inhibition and impulse control (Zikopoulos, Höistad, John, & Barbas, 2017). Although we cannot state that these are the functions being performed by these brain areas in a resting-state fMRI scan (Poldrack, 2006), they do suggest that task-based fMRI studies should examine patterns of activity that occur when individuals with ASMR perform sensory integration and response inhibition tasks.

**Table 7**

A summary of the brain areas showing decreased functional connectivity.

Trigger	Network	Brain Region
Watching	Saliency Network	Posterior Cingulate Cortex (L)
	Visual Network	Anterior Cingulate Gyrus (Bilateral)
Touching	Default Mode Network	Middle Frontal Gyrus (R)
		Angular Gyrus (R)
		Supramarginal Gyrus (L)
		Precuneus (L)
		Temporal Pole (R)
Repetitive Sounds Simulations	Default Mode Network	Temporal Pole (R)
		Superior Frontal Gyrus (L)
		Postcentral Gyrus (L)
		Lateral Occipital Cortex (L)
		Lateral Occipital Cortex (L)
Mouth Sounds	Sensorimotor Network	Postcentral Gyrus (L)
	Frontoparietal Network	Inferior Temporal Gyrus (R)
	Sensorimotor Network	Lateral Occipital Cortex (L)

Abbreviations: R, right; L, left.

**Table 8**  
A summary of the brain areas showing increased functional connectivity.

Trigger	Network	Brain Region
Touching	Dorsal Attention Network	Precentral Gyrus (R) Supramarginal Gyrus (R)
Mouth Sounds	Frontoparietal Network Sensorimotor Network	Parietal Operculum (L) Midcingulate Gyrus (R)

Abbreviations: R, right; L, left.

The significant results associated with *Simulations* scores also consisted only of negative correlations. The FP was negatively correlated with activity in the lateral occipital cortex, a brain area involved with object perception (Erdogan, Chen, Garcea, Mahon, & Jacobs, 2016). It was also negatively correlated with the left superior frontal gyrus, a region involved with both working memory and the processing of spatial information (du Boisgueheneuc et al., 2006). Activity in the left postcentral gyrus was negatively correlated with both the FP and the SMN. Taken together, the data related to *Simulations* scores are largely consistent with the view that sensitivity to specific ASMR triggers is related to reduced functional connectivity.

The results associated with *Touching* scores were consistent with previous studies of ASMR which found that ASMR is linked with weaker functional connectivity in the DMN (Smith et al., 2017, 2019). In the current data, higher *Touching* scores were negatively correlated with the functional connectivity of four clusters of voxels in the DMN component. In contrast, these scores were positively correlated with the functional connectivity of two clusters of voxels in the DAN component. One cluster was centred in the right precentral gyrus (i.e., the right primary motor cortex). The other had its peak in the supramarginal gyrus. This brain area has a number of functions that *could* be related to ASMR phenomenology. These include the interpretation of tactile information, the interpretation of other people's postures and movements, and the formation of social judgments (e.g., Boehme, Hauser, Gerling, Heilig, & Olausson, 2019; Silani, Lamm, Ruff, & Singer, 2013). Given that viewing *Touching*-related videos involves understanding what other people are doing, it is likely that the supramarginal gyrus would play some sort of role; however, future research would be necessary to test this hypothesis.

The positive correlation between activity in the DAN component and *Touching* scores is consistent with a previous survey-based experiment examining the relationship between ASMR and trait mindfulness (Fredborg, Clark, & Smith, 2018). In this study, individuals with ASMR scored higher on the Mindful Attention and Awareness Scale (MAAS; Brown & Ryan, 2003), a univariate measure of the attentional component of trait mindfulness. Fredborg and colleagues speculated that these results could indicate that ASMR is an active, attention-driven phenomenon. The current resting-state fMRI data support this view and suggests that attention may be particularly important for ASMR participants who are sensitive to *Touching*-related stimuli.

The functional connectivity of a cluster of voxels in the DAN was also positively correlated with scores on ASMR Checklist items related to *Mouth Sounds*. This cluster was located in the left occipital pole and again reflects the role of attention in constructing ASMR experiences. Interestingly, the functional connectivity of two other vision-related regions was negatively correlated with *Mouth Sounds* scores. These clusters included the left lateral occipital cortex in the SMN component and the right inferior temporal gyrus in the FP component. One possible explanation for these results is that sensory regions are associated with less functional connectivity in ASMR except when recruited by attentional networks. However, an additional neuroimaging study would be necessary to test this hypothesis.

An obvious question raised by the current data is how these differences relate to task-based investigations of ASMR activity. In a previous experiment using the same participants (as well as two additional participants who did not complete the ASMR Checklist), we found that ASMR videos elicited greater levels of neural activity in ASMR than control participants in the right paracentral lobule, right cingulate gyrus, left precuneus, bilateral thalamus, and the culmen and lingula of the cerebellum (Smith, Fredborg, & Kornelsen, 2019b). An earlier study that examined neural activity in ten ASMR-sensitive individuals found that ASMR tingles were associated with bilateral activity in the medial prefrontal cortex, insula, nucleus accumbens, and supplementary motor area, and left-lateralized responses in secondary somatosensory cortex (Lochte, Guillory, Richard, & Kelley, 2018). Several, but not all, of these brain regions showed altered functional connectivity in the current study. The paracentral lobule consists of the medial aspect of the primary motor and somatosensory cortices, regions that varied as a function of several ASMR trigger types. In the current study, more lateral aspects of the pre- and postcentral gyri showed altered connectivity as a function of individual differences in sensitivity to different ASMR triggers. Two additional structures detected in our earlier task-based study were each related to one ASMR trigger type. The functional connectivity of the precuneus was related to *Touching* and the anterior cingulate (in a region slightly superior to that reported by Smith et al., 2019b) correlated with *Watching* scores. Although it is important not to draw any definitive conclusions about the overlap between these studies, the results do suggest that there are several specific brain structures that are involved with ASMR experiences.

#### 4.1. Limitations

One weakness of the current study is that the tool used to generate ASMR trigger sensitivity scores did not separate the sensory and emotional components of ASMR. Thus, each score on the ASMR Checklist includes the intensity of both the tingling sensations and the pleasant emotional feeling associated with this response. Although none of the participants verbally reported having different

proportions of sensory and emotional responses to different triggers, it is possible that these differences exist (Roberts, Beath, & Boag, 2019). Future studies should utilize both measures of sensory and emotional sensitivity when examining the behavioral and biology components of ASMR. An additional weakness is that physiological measures were not obtained to verify that individuals who claimed to experience ASMR actually did so. Future studies should include physiological responses to both ASMR and non-ASMR videos during screening to confirm whether participants experience ASMR.

Additional limitations of the current study include both the sample size and the homogeneity of the participants. Although fifteen participants is a satisfactory sample size for an initial examination of ASMR phenomenology, a larger sample size is likely needed in order to study more nuanced elements of this experience, such as the relative impact of the sensory and emotional components of ASMR. A larger sample size would also provide more statistical power, thus allowing us to use a more restrictive significance threshold. Similarly, having Caucasian participants from a city in central Canada limits the generalizability of the results. Although no data have definitely shown that ASMR is experienced differently across cultures, it is likely that culture has some effect on this phenomenon. A larger and more culturally diverse group of participants would allow these possibilities to be empirically assessed. It is also important to note that given the requirement that participants experience ASMR in order to complete the ASMR Checklist, it was not possible to use a control group. However, the ASMR participants in the current study were previously shown to differ in functional connectivity from non-ASMR participants in the resting state networks examined.

The results of the current experiment highlight the need for several additional studies. The current study reports on functional connectivity as measured by ICA where voxels typically associated with different networks showed time courses similar in correlation with the ASMR sensitivity scores. Additional fMRI studies will be helpful. Resting state fMRI restricting analysis to regions-of-interest isolating network nodes would deepen our understanding of how the interplay between networks is related to the ASMR experience. A task-based fMRI study would allow us to confirm that self-reported differences in sensitivity to different ASMR trigger types lead to different neural responses during the ASMR experience itself. Such a study would expand upon the very small number of task-based neuroimaging examinations of ASMR (Lochte et al., 2018; Smith et al., 2019b). A similar study using electroencephalography (EEG) would provide complementary information about changes in different frequencies of brain activity (e.g., alpha waves) associated with ASMR, and whether these changes differ as a function of sensitivity to specific triggers. Additionally, positron emission tomography (PET) could be used to determine whether responses to different ASMR triggers were associated with the release of neurotransmitters related to reward (i.e., dopamine); a similar link has been identified during the experience of “musical frisson” (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). Such a study would highlight the mechanism linking the perception of specific ASMR triggers to the pleasurable response reported by participants. Finally, future research should use diffusion tensor imaging to measure structural, rather than functional, connectivity (see Reid et al., 2019, for a discussion of the dangers of over-interpreting functional connectivity results as reflecting structural, biological mechanisms).

## 5. Conclusion

In conclusion, the current data indicate that there is a neural explanation for why some individuals with ASMR are sensitive to some triggering stimuli but not others. Individual differences in sensitivity scores for five different ASMR triggers were associated with unique patterns of functional connectivity. A second notable result was that sensitivity to most ASMR triggers was negatively correlated with brain areas related to the perception of that type of stimulus. A third trend indicated that while most resting-state networks included clusters that were negatively correlated with ASMR sensitivity, the clusters in the DAN were positively correlated with these scores. This result suggests that, at least for some individuals, ASMR is an attention-driven process. Taken together, these data indicate that ASMR is a complex phenomenon, and that more neuroimaging research is necessary in order to understand the neural substrates of this atypical sensory-emotional experience.

## Author contributions

SDS, BF, and JK designed the experiment. SDS and BF conducted the experiment. SDS and JK analyzed the data. All authors contributed to the writing of the manuscript.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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