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Sex commonalities and differences in the relationship between resilient personality and the intrinsic connectivity of the salience and default mode networks

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Abstract

Increased resilience is associated with better health outcomes and reduced morbidity in response to injury and homeostatic perturbations. Proper functioning of the salience network (SN) and modulation of the default mode network (DMN) by SN may play a role in adaptively responding to stress. Here, we demonstrate that resilient personality in healthy subjects is associated with SN and DMN connectivity patterns and that these patterns are influenced by sex. While connectivity of SN with several brain regions including right anterior insula was significantly associated with resilient personality in both men and women, results suggest that increased functional integration of anterior DMN preferentially benefits women while increased functional integration of posterior DMN preferentially benefits men in terms of resilience. These findings may relate to previous demonstrations that men and women engage different information processing and behavioral strategies to achieve resilience and highlight the importance of considering sex in resilience research.

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Keywords

resilience; NEO personality inventory; resting state networks; default mode network; salience network; sex differences

INTRODUCTION

While the great majority of behavioral and biopsychosocial research has focused on disease mechanisms and interventions for patients affected by disease, it is only during the past decade that there has been an increasing focus on the phenomenon of resilience. Although definitions of resilience vary in details, resilience is an adaptive response to adversity. A common feature is the ability to maintain normal psychological and physical functioning (homeostasis) and avoid serious mental or physical illness following exposure to even extraordinary levels of stress or trauma (1). Resilience is difficult to operationalize as it may include many different phenotypes, including psychological resilience (the ability to “bounce back” after a stressful situation) (2, 3), the tendency to not develop psychiatric disease despite genetic risk or stress exposure (4, 5), or the tendency to not develop chronic medical illness despite high risk exposure (6, 7). Thus, different approaches to quantify resilience have been proposed (8).

The NEO Personality inventory (NEO) has been used to examine one factor influencing resilience: personality. Additional factors include: social resources, perceived economic resources, and cognitive skills. The NEO includes five dimensions of personality traits: Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness (9). A characteristic pattern of low neuroticism and above average extroversion, openness, agreeableness and conscientiousness on the NEO has been described as a ‘resilient personality’ (10-12). Increased resilience as measured by the NEO has been associated with normal BMI, decreased violence and improved social problem solving abilities in recent veterans, and improved recovery in spinal cord injury patients (10, 13), whereas reduced resilient personality has been linked to medical conditions, including chronic inflammation, obesity and metabolic syndrome (14, 15). Thus, the NEO assesses an important aspect of resilience, even though it does not directly measure adaptation to specific instances of adversity.

Although much attention has been paid to the psychological and organizational factors promoting resilience, much less work has focused, until recently, on the neurobiology of resilience (14). A small number of functional brain imaging studies have reported findings suggesting resilience-related differences in brain structure (16), responses to acute experimental paradigms (17-21) and resting state brain activity (22). However these studies ignore the potential for sex differences in the neurobiology of resilience. There is considerable evidence that stress response patterns of men and women differ with women displaying greater tendency towards “tend and befriend” responses while males are more likely to engage in “flight or fight” responses (23). Additional evidence shows that men and women differ in preferred coping and defense strategies with women reporting more social support strategies (24, 25). For example, female melanoma survivors reported more secure attachment styles while male survivors reported more secondary cognitive appraisal strategies to achieve the same level of well-being (26). Thus, men and women may differ in the biological systems engaged and behavioral strategies taken to achieve resilience.

Even during resting conditions, brain activity is highly organized (27). Examination of the brain through resting state fMRI has provided insights into the impact of experience, disease, and traits on the organization of large-scale brain networks (28). One widely recognized resting state network that may be relevant for resilience is the salience network (SN). SN is a brain network important for assessing the homeostatic relevance of stimuli (29). Altered SN connectivity has been demonstrated in returning male veterans with PTSD (30), social anxiety disorder (31), and in patients with psychogenic non-epileptic seizures (32). The SN is also considered pivotal in regulating activity of other networks, including the default mode network (DMN) (29). The DMN is engaged when individuals are left to think undisturbed, but has also been found to be engaged in tasks of theory of mind, social cognition, prospection and self-reflection (33). Altered DMN connectivity was been seen in a wide variety of psychiatric and neurological disorders including Alzheimer's Disease, depression, autism, and schizophrenia (34, 35), and has also been related to traits such as pessimism (36). Thus, DMN integrity and interaction with other networks has become an interest in the study of mental health. Disrupted SN integrity following traumatic brain injury has been shown to impact DMN function supporting the concept that SN regulates dynamic changes in the DMN (37). Proper SN functioning and modulation of the DMN by SN may function to adaptively respond to stress and may be a significant factor in resilience.

In the current study, we aimed to identify relationships between a NEO personality profile associated with high resilience and the resting scan connectivity of the SN and DMN in a large sample of male and female healthy subjects. We hypothesized that variations in resilience in terms of personality traits would be reflected in SN integrity and connectivity with the DMN. Furthermore, we hypothesized that sex differences exist in the neurobiology underlying a resilient personality.

METHODS AND MATERIALS

Subjects

82 healthy right-handed subjects (46 female; 36 male; ages 20-52) participated. Subjects were screened via medical exam and the MINI structured psychiatric interview (38) for absence of significant health or psychiatric conditions. Exclusion criteria also included pregnancy, substance abuse, and tobacco dependence. Study protocols were approved by UCLA's Office of Protection for Research Subjects and informed consent was obtained from all subjects.

Behavioral Measures

All subjects completed the NEO PI-R, a 240 question survey designed to measure five dimensions of personality including: Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness (9). Scale scores for each dimension are expressed as T-scores that vary from 20 to 80 with higher numbers reflecting an individual with more characteristics of the specific trait.

fMRI Acquisition

A high resolution structural image was acquired from each subject before the resting state scan with a magnetization-prepared rapid acquisition gradient echo (MP-RAGE) sequence, repetition time (TR) = 2200 ms, echo time (TE) = 3.26 ms, slice thickness = 1 mm, 176 slices, 256 × 256 voxel matrices, and 1.0×1.0×1.0 mm voxel size. Resting scan fMRI was performed on a Siemens 3 Tesla Trio using the following parameters: Echo time (TE) = 28ms, Repetition time (TR) = 2000ms, flip angle = 77 degrees, FOV = 220, slice thickness = 4.0mm, 40 slices were obtained with whole-brain coverage. The duration of the resting scan varied from 8 - 10 minutes. Subjects rested with eyes closed during the scan.

fMRI Preprocessing

Using DPASRF (39) and SPM8 software (Welcome Department of Cognitive Neurology, London, UK), data were slice-time and motion corrected, spatially normalized to the MNI template using their structural image, and spatially smoothed with a 3mm Gaussian kernel. The first two volumes were discarded to allow for stabilization of the magnetic field.

Statistical Analyses

Resilient personality scores—The NEO subscale scores for all subjects were entered into a factor analysis using SPSS v22 (IBM Corp, Armonk, NY). The first principal component accounted for 49% of the variance and reflected a personality dimension consistent with the resilience dimension reported in previous studies: negative weight for Neuroticism (−0.88) and positive weights for Extraversion (0.76), Openness (0.12), Agreeableness (0.61), and Conscientiousness (0.85). Resilient personality profile scores were computed for each subject by regression using this first principal component.

Network Identification—Group independent component analysis (gICA) was conducted to compute network connectivity. All subjects were entered into the gICA implemented in GIFT (http://icatb.sourceforge.com). Twenty independent components were extracted by independent component decomposition using the infomax algorithm (40). Multiple runs (20 iterations) were performed using ICASSO to increase robustness of the results (41). The components containing SN and DMN were identified by spatial correlation with templates provided by Laird et al (42). Individual subject maps were back-reconstructed and converted into z-score maps representing the degree of correlation between voxel signal and the overall timecourse of the network (35). Functional connectivity maps produced by ICA are similar but not identical to those produced by seed-based correlation analyses (43). Functional connectivity weights in ICA reflect the relationship between activity of a region (voxel) with a network as a whole, which may be somewhat different from pairwise relationships between regions. A mask containing all of the SN and DMN regions was created for subsequent analyses using voxels with $p > 0.05$ with family-wise error correction.

Resilience-Related Network Connectivity—To examine the relationship between resilient personality and SN/DMN connectivity in male and female individuals, a partial least squares (PLS) multivariate analysis was employed. PLS (http://www.rotman-baycrest.on.ca) is a multivariate statistical technique similar to principal component analysis, where solutions can be restricted to the part of the covariance structure that is attributable to covariate measures (44). The PLS analysis was designed to simultaneously examine sex differences and commonalities in the relationship between resilient personality and intrinsic connectivity within SN and DMN as well as between these networks. In this analysis, the across-subject correlations between resilient personality scores and connectivity measures for each of the networks of interest were computed for each sex, then singular value decomposition was performed to extract patterns in these correlations. PLS selects only the most robust patterns, which may reflect sex differences or commonalities in one or more of the networks, negating the need for specifying contrasts of interest, unlike a general-linear based approach (44, 45). Significance of the extracted brain-behavior patterns were assessed using permutation testing (500 permutations). The reliability of brain voxels contributing to the brain-behavior pattern was assessed using bootstrap estimation (500 samples). Clusters with a peak voxel bootstrap standard error ratio (BSR) exceeding ±3.3 ($p<.001$) with an extent of at least 50 voxels were considered reliable and are reported.

RESULTS

Subject Characteristics

Subjects' average age, NEO subscale scores and resilience factor scores are presented in Table 1. Male and female subjects did not differ in terms of age, NEO subscale scores, or resilient personality scores (p's > 0.05).

Identification of SN and DMN components

SN—The SN was identified by spatial correlation with the template for ICN 4 provided by Laird et al. (42), which largely consisted of bilateral anterior insula/frontal opercula and anterior cingulate cortex (ACC), consistent with the literature on SN. A single component demonstrated strong spatial correlation ($r = 0.46$) with the SN template and was thus selected as representing the SN. The identified component included anterior and posterior insula, rolandic operculum, ACC, midcingulate cortex as well as some portions of the dorsolateral prefrontal cortex (Figure 1).

DMN—The DMN was identified by spatial correlation with the template for ICN 13 provided by Laird et al. (42), which largely consisted of medial prefrontal and posterior cingulate/precuneus areas, consistent with the literature on DMN. Unexpectedly, 3 components demonstrated spatial correlation with the DMN template (r's = 0.51, 0.46, 0.41). One component (anterior DMN; aDMN) consisted mainly of the medial prefrontal cortex (middle and superior frontal gyri) and ACC. A second component (posterior DMN; pDMN) consisted mainly of the posterior cingulate cortex, retrosplenial cortex, and precuneus. The third component (lateral DMN; latDMN) consisted mainly of regions along the superior temporal sulcus (STS; middle and superior temporal gyri) and tempoparietal junction (TPJ; angular gyrus and supramarginal gyri) (see Figure 1). While it is fairly common in an ICA analysis for the DMN to split into 2 components (usually representing anterior and posterior subnetworks of the DMN), it is less common for the DMN to be represented in 3 components. However, Liemburg et al. (46) described a situation in which the DMN split into 3 subnetworks similar to our own. Thus, all 3 components were selected for further analysis.

Intrinsic connectivity correlated with resilient personality

Individual subject component maps for the 3 DMN subnetworks and the SN were entered into a single PLS analysis grouped by sex. The PLS analysis identified 2 significant brain-behavior patterns reflecting mainly significant sex differences in the relationship between resilient personality and connectivity patterns among SN and DMN subnetworks. The first significant brain-behavior pattern (accounting for 17.8% of the cross-block variance; p=.046), reflected sex differences in the correlation between resilient personality and connectivity of the SN, latDMN and pDMN (Figure 2A). Collectively, regions with a positive boot strap ratio, including medial superior frontal gyrus (mSFG), demonstrated greater (more positive) correlation between resilience and latDMN connectivity and less positive correlation between resilience and pDMN/SN connectivity in men compared to women while regions with a negative boot strap ratio, including ACC, left anterior insula (aINS), and middle temporal gyrus (MTG), demonstrated more positive correlation between resilience and latDMN connectivity and less positive correlation between resilience and pDMN/SN connectivity in women compared to men (Table 2).

The second significant brain-behavior pattern (accounting for 14.7% of cross-block variance; p=.048), reflected sex similarity in the correlation between resilient personality and connectivity of the SN but sex differences in the correlation between resilient personality and connectivity of the aDMN, pDMN, and latDMN (Figure 2B). Collectively, regions with a positive bootstrap ratio, including the angular gyrus, STS, caudate head, retrosplenial cortex, and right aINS, demonstrated a positive correlation between resilience and SN connectivity in both men and women. These regions had greater (more positive) correlation between resilience and pDMN/latDMN connectivity and less positive correlation between resilience and aDMN connectivity in women compared to men while regions with a negative boot strap ratio, inlcuding precuneus, demonstrated a more positive correlation between resilience and aDMN connectivity and less positive correlation between resilience and pDMN/latDMN connectivity in men compared to women (Table 2).

For each significant region, the correlation between resilient personality and network connectivity was computed for each voxel in men and women and is depicted in Figure 3 (SN connectivity) and Figure 4 (DMN connectivity). Individually, many regions were weakly to moderately associated with resilient personality; it is the overall connectivity patterns that are more strongly correlated with resilient personality (Figure 2). Correlations with magnitude less than 0.15 were considered negligible and are not shown. Examination of Figures 3 and 4 allow one to determine if sex differences in the association between resilient personality and connectivity reflects mainly a change in direction or magnitude for each of the regions identified in the PLS analysis. A positive correlation indicates that with higher resilience, the region becomes more functionally integrated into the network (stronger positive coupling weights) while a negative correlation indicates that with higher resilience, the region is less functionally integrated into the network. There were two exceptions:

independent of resilience, the pACC/aMCC cluster was negatively coupled (anticorrelated) with latDMN and the retrosplenial cortex was negatively coupled with the SN. Thus higher resilience in men is associated with stronger anticorrelation between pACC/aMCC and the latDMN while in women higher resilience is associated with weaker anticorrelation between pACC/aMCC and the latDMN. For both men and women, higher resilience is associated with weaker anticorrelation between the retrosplenial cortex and SN.

DISCUSSION

Our study is the first to link a resilience-related pattern of “Big Five” NEO domains to altered intrinsic connectivity of the brain. This personality dimension previously associated with high psychological resilience (low neuroticism, high extraversion, high openness, high agreeableness, and high conscientiousness) (10, 11) showed robust sex differences in its relationship to intrinsic connectivity of SN and DMN such that connectivity patterns associated with increased resilience in one sex was often associated with decreased resilience in the other sex. Furthermore, although some resilience-related connectivity occurred within a single network, resilient personality was largely related to regional shifts in connectivity from one network/subnetwork to another. Remarkably, it appears that a widespread shift in connectivity towards aDMN benefits women in terms of resilience while a shift in connectivity towards pDMN benefits men. Below, we discuss potential specialized functions of the three DMN subnetworks identified in the current analysis followed by a discussion of the implications of the major findings.

Functional specialization of DMN sub-networks

In our analysis, the DMN split into subnetworks representing anterior, posterior, and lateral aspects of the DMN. Numerous studies have demonstrated the existence of fractionalization within the DMN with distinctions made between anterior and posterior portions of the DMN as well as between the lateral and medial portions of the DMN based on functional and structural connectivity (47-50). While DMN regions are commonly active during self-referential tasks, DMN subnetworks likely provide unique contributions. Although there is incomplete consensus on the specific functional characteristics of individual subnetworks, one possibility is that aDMN is more involved in emotion regulation and emotion-cognitive interactions; latDMN is more oriented towards theory of mind; and pDMN is more involved in emotion-episodic memory interactions. The aDMN is largely comprised of the mPFC and ACC which are consistently activated in tasks of emotion and interoception (50) and are considered to be heavily involved in emotion regulation, social cognition and cognitive control (51, 52). These regions are considered key for integrating cognitive-affective information and have been shown to regulate autonomic and immune responses to stressors (53). The major regions of the latDMN are the STS and the inferior parietal cortex encompassing the TPJ. These regions are consistently activated in theory of mind tasks (the ability to attribute mental states to oneself and others) (54, 55) and are also involved in bodily self-consciousness, specifically in the location of self in space and first person perspective (56, 57). Out of body experiences have been associated with altered activity in the TPJ (58). The PCC, ventral precuneus, and retrosplenial cortex are the major regions of the pDMN. These regions receive input from regions with emotion-related functions and are strongly linked to episodic memory and learning functions (59-62). In particular, posterior cingulate activity is thought to assist in adapting to a changing environment by promoting flexibility, exploration, and renewed learning (63).

Resilient personality and SN connectivity

Sex commonalities were seen in the relationship between resilient personality and connectivity of the SN with the right aINS (a node within the SN) and several lateral and posterior DMN regions including angular gyrus, STS and retrosplenial cortex. We had hypothesized that within-network connectivity of the SN would be related to resilience. Supporting our hypothesis, stronger right aINS connectivity within the SN was associated with increased resilient personality in both men and women. Thus, right aINS connectivity within the SN appears to be relevant for resilience in all individuals. The SN functions to identify the most homeostatically relevant among internal and external stimuli in order to guide behavior (64). The aINS plays a prominent role in the detection of salient stimuli and the right aINS in particular, may be the major input node of the SN, initiating SN response to salient events (65). Thus the integrity of aINS connectivity within the SN may impact the efficiency of salience detection and the subsequent generation of appropriate behavioral response.

In addition, sex-differences in the relationship between resilient personality and SN connectivity with several ACC/mPFC regions of the aDMN were demonstrated. Specifically, for women, reduced resilience was associated with increased integration (stronger positive coupling) of a more ventral portion of the aDMN (ACC) into the SN while for men, reduced resilience was associated with increased integration of a more dorsal portion of the aDMN (mSFG) and decreased integration of ventral aDMN into the SN. These results may parallel another domain of research concerning the interaction between cognitive and emotional systems and the impact on behavioral performance. In females, sensitivity of ventral regions involved in emotion processing and limbic regulation in response to negative emotional distractors during a working memory task has been related to poorer working memory performance (possibly reflecting less resilience to the emotional challenge) while in males, sensitivity of dorsal regions involved in executive processing have been related to poorer performance (66). Increased integration of more ventral portions of the aDMN into the SN may increase the sensitivity of ventral emotion regulation systems to salient stimuli which in the current study appears to be more problematic in women than in men in terms of resilience. Similarly, increased integration of more dorsal portions of the aDMN into the SN may increase the sensitivity of dorsal evaluative systems to salient stimuli which in the current study appears to be more problematic in men than in women.

Resilient personality and DMN connectivity

Sex differences in the relationship between resilient personality and DMN connectivity were demonstrated, including DMN connectivity with the right and left aINS (nodes of the SN). We had hypothesized that resilience would impact SN connectivity with the DMN. The aINS is believed to be involved in condition-dependent switching and modulation of other major networks in the brain, including the DMN, to facilitate access to attention and other resources during a salient event (64). Disruption of insula connectivity has been show to affect functioning of other systems, including DMN (37). The current results support the idea that interactions between the SN and DMN through the aINS are important for resilience, albeit in a sex-specific fashion. The integration of the right aINS into the aDMN was associated with resilient personality in females, while integration of the left aINS into the pDMN was associated with resilient personality in males. Thus, in more resilient females, the aINS may preferentially engage aDMN while preferentially engaging the pDMN in more resilient males. This aDMN/pDMN distinction may bias the behaviors taken by resilient men and women and appears to be part of a larger pattern in which the connectivity of the aDMN vs pDMN has differential impact on male and female resilience (discussed in the next section).

Functional integration of the aDMN is important for resilience in females while functional integration of the pDMN is important for resilience in males

One striking pattern emerging from the results can be seen in Figures 4A and B. In women, numerous regions demonstrate increased connectivity with aDMN with a more resilient personality (seen in Figure 4A). In men, these same regions demonstrate a negative or negligible association between resilient personality and connectivity with the aDMN. In contrast, numerous regions demonstrate increased connectivity with pDMN with a more resilient personality in men (seen in Figure 4B) while in women, few regions demonstrate positive resilience-related connectivity with the pDMN. Although the aDMN and pDMN are both involved in self-referential tasks, the subnetworks do have structural and functional differences. As mentioned previously, aDMN is considered more involved in emotion-cognition interactions while the pDMN is more involved in emotion-memory interactions. In addition, regions of the aDMN, play a special role in social cognition, performing many processes that are critical for successful social interaction (51). Along these lines, aDMN regions have been shown to be preferentially involved in socially guided decision-making in conditions of uncertainty whereas internally guided decision-making involves pDMN regions (67). Thus, the sex differences in anterior vs posterior DMN resilience-related connectivity may be related to reported sex differences in utilization of social support in coping (24). Finally, aDMN regions have verbal (and non-verbal) expression-related functions, modulating emotional expression and speech (68-70), while pDMN regions have visuospatial-related functions pertaining to the salience of objects and locations in space (71, 72). It is possible that well-established sex differences in verbal and visuospatial skills may be associated with subtle differences in neurocircuitry that influence preferred strategies, including coping strategies, taken by men and women as well as the success of these strategies in producing resilience.

The regions demonstrating sex differences in resilience-related connectivity are multifunctional and functional relevance at any given instance depends on the status of other connected areas (i.e. neural context) (73). For women, increased aDMN connectivity with additional cortical regions associated with the mirror neuron system and social cognition (STS, TPJ, and aINS) may support an enhanced ability to build and utilize an effective social support system. For men, these regions may enhance pDMN function in engaging in adaptive learning and memory processes.

Conclusions

Brain networks are organized with both highly segregated and integrated properties to allow optimal and efficient information processing and learning (74). Our results suggest individual differences in network organization of two important networks, the DMN and SN, have implications for resilience. In addition, our results highlight the need to consider sex differences in the investigation of the neurobiology of psychological resilience. In response to adversity or a challenge, the male and female brain appear to differ in allocation of attentional and other neural resources due to differences in neurocircuitry (75-77). Our data therefore suggests that sex differences in successful adaptation to adversity, as reflected in higher resilience, is not just a matter of differential application of conscious coping strategies but is based in alterations in how information is processed by the male and female brain. Behavioral strategies supporting successful resilience are in part shaped by the social environment, thus gender biased environmental responses may also contribute to the sex differences found in the neurobiology of resilience in addition to those derived from sexual dimorphism. Given known differences in preferred adaptive strategies taken by men and women, it may not be surprising that sex differences in the neurobiology of resilience exists; the integrity and strength of systems supporting preferred strategies likely impacts resilience, yet sex differences have been ignored in previous literature. Our work suggests some of the brain features that may increase the success of different preferred strategies. In general, the current results suggest more expansive connectivity of the aDMN, a network involved in emotion regulation, is preferentially beneficial for female resilience while more expansive connectivity of the pDMN, involved in learning and memory, is preferentially beneficial for male resilience.

Implications—The capacity of human beings to maintain normal psychological and physical functioning in the face of stress or trauma may be reflected in intrinsic functional brain processes, providing an ability to develop brain markers of resilience for men and women. Brain biomarkers associated with reduced resilience, which may be sex specific, may be used to select targeted interventions to increase resilience for individuals following stress or trauma. In addition, brain biomarkers may be used to identify and preemptively intervene (inoculate) high risk individuals facing stressful situations (e.g. military).

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HIGHLIGHTS

- Resilient personality is reflected in salience and DMN connectivity.
- Sex impacts resilience-related connectivity patterns.
- Women showed expanded anterior DMN connectivity with more resilient personality.
- Men showed expanded posterior DMN connectivity with more resilient personality.
- Insula-salience network connectivity related to resilience in both men and women.

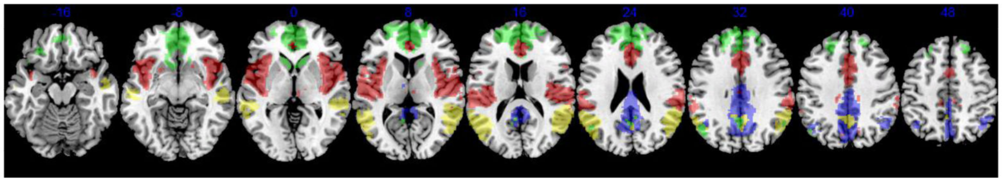


Figure 1.

Identified networks of interest (SN in red, aDMN in green, pDMN in blue, and latDMN in yellow) are depicted.

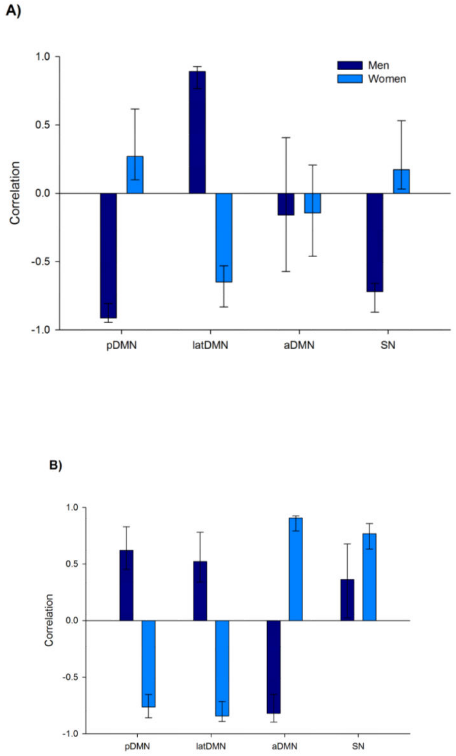
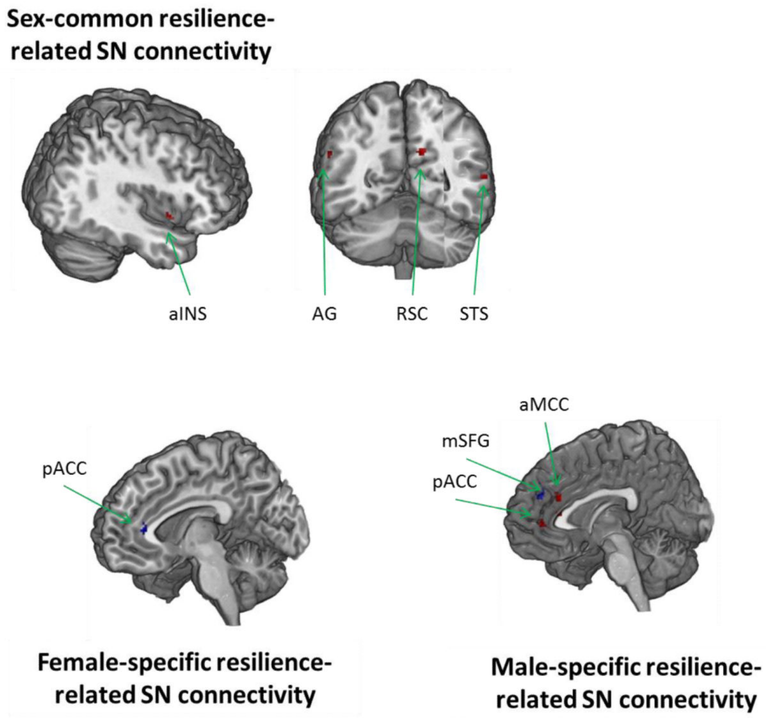


Figure 2.

Network connectivity covarying with resilience. A) The first significant brain-behavior pattern was driven by sex differences in the relationship between resilience and connectivity of ACC, medial SFG, MTG, and left aINS (Table 2) with pDMN, latDMN, and SN. B) A second significant brain-behavior pattern was driven by sex differences (pDMN, latDMN, aDMN) and sex commonalities (SN) in the relationship between resilience and network connectivity of the precuneus, angular gyrus, STS, caudate, restrosplenial cortex, and right aINS (Table 3). ACC: anterior cingulate cortex; SFG: superior frontal gyrus; MTG: middle temporal gyrus; aINS: anterior insula; STS: superior temporal sulcus



Sex-common resilience-related SN connectivity

Female-specific resilience-related SN connectivity

Male-specific resilience-related SN connectivity

Figure 3.

Sex commonalities and differences in resilience-related connectivity of SN/DMN regions with the SN. Regions in red demonstrate a positive correlation (r>0.15) between resilience and connectivity while regions in blue demonstrate a negative correlation (r<−0.15). pACC: pregenual anterior cingulate cortex; AG: angular gyrus; RSC: retrosplenial cortex; mSFG: medial superior frontal gyrus; aINS: anterior insula; STS: superior temporal sulcus

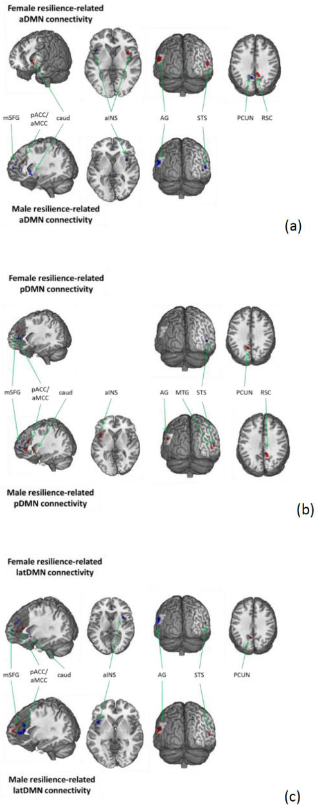


Figure 4.

A) Sex differences in resilience-related connectivity of SN/DMN regions with the aDMN. B) Sex differences in resilience-related connectivity of SN/DMN regions with the pDMN. C) Sex differences in resilience-related connectivity of SN/DMN regions with the latDMN. Regions in red demonstrate a positive correlation ($r>0.15$) between resilience and connectivity while regions in blue demonstrate a negative correlation ($r<-0.15$). pACC: pregenual anterior cingulate cortex; aMCC: anterior midcingulate cortex; caud: caudate; AG: angular gyrus; RSC: retrosplenial cortex; mSFG: medial superior frontal gyrus; aINS: anterior insula; STS: superior temporal sulcus ; PCUN: precuneus; MTG: middle temporal gyrus

Table 1

Mean and standard error for age and NEO personality scores

	Males	**Females**
Age	32.8 (1.7)	30.1 (1.4)
Neuroticism	47.6 (1.7)	47.3 (1.8)
Extraversion	43.5 (1.5)	46.5 (1.2)
Openness	56.1 (1.6)	58.3 (1.4)
Agreeableness	48.8 (1.5)	44.8 (1.6)
Conscientiousness	51.8 (1.7)	50.0 (1.7)
Resilience Factor Score	0.02 (0.16)	−0.01 (0.15)

Table 2

Brain regions reliably contributing to the brain-behavior pattern depicted in Figure 2A.

	Peak Coordinates	**Cluster Size**	**Bootstrap Ratio**	**p-value**
mSFG	2 46 28	79	4.14	<.001
mSFG	10 60 2	54	3.49	<.001
pACC/aMCC	2 32 22	108	−5.31	<.001
pACC	10 38 −4	229	−3.84	<.001
MTG	50 −58 4	65	−3.65	<.001
aINS	−44 16 0	81	−3.58	<.001

Table 3

Brain regions reliably contributing to the brain-behavior pattern depicted in Figure 2B.

	Peak Coordinates	Cluster Size	Bootstrap Ratio	p-value
Angular Gyrus	−56 −54 26	177	5.25	<.001
STS	58 −50 10	79	4.52	<.001
Caudate	−14 16 −8	87	4.41	<.001
Retrosplenial Cortex	6 −52 28	74	3.92	<.001
aINS	36 10 8	72	3.73	<.001
Precuneus	−2 −56 22	81	−3.42	<.001