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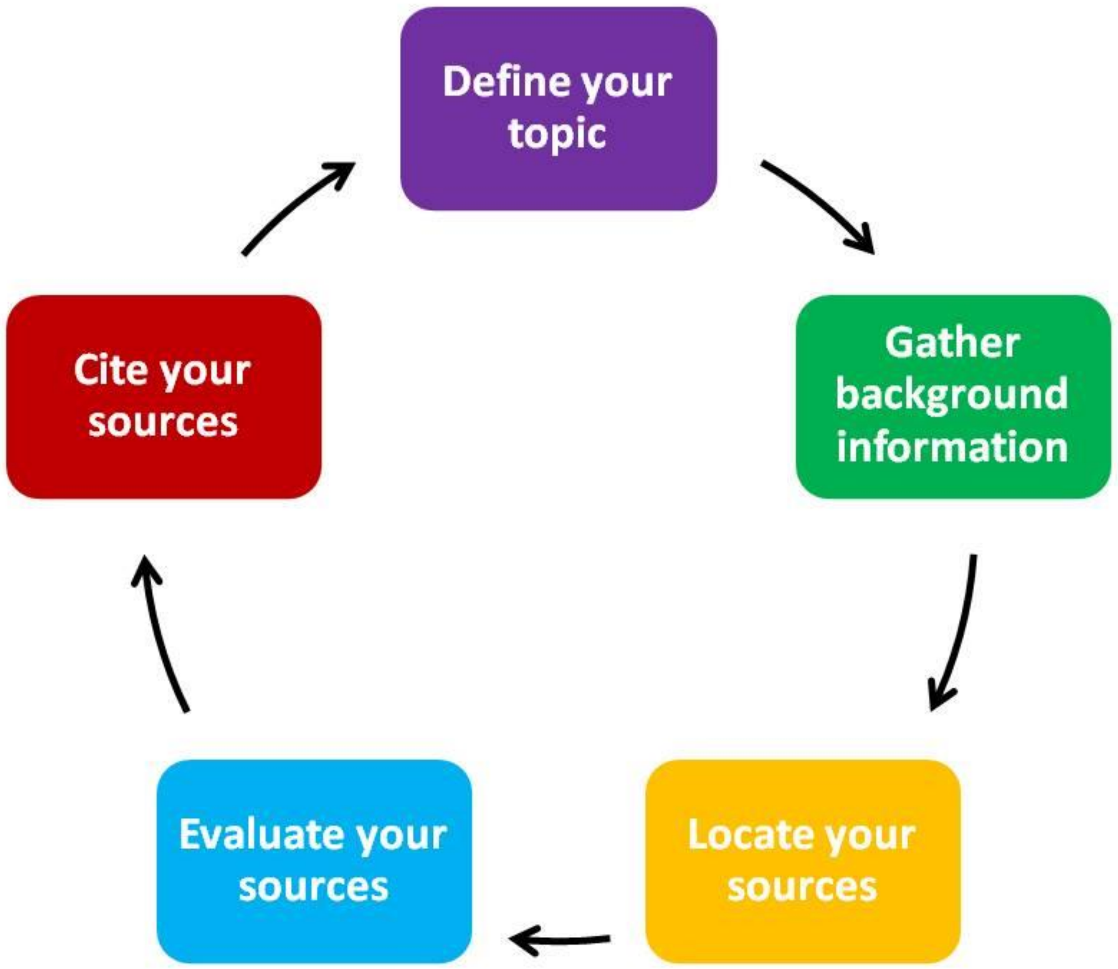

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step 3 Amygdala hippocampus and hypothalamus

Q130 Unhealthy behaviors, including smoking, poor nutrition, excessive alcohol consumption, physical inactivity and sedentary lifestyles, are global risk factors for non-communicable diseases and premature death.

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Convergence of interoception, emotion, and social cognition: A twofold fMRI meta-analysis and lesion approach (Article)

Adolfi, F.[abg], Couto, B.[a], Richter, F.[c], Decety, J.[d], Lopez, J.[e], Sigman, M.[fg], Manes, F.[agi], Ibáñez, A.[aghij]

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Abstract

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Guided by indirect evidence, recent approaches propose a tripartite crosstalk among interoceptive signaling, emotional regulation, and low-level social cognition. Here we examined the neurocognitive convergence of such domains. First, we performed three meta-analyses of functional magnetic resonance imaging studies to identify which areas are consistently coactivated by these three systems. Multi-level Kernel Density Analysis (MKDA) revealed major overlaps in the right anterior insular and frontotemporal regions (viz., the orbitofrontal and inferior frontal gyri, the amygdala, and mid temporal lobe/subcortical structures). Second, we explored such domains in patients with fronto-insulo-temporal damage. Relative to controls, the patients showed behavioral impairments of interoception, emotional processing, and social cognition, with preservation of other cognitive functions. Convergent results from both studies offer direct support for a model of insular-frontotemporal regions integrating interoception, emotion, and social cognition. © 2016 Elsevier Ltd

Author keywords

Frontotemporal networks | Insula | Multi-level Kernel Density Analysis | Stroke

Indexed keywords

EMTREE medical terms: amygdala | anterior insula | Article | caudate nucleus | cerebellum | cingulate gyrus | claustrum | emotion | functional magnetic resonance imaging | functional neuroimaging | human | inferior frontal gyrus | interoception | meta analysis | orbital cortex | postcentral gyrus | social cognition | superior temporal gyrus | temporal lobe | thalamus | adult | aged | brain | brain ischemia | diagnostic imaging | emotion | female | frontal lobe | interoception | male | middle aged | nuclear magnetic resonance imaging | pathophysiology | perception | physiology

MeSH: Adult | Aged | Brain | Brain Ischemia | Emotions | Female | Frontal Lobe | Humans | Interoception | Magnetic Resonance Imaging | Male | Middle Aged | Social Perception

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Research report

Convergence of interoception, emotion, and social cognition: A twofold fMRI meta-analysis and lesion approach

Federico Adolfi [a,b,g,1], *Blas Couto* [a,1], *Fabian Richter* [c], *Jean Decety* [d], *Jessica Lopez* [e], *Mariano Sigman* [f,g], *Facundo Manes* [a,g,i] and *Agustín Ibáñez* [a,g,h,i,j,*]

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ABSTRACT

Guided by indirect evidence, recent approaches propose a tripartite crosstalk among interoceptive signaling, emotional regulation, and low-level social cognition. Here we examined the neurocognitive convergence of such domains. First, we performed three meta-analyses of functional magnetic resonance imaging studies to identify which areas are consistently coactivated by these three systems. Multi-level Kernel Density Analysis (MKDA) revealed major overlaps in the right anterior insular and frontotemporal regions (viz., the orbitofrontal and inferior frontal gyri, the amygdala, and mid temporal lobe/subcortical structures). Second, we explored such domains in patients with fronto-insulo-temporal damage. Relative to controls, the patients showed behavioral impairments of interoception, emotional processing, and social cognition, with preservation of other cognitive functions. Convergent results from both studies offer direct support for a model of insular-frontotemporal regions integrating interoception, emotion, and social cognition.

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1. Introduction

1.1. *Network models of interoception, emotion, and social cognition*

Interoception, the sensing of internal bodily signals (Cameron, 2001; Craig, 2002), has been recently linked to emotion recognition and social cognition (Craig, 2009b; Garfinkel & Critchley, 2013; Ibanez & Manes, 2012; Uddin, Kinnison, Pessoa, & Anderson, 2014). The integration of these three domains likely depends on the insular cortex (IC), whose anterior portion (aIC) plays a crucial role in interoception (Caruana, Jezzini, Sbriscia-Fioretti, Rizzolatti, & Gallese, 2011; Decety, Michalska, & Kinzler, 2012; Ibanez & Manes, 2012; Melloni, Lopez, & Ibanez, 2014; Saarela et al., 2007; Singer et al., 2004). As part of the salience network and the ventral attention system, the right aIC is assumed to reorient attention towards emotionally salient stimuli (Corbetta, Patel, & Shulman, 2008; Eckert et al., 2009; Fox, Corbetta, Snyder, Vincent, & Raichle, 2006; Menon & Uddin, 2010; Nelson et al., 2010; Seeley et al., 2007). The IC features profuse connections with the medial prefrontal cortex (mPFC, including the anterior cingulate cortex, ACC) and the posterior bank of the superior temporal sulcus (pSTS), forming a network that is consistently engaged during social and emotion recognition tasks. The pSTS is sometimes denoted as temporo-parietal junction (TPJ), roughly characterized as an area at the border between the temporal and parietal lobes (surrounding the superior end of the STS) which is consistently activated during social cognition tasks (Melloni et al., 2016; Schurz, Radua, Aichhorn, Richlan, & Perner, 2014). These regions integrate signals from distant hubs, bringing together different functional networks (Ibáñez et al., 2016; Liang, Zou, He, & Yang, 2013; van den Heuvel & Sporns, 2013). This is especially true of the IC, which constitutes a "rich club" integrating global information patterns from all over the brain (Harriger, van den Heuvel, & Sporns, 2012; van den Heuvel & Sporns, 2011; Sepulcre, Sabuncu, Yeo, Liu, & Johnson, 2012; Sporns, 2014).

Further insights into the functional organization of this fronto-insulo-temporal network come from functional activation and lesion studies (Adolphs, Damasio, & Tranel, 2002; Cauda et al., 2012; Chang, Yarkoni, Khaw, & Sanfey, 2013; Kelly et al., 2012; Khalsa, Rudrauf, Feinstein, & Tranel, 2009), which reveal multiple connections between the IC and structures subserving interoceptive, emotional, and social processes, such as the orbitofrontal cortex (OFC), the dorsolateral prefrontal cortices (dlPFCs), the ACC, the medial and lateral temporal lobes, the ventral striatum, and the amygdala (Mufson & Mesulam, 1982; Viskontas, Possin, & Miller, 2007). In sum, as indicated by anatomical (Couto, Sedeno, et al., 2013; Mesulam & Mufson, 1982a, 1982b), lesion (Calder, Keane, Manes, Antoun, & Young, 2000; Couto, Adolfi, Sedeno, et al., 2015; Couto, Sedeno, et al., 2013; Khalsa et al., 2009), and functional (Cauda et al., 2012; Kelly et al., 2012; Kurth, Zilles, Fox, Laird, & Eickhoff, 2010) studies, the IC interacts with frontotemporal networks to coordinate social cognition, emotion, and interoception. To date, however, no study has directly examined the convergence of these domains, arguably

1.2. *Interoception and emotion*

One of the key sources of interoceptive signals related to emotion is the heartbeat. Indeed, heartbeat detection (HBD) tasks are the gold standard to assess cardiac interoception (Khalsa et al., 2008). In such tasks, moment-to-moment encoding of heartbeat signals activates the IC, the ACC, and the secondary somatosensory cortex (S2) (Bechara & Naqvi, 2004; Canales-Johnson et al., 2015; Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004; Ferri, Ardizzi, Ambrosecchia, & Gallese, 2013; Pollatos, Kirsch, & Schandry, 2005a; Pollatos, Schandry, Auer, & Kaufmann, 2007). Moreover, performance in the HBD task correlates with the volume of the right aIC —and so do negative affective states (Bechara & Naqvi, 2004; Critchley et al., 2004).

Interoception has also been associated with emotional processing (Couto, Adolfi, Velasquez, et al., 2015). Autonomic changes (e.g., increase in heart rate) signal emotional modulations, suggesting emotional self-assessment entails interoceptive processes (Lee & Siegle, 2012). Recent evidence suggests a proportional relationship between emotional experience and interoceptive sensitivity (Critchley et al., 2004; Pollatos, Kirsch, & Schandry, 2005b; Werner, Duschek, Mattern, & Schandry, 2009), indexed by IC activity (Critchley et al., 2004). Moreover, interoceptive and emotional processes yield overlapping activations in the aIC and the ACC (Craig, 2002; Critchley, Mathias, & Dolan, 2001; Damasio et al., 2000; Terasawa, Fukushima, & Umeda, 2013). A meta-analysis of 162 neuroimaging studies revealed that the IC is one of the most consistently activated areas in the emotion literature (Kober et al., 2008). Taken together, this evidence further highlights interoception as an element for emotional processing and self-awareness.

1.3. *Interoception and social cognition*

Central monitoring and the representation of bodily signals have been further associated with social cognition. Although social cognition is a complex domain involving many subcomponents, we focus here on the most classically associated processes: cognitive and affective Theory of Mind (ToM, the attribution of cognitive and affective mental states to oneself and others; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). ToM is one of the most essential aspects of social cognition (Kanske, Bockler, Trautwein, & Singer, 2015), and there is evidence for its specific association with interoception (Brewer, Happe, Cook, & Bird, 2015; Couto et al., 2014). For example, good interoceptive skills seem necessary to develop ToM (Keysers & Gazzola, 2007). Such domain is compromised following bilateral IC degeneration (Couto, Manes, et al., 2013). In addition, meta-analytic evidence has revealed IC involvement in non-story-based ToM studies (Mar, 2011). Finally, the interoceptive network is connected with regions that subserve varied social cognition domains, particularly the aIC and the ACC (Denny, Kober, Wager, & Ochsner, 2012; Fan, Duncan, de Greck, & Northoff, 2011; Kennedy & Adolphs, 2012; Mar, 2011; Van Overwalle, 2009; Van Overwalle & Baetens, 2009). Taken

1	Adolfi F., Couto B., Richter F., Decety J., Lopez J., Sigman M., Manes F., Ibáñez A.	Guided by indirect evidence, recent approaches propose a tripartite crosstalk among interoceptive signaling, emotional regulation, and low-level social cognition. Here we examined the neurocognitive convergence of such domains. First, we performed three meta-analyses of functional magnetic resonance imaging studies to identify which areas are consistently coactivated by these three systems. Multi-level Kernel Density Analysis (MKDA) revealed major overlaps in the right anterior insular and frontotemporal regions (viz., the orbitofrontal and inferior frontal gyri, the amygdala, and mid temporal lobe/subcortical structures). Second, we explored such domains in patients with fronto-insulo-temporal damage. Relative to controls, the patients showed behavioral impairments of interoception, emotional processing, and social cognition, with preservation of other cognitive functions. Convergent results from both studies offer direct support for a model of insular-frontotemporal regions integrating interoception, emotion, and social cognition. © 2016 Elsevier Ltd	*Frontal brain and amygdala work together, and involved with emotional processing and social cognition,*
3	Åhs F., Gingnell M., Furmark T., Fredrikson M.	Anxiety reduction following repeated exposure to stressful experiences is generally held to depend on neural processes involved in extinction of conditioned fear. We predicted that repeated exposure to stressful experiences would change activity throughout the circuitry serving extinction, including ventromedial prefrontal cortex (vmPFC), the hippocampus and the amygdala. To test this prediction, 36 participants diagnosed with SAD performed two successive speeches in front of an observing audience while regional cerebral blood flow (rCBF) was recorded using positron emission tomography. To control for non-anxiolytic effects of repeated exposure, rCBF was also measured during repeated presentations of neutral and angry facial expressions. Results showed that anxiety ratings and heart rate decreased from the first to the second speech, indicating an anxiolytic effect of repeated exposure. Exposure attenuated rCBF in the amygdala whereas no change in rCBF was observed in the vmPFC or hippocampus. The rCBF-reductions in the amygdala were greater following repetition of the speech task than repetition of face exposure indicating that they were specific to anxiety attenuation and not due to a reduced novelty. Our findings suggest that amygdala-related attenuation processes are key to understanding the working mechanisms of exposure therapy. © 2017 The Authors	*REWIND*
5	Albert K., Gau V., Taylor W.D., Newhouse P.A.	Background Cognitive bias is a common characteristic of major depressive disorder (MDD) and is posited to remain during remission and contribute to recurrence risk. Attention bias may be related to enhanced amygdala activity or altered amygdala functional connectivity in depression. The current study examined attention bias, brain activity for emotional images,	*Amygdala activity increased when view negative things - primitive brain, also sees things*

Let's understand how the brain works

The 'Intellectual brain' and the primitive 'emotional brain'

The explanation (always remember it has to relate to the client)

"Let's understand how the brain works. How depression, anxiety, OCD etc. is created. How we can suffer in the way we do and what we can do about it. or - How we create these phobia/fear responses, how the interference comes and goes and what we are going to do about it.

Let's have a look at the brain - this is to the bit you know as you. It is your conscious part. The part that interacts with the world. The part we are using to be aware of our interactions together. At the moment it is attached to a vast intellectual resource, the intellectual mind. This part we don't share with other animals.

"Now, when we operate from this part of the brain we generally get things right in life. It will always come up with answers based on a proper assessment of the situation and is generally very positive.

A meta-analysis (see explanation below) on three sets of published papers using fMRI was conducted to identify the activity of different locations of the brain. The first meta-analysis demonstrated a clear link between the frontal (conscious) brain and the anterior insular (intellectual brain). The second meta-analysis looked at patients with damage to the frontal brain and found that these patients had impairments of emotional processing, interoception (the sense controlling survival behaviours such as breathing, heart rate, feelings of hunger and the need to go to the toilet), and social cognition (understanding social behaviour and distinguishing threatening events). The third meta-analysis revealed that the frontal brain and the primitive brain work together to deliver all these survival behaviours, emotion and social cognition[1].

Meta-analysis - the statistical procedure for combining data from multiple studies. When the treatment effect (or effect size) is consistent from one study to the next, meta-analysis can be used to identify this common effect. It works above a systematic review of the literature in that it provides a quantitative estimate for the effect of a treatment intervention or exposure. Where a systematic review provides evidence of the effectiveness of a treatment, a meta-analysis provides you with an indication of how effective that treatment is.