The Social Context Network Model in Psychiatric and Neurological Diseases

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Abstract The role of contextual modulations has been extensively studied in basic sensory and cognitive processes. However, little is known about their impact on social cognition, let alone their disruption in disorders compromising such a domain. In this chapter, we flesh out the social context network model (SCNM), a

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neuroscientific proposal devised to address the issue. In SCNM terms, social context effects rely on a fronto-temporo-insular network in charge of (a) updating context cues to make predictions, (b) consolidating context–target associative learning, and (c) coordinating internal and external milieus. First, we characterize various social cognition domains as context-dependent phenomena. Then, we review behavioral and neural evidence of social context impairments in behavioral variant frontotemporal dementia (bvFTD) and autism spectrum disorder (ASD), highlighting their relation with key SCNM hubs. Next, we show that other psychiatric and neurological conditions involve context-processing impairments following damage to the brain regions included in the model. Finally, we call for an ecological approach to social cognition assessment, moving beyond widespread abstract and decontextualized methods.

Keywords Social cognition · The social context network model · Psychatric disorders · Neurological disorders · Context processing

Contents

1 Introduction

Social interactions naturally occur in context-rich settings (Ibanez and Manes 2012) which modulate all aspects of cognition, from basic perception to interpersonal domains. Perception of specific objects and colors always occurs in the context of other objects and colors. Listening and speaking processes are driven by the anticipation of upcoming discourse choices. Facial emotions are perceived and interpreted under the influence of verbal, visual, and gestural information. Likewise, adequate social behavior requires the integration of explicit and implicit contextual cues to properly deploy politeness, humor, irony, agreement, disagreement, or even silence.

In neuroscientific research, the role of context has been widely explored in low-level domains (e.g., visual perception), with relatively exhaustive anatomical and explanatory models (Bar 2004). Strikingly, although some authors (e.g., Adolphs 2009; Todorov et al. 2006) have addressed the relevance of contextual modulations in social cognition, no model has attempted to explain how specific mechanisms and brain regions contribute to context processing. In this chapter, we describe the social context network model (SCNM), which proposes that contextual modulations of social cognitive processes depend on a fronto-temporo-insular network (Ibanez and Manes 2012). Moreover, we propose that psychiatric and neurological disorders can be described as featuring marked contextual social cognition impairments. Finally, we present evidence that highlights the importance of assessing social cognition by means of ecological instruments.

2 Contextual Social Cognition

Social cognition is deployed in specific scenarios which mold meanings during interaction (Ibanez and Manes 2012; Kennedy and Adolphs 2012). The notion of social cognition involves several domains, such as emotion recognition, theory of mind (ToM), empathy, moral judgment, and decision making. Relevant cognitive operations involve perceiving, inferencing, and interpreting situational elements to derive an integrated construal of context which biases an action's meaning (Adolphs 2009; Ibanez and Manes 2012). For instance, structural processing of faces and subsequent recognition of their emotions occur against a backdrop of gestural, lexical, prosodical, and otherwise situational clues, all of which influence emotional assessment (Barrett et al. 2011). As a further example, consider empathy for pain. This highly contextual phenomenon (Melloni et al. 2014) depends on the recognition and vicarious experiencing of another person's physical (Lamm et al. 2007) and psychological (Masten et al. 2011) suffering. If we witness an assault in which the victim gets beaten, our initial empathy may be modulated by situational variables, to the extent that it can be accompanied or superseded by feelings of risk or the urge to escape or attack. Moreover, empathy is modulated by perceived fairness of others (Singer et al. 2006). Thus, empathic neural responses are reduced when observing an unfair person receiving pain. In addition, neural activity related to affective sharing and empathy for social pain is sensitive to the degree of closeness with the other person (Muller-Pinzler et al. 2015).

No less important is the impact of context on ToM, namely the capacity to attribute cognitive and affective states to oneself and others. Indeed, beliefs, intentions, and other mental states are more reliably inferred when embedded in contextual frames. The same is true for social decision making. In some cases, this process is guided by ambiguous clues in the absence of predictions about the outcome; in other situations, however, decisions cannot be made without full awareness of the risks and potential consequences. More generally, our gregarious behavior at large is driven by context-sensitive social norms. The joyful demeanor we adopt at a birthday party would be less than decorous at a funeral. Context also shapes our emotional responses while witnessing threats to another's social integrity. For instance, different behavioral reactions and neural circuits are involved in embarrassment with and embarrassment for another person's mishaps (Paulus et al. 2015). Furthermore, the feelings we express about other "racial," ethnic, or social groups other than our own are partially determined by situational constraints, in general, and the presence of members of these groups, in particular. In this vein, Johns et al. (2005) found that social emotions such as guilt or shame for the negative actions of in-group members are modulated by identity with the group and the perceived negativity of the event.

In sum, social cognition processes seem to be embedded in specific contextual circumstances that help to build intrinsic social meanings. To account for this crucial observation and based on multiple sources of evidence (detailed below), the SCNM proposes that the contextual influence on social cognitive processing is mediated by a fronto-temporo-insular network which (a) updates context cues to make predictions, (b) supports context–target associative learning, and (c) coordinates internal and external milieus.

3 The Social Context Network Model

During everyday interactions, common sense and implicit experience-based associative learning come together so that contextual frames can be updated to predict the meaning of probable socially relevant events. In terms of the SCNM, such contextual associations are mediated by a cortical network (Fig. 1) engaging frontal, temporal, and insular regions (Ibanez and Manes 2012). The updating of ongoing contextual information and its association with episodic memory supports target–context relations driven by activity in frontal regions (e.g., orbitofrontal cortex, lateral prefrontal cortex, superior orbital sulcus). The value of target–context associations is indexed in temporal circuits distributed throughout the amygdala, the hippocampus, and the perirhinal and parahippocampal cortices. Finally, internal and external milieus are coordinated by the insula to trigger internal motivational states.

3.1 The Role of Frontal Lobes in Contextual Integration

Access to episodic information is updated via context-driven predictions mediated by orbitofrontal, lateral prefrontal, and superior orbital regions (Watanabe and Sakagami 2007). In nonhuman animals, prefrontal neurons rapidly adapt to circumstantial meanings in short-term context paradigms, and they seem to update the same targets in different contexts (Sigala et al. 2008). Neurons in the orbitofrontal cortex are attuned to information about the organism's motivational context (Watanabe and Sakagami 2007). In primates, lateral prefrontal neurons fire in a

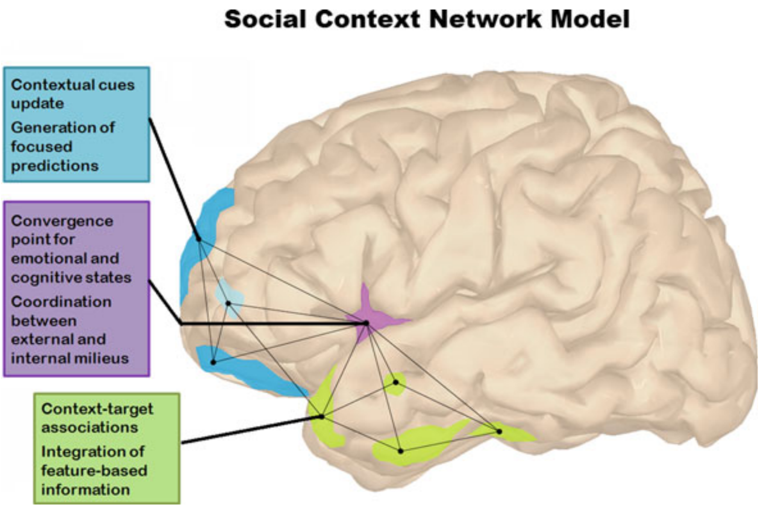

Fig. 1 Social context network model (SCNM). Lateral view of the left hemisphere showing the fronto-temporo-insular network. In this network, prefrontal areas would be involved in the generation of focused predictions by updating associations among representations in a specific context. Target–context associations subserved by temporal regions would be integrated with feature-based information processed in frontal regions. Finally, the insular cortex would support the convergence of emotional and cognitive states related to the coordination between external and internal milieus. Connected nodes represent fronto-temporo-insular interactions. Reproduced with authorization from Baez and Ibanez (2014)

context-dependent fashion, independently of the stimuli's physical attributes (Watanabe and Sakagami 2007). Contextual update of visual targets also implicates the superior orbital sulcus, as shown in both human and animal research. This frontal area would be important to generate focused predictions by updating associations among varied forms of information in specific contexts (Bar 2004).

Recent theories have suggested that functions related to metacognition, including mentalizing and self-knowledge, are specific to rostral prefrontal cortex (Burgess and Wu 2013). More specifically, Fleming and Dolan (2012) proposed a model in which the function of the rostral and dorsal lateral prefrontal cortex is important for the accuracy of retrospective metacognitive judgments of performance. In contrast, prospective judgments may depend upon the medial prefrontal cortex. Moreover, the rostro-lateral prefrontal cortex may receive input from interoceptive cortices (insula and anterior cingulate), generating an accurate metacognitive representation. However, unlike contextual updates and predictions mediated by the prefrontal cortex, metacognitive processes are consciously reportable (Fleming and Dolan 2012). Context-driven predictions in social cognition range from implicit to explicit levels (Ibanez and Manes 2012). Metacognitive processes may modulate explicit predictions but not implicit ones, which suggests that these are not critical aspects of the functioning of the frontal hub proposed by the SCNM.

Accordingly, disturbances of frontal lobe function are associated with deficits to recognize how context alters the meaning of stimuli (Mesulam 2002). In patients featuring such impairment, thinking becomes concrete and behavior is guided by superficial cues from the environment. Indeed, some patients seem impervious to contextual incongruity (Mesulam 2002). Notably, while these impairments are manifest in the patients' daily life (Burgess et al. 2009), they behave impeccably in the doctor's office. Thus, as proposed by Mesulam (1986), the major deficits caused by frontal damage become evident when external control of behavior is minimal (as in the case of everyday life).

Finally, predictive coding research corroborates the role of frontal areas in the anticipation of upcoming events based on previous experience (Friston 2012). Inferences occur as the system anticipates the causes of sensory inputs through top-down predictions, which are updated by frontal regions via bottom-up prediction errors. Note that predictive coding principles, though originally intended to account for basic brain function, also apply to social cognition and emotional phenomena (Seth et al. 2011).

3.2 Target–Context Associations in the Temporal Lobes

Contextual learning is rooted in the establishment of target–context associations (Greene et al. 2006). Basic associative processes, such as extinction (Bouton et al. 2006), involve activity in the hippocampus, the amygdala, and related temporal sites (e.g., perirhinal cortex). Associative processing seems to depend on the medial temporal lobes (Bar 2004), which are critical for the representation of contextual markers and their integration with signals coming from frontal regions. In humans, global contextual associations engage the parahippocampal cortex, which receives polysensory and somatosensory information (Bar 2004) and is also implicated in episodic memory.

Moreover, clinical research underscores the role of temporal lobes in contextual processing for social cognition. For instance, a recent study with patients with temporal lobe epilepsy or lobectomy (Cohn et al. 2015) showed relationships between hippocampal atrophy and social inference abilities, and between anterior temporal neocortex atrophy and sarcasm comprehension. By the same token, studies on neurodegenerative diseases—e.g., behavioral variant frontotemporal dementia (bvFTD), Alzheimer's disease, and semantic dementia—have shown that anterior temporal pole atrophy impairs several social cognition domains, including ToM (Torralva et al. 2007), empathy (Baez et al. 2014b), and moral judgment (Baez et al. 2014a, 2015b). In addition, neuroimaging evidence from bvFTD patients (Baez et al. 2015c) and direct electrophysiological recordings in intractable epileptic patients (Hesse et al. 2015) show that the amygdala is critical to detect the intentionality of other's actions, an ability that depends on the appraisal of contextual cues.

3.3 The Insular Cortex as a Convergence Area

The insula seems to act as an integrative hub for signals from the internal and external milieus (Ibanez et al. 2010; Singer et al. 2009). It also brings about global feeling states by merging contextual information together with modality-specific feeling states, uncertainty, and individual preferences (Singer et al. 2009). These experience-guided processes link intentions and motivations for goal-oriented behavior. The synergistic role of the insula seems to depend on its connections with frontotemporal regions (Couto et al. 2013), especially those involved in the regulation of context-dependent behavior (anterior cingulate and orbitofrontal cortex). Subcortical regions connected to the insula (amygdala and striatum) also play an important role in context-dependent responses (Apicella 2007). Thus, contextual effects are largely driven by reciprocal modulations between the insula and frontotemporal structures. Specifically, in the SCNM, the insula would constitute a convergence point for emotional and cognitive operations related to the coordination between external and internal states, facilitating frontotemporal interactions in social context processing.

The insula is also crucial for sensing visceral signals (Ibanez and Manes 2012). This interoceptive function has been directly linked with emotion recognition (Craig 2009), empathy (Singer et al. 2009), and decision making (Furman et al. 2013). In particular, the right anterior insula, as part of the salience network, biases attention toward emotionally salient stimuli (Fox et al. 2006). Also, convergent activity from the insula and other interoceptive regions, such as the anterior cingulate, is implicated in varied emotional and social cognition domains (Kennedy and Adolphs 2012). In this vein, Critchley et al. (2004) showed that neural activity in the anterior insula and the opercular cortex mediates explicit awareness of internal bodily processes. Moreover, negative emotional experiences correlate with interoceptive awareness (Critchley et al. 2004). In sum, interoceptive mechanisms involving the insula modulate contextual effects on social cognition.

4 The Social Context Network Model in Psychiatric and Neurological Diseases

Most psychiatric and neurological conditions are characterized by social cognition deficits and/or abnormal activation of “social brain” areas (Kennedy and Adolphs 2012). Indeed, upon a breakdown of frontotemporal dynamics, these disorders disrupt implicit social interaction (Schilbach et al. 2013) and context–target associations. The SCNM offers a framework to understand such deficits in psychiatric and neurological diseases. By way of illustration, below, we discuss how these impairments manifest in bvFTD, autism spectrum disorder (ASD), and other conditions.

4.1 Behavioral Variant Frontotemporal Dementia

Patients with bvFTD exhibit insidiously progressive changes in personality and social interaction, even before the onset of other cognitive deficits. Episodic memory, visuospatial abilities, and praxias are typically intact or relatively well preserved. Conversely, deficits in social interaction, lack of empathy, disinhibition, and impulsiveness are evident since early stages of the disease (Piguet et al. 2011).

Affected social cognition domains include emotion recognition (Lough et al. 2006), empathy (Baez et al. 2014b, 2015c), decision making (Manes et al. 2011), ToM (Torralva et al. 2007), and moral judgment (Baez et al. 2014a, 2015b). All of these impairments could reflect a general disturbance of social context processing subsequent to alterations in a broad fronto-temporo-insular network (Ibanez and Manes 2012), which is impaired in bvFTD patients (Seeley et al. 2009). For instance, relative to controls, bvFTD patients take less objection to scenarios where the protagonists deliberately inflicted pain on another, and they are less willing to exonerate protagonists for accidentally causing harm (Baez et al. 2014a). Exculpating agents who unwillingly inflict harm require a robust representation of their intentions, as the preponderant negative response to the outcome must be overridden by reference to situational cues. This ability seems to be affected in bvFTD patients.

Additionally, when performing an empathy-for-pain task, bvFTD patients do not easily discriminate between accidental and neutral or intentional situations (Baez et al 2014b, 2015c). This is expected because empathy is a contextual phenomenon affected by stimulus ambiguity (Melloni et al. 2014): since accidental pain situations are less clear and explicit, they imply more ambiguity and greater demands to ascertain the action's intentionality. In healthy subjects, ambiguity resolution benefits from contextual cues (Bar 2004), especially when the scenario involves someone in pain (Melloni et al. 2014). Accordingly, social cognition impairments in bvFTD may reflect underlying deficits in context processing.

Consistent with the brain regions proposed by the SCNM, neuroimaging studies, Viskontas et al. (2007) suggested that bvFTD patients are characterized by frontal, temporal, anterior insular, and anterior cingulate abnormalities, with pronounced orbitofrontal atrophy. Some studies (Baez et al. 2015c; Viskontas et al. 2007) have reported correlations between behavioral symptoms and orbitofrontal cortex volume, suggesting that behavior regulation depends on this region, in connection with a predominantly right-sided network involving the insula and striatum. In addition, voxel-based morphometry studies on bvFTD have revealed significant gray matter loss in the anterior insula and varied frontal areas. Particularly, a recent study (Baez et al. 2015c) showed that atrophy of limbic structures (amygdala and anterior paracingulate cortex) in bvFTD is related to impairments in intentionality comprehension, while atrophy of the orbitofrontal cortex correlates with deficits in empathic concern (see Fig. 2).

Also, resting-state fMRI of bvFTD patients has revealed abnormalities in functional connectivity among hubs of the SCNM. A recent study employing graph

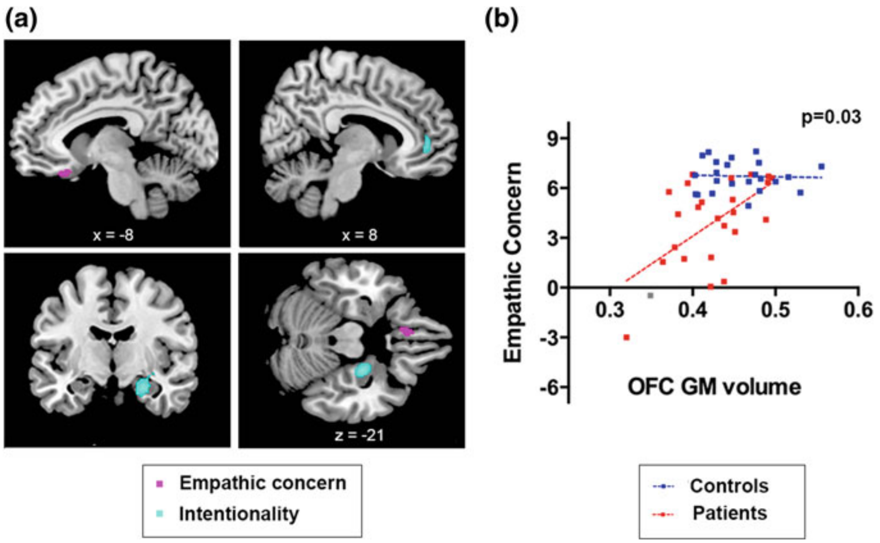

Fig. 2 Atrophied brain regions related to behavioral impairments in bvFTD patients. **a** Regions of reduced GM volume associated with intentionality comprehension of accidental harms and empathic concern for intentional harms. **b** Significant associations between GM volume in the left OFC and ratings of empathic concern for intentional harms. Reproduced with authorization from Baez et al. 2015c

theory analyses (Sedeno et al. 2015) showed that these patients have decreased network centrality in the fronto-temporo-insular network (Fig. 3). Furthermore, in agreement with the SCNM, this aberrant network organization predicted social-executive dysfunction profiles in the patients. The metric used in this study seems useful to distinguish bvFTD patients from patients with fronto-insular strokes and healthy controls. Thus, the SCNM would provide an adequate model to understand social impairments in bvFTD.

4.2 Autism Spectrum Disorder (ASD)

The term ASD describes multiple disorders characterized by impairments in social communication and repetitive behaviors. In particular, individuals with ASD exhibit deficits in emotion recognition (Falkmer et al. 2011), ToM (Cheng et al. 2015), and moral judgment (Moran et al. 2011). Individuals with ASD also showed reduced empathy as measured by self-report questionnaires (Baron-Cohen et al. 2004) and empathy for pain tasks (Baez et al. 2012). However, as suggested by Bird et al. (2010), empathy for pain impairments observed in ASD are explained by the degree of alexithymia, rather than the autism spectrum condition per se. Moreover, a recent study (Krach et al. 2015) showed that although ASD patients may have

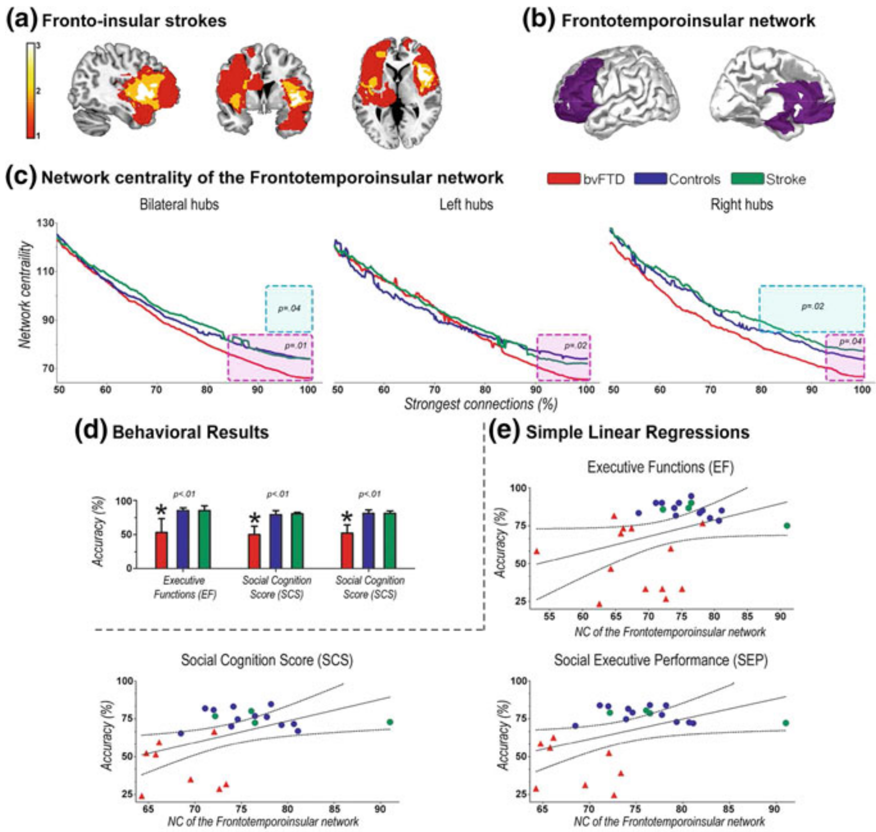

Fig. 3 Decreased centrality in the fronto-temporo-insular network in bvFTD. **a** Frontal and insular structures that were injured in stroke patients. **b** Regions included in the fronto-temporo-insular network. **c** *Pink* boxes indicate the clusters where the bvFTD patients presented decreased network centrality (NC) compared to controls. *Light blue* boxes indicate the clusters where bvFTD patients showed decreased NC compared to the fronto-insular stroke group. **d** Compared with controls and stroke patients, bvFTD patients showed impairments in executive functions and social cognition. **e** The network centrality of the bilateral fronto-temporo-insular network was associated with participants' performance in executive functions and social cognition. Reproduced with authorization from Sedeno et al. (2015)

preserved abilities to share another's physical pain, they have problems in processing more complex scenarios involving social pain. In particular, the patients' behavioral responses for complex social situations, unlike those of controls, lacked correspondence with the anterior cingulate and insular cortex activity. Instead, they presented distinctive hippocampal activity. This finding suggests that in ASD, the evaluation of complex social situations may be based on learned social scripts rather than on an interoceptive assessment of their emotional states (Krach et al. 2015).

Social cognition impairments in ASD are related to contextual sensitivity (Baez and Ibanez 2014; Klin 2000), probably reflecting a single underlying factor: deficits to implicitly encode and integrate contextual information required to construe social meanings (Baez et al. 2012). For instance, Baez et al. (2012) assessed the performance of adults with ASD in social cognition tasks with different levels of contextual dependence and involvement of real-life scenarios. Specifically, the authors assessed the following: (a) emotion recognition through the Awareness of Social Inference Test (TASIT); (b) emotional and cognitive aspects of ToM with the Reading the Mind in the Eyes Test (RMET) and the Faux Pas Test (FPT); (c) the cognitive and affective components of empathy through an Empathy for Pain Task (EPT) and the Interpersonal Reactivity Index; (d) moral judgment with a well-characterized moral task (Baez et al. 2014a); (e) self-monitoring skills by means of the Revised Self-Monitoring Scale; and (f) knowledge of social norms through an explicit (abstract and context independent) instrument, namely the Social Norms Questionnaire (SNQ).

The patients performed poorly on social cognition tasks that involved implicit encoding of socially relevant information and automatic integration of contextual information to interpret social scenarios. In this population, difficulties to implicitly recognize contextual clues may be the trigger behind social cognition impairments (Baez and Ibanez 2014; Baez et al. 2012). This possibility is reinforced by the observation of preserved performance in tasks which feature clearly defined situational elements and can be solved with relatively abstract universal rules (Baez and Ibanez 2014; Schilbach et al. 2012) (Fig. 4). A general executive deficit may be partially related to the patients' difficulties to integrate socially relevant contextual information. However, this possibility is undermined by the evidence of positive

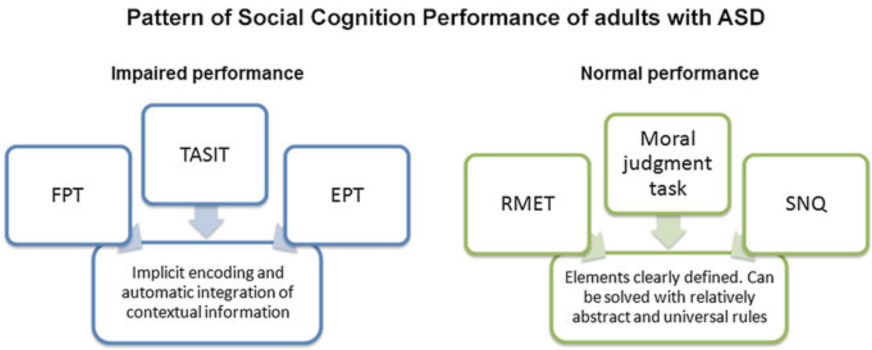

Fig. 4 Pattern of performance of adults with ASD in social cognition tasks. Adults with ASD were impaired in tasks that involved implicit encoding and automatic integration of contextual cues to interpret a given social situation. Conversely, they performed as well as controls in tasks with well defined situational elements that can be solved using relatively abstract, universal rules. *FPT* Faux Pas Test; *TASIT* The Awareness of Social Inference Test; *EPT* Empathy for Pain Task; *RMET* Reading the Mind in the Eyes Test; *SNQ* Social Norms Questionnaire. Reproduced with authorization from Baez and Ibanez (2014)

(e.g., Ozonoff et al. 1991) and null (e.g., Baez et al. 2012; Landa and Goldberg 2005) associations between executive functions and social cognition performance. Further studies are needed to reveal the specific contribution of executive functions to contextual social cognition in ASD.

In neural terms, individuals with ASD present structural and functional abnormalities in several brain structures, including the cingulate gyrus, the temporo-parietal junction, and the precuneus (Via et al. 2011), as well as frontal, temporal, and insular areas (Kosaka et al. 2010). Thus, the contextual social cognition impairments observed in ASD may also be partially explained by the abnormal functioning of the fronto-temporo-insular network proposed by the SCNM.

4.3 Other Neuropsychiatric Disorders

The previous two sections suggest that social cognition impairments may result from a general inability to integrate contextual information, triggered by abnormalities in a fronto-temporo-insular network. Contextual social cognition impairments may be also related to a general executive deficit. However, evidence is not conclusive and further studies should explore the issue in a broad array of neuropsychiatric conditions. Beyond this observation, the interpretation proposed by the SCNM may be extended to other neurological and psychiatric disorders involving deficits in social cognition domains.

Especially relevant are patients with frontal lobe damage (Mesulam 1986), whose deficits become evident in ecological tasks featuring implicit contextual cues (Burgess et al. 2009). In the same vein, short-term contextual processing tasks reveal abnormal behavioral and electrophysiological responses in patients with prefrontal compromise (Fogelson et al. 2009). Evidence from other brain diseases further emphasizes the role of context-processing skills in social cognition. In Huntington's disease, for instance, difficulties to appraise disgust and other negative emotions are reduced when target faces are accompanied by contextual clues (Baez et al. 2015a).

Similar difficulties have been observed in other psychiatric disorders. For instance, Baez et al. (2013) assessed the performance of patients with schizophrenia and bipolar disorder in social cognition tasks including different levels of contextual dependency and real-life involvement. Similar to adults with ASD, both patient groups exhibited deficits when such levels were high. The deficits were particularly severe in patients with schizophrenia, who also exhibit reduced affect recognition when faces are integrated within broader social contexts (Sasson et al. 2015). Moreover, relative to controls, these patients did not notably improve emotion recognition accuracy when faces appeared within congruent contexts, suggesting reduced benefit from complementary contextual information. In addition, although patients with schizophrenia preserve the ability to identify archetypal gestures, they are more likely than controls to perceive other people's gestures as self-referential when contextual information is ambiguous (White et al. 2016). Note that, in this population, inefficient integration of situational information may influence other deficits, supporting the idea that social context processing is impaired. Notably, such deficits, which affect both social and nonsocial domains, become more marked in ecological tasks (Baez et al. 2013), highlighting the need for novel context-sensitive approaches.

In anatomical terms, patients with schizophrenia (Wong et al. 2003) and, to a lesser degree, patients with bipolar disorder (Bearden et al. 2001) exhibit disturbances in the temporal and frontal areas proposed by the SCNM. These differences in the degree of frontotemporal disruption may explain the more severe social context-processing impairments observed in the former group. Finally, increased attentional demands in complex scenarios worsen emotion-related deficits in psychopaths and young offenders (Gonzalez-Gadea et al. 2014).

In summary, social cognition deficits present in psychiatric and neurological disorders may be partially explained by a general social context-processing impairment produced by fronto-temporo-insular network atrophy. The above-mentioned findings provide preliminary evidence for this hypothesis; however, future research should empirically test the assumptions of the SCNM, providing more refined evidence on processes and regions critically involved in contextual modulation of social cognition, and testing the model against other alternative accounts.

5 Toward an Ecological Assessment of Social Context

Altogether, the above-mentioned findings highlight the contextual appraisal disturbances as one further commonality between neurological and psychiatric conditions. As predicted by the SCNM, such deficits are caused by damage to prefrontal, insular, or temporal regions (Ibanez and Manes 2012). However, most tasks available to explore the cognitive profile of relevant populations fail to tap the ability to process implicit contextual information. Most of the traditional tests are not good "models of the world" (Burgess et al. 2009) because of their abstract, decontextualized nature. Instead, the comparatively few tasks involving real-life social scenarios have shown greater sensitivity in the clinical assessment of psychiatric and neurological populations (Baez et al. 2012, 2013, 2014b; Ibanez et al. 2014). These observations emphasize the importance of developing more ecological measures assessing contextual sensitivity.

Most social cognition experiments employ isolation paradigms (Schilbach et al. 2013), in which individual participants view pictures, words, or videos and categorize/judge their contents or infer their protagonists' mental/emotional states. In these conditions, subjects act as detached spectators of artificial situations (Garcia and Ibanez 2014). Despite its valuable contributions, this widespread approach fails to address the core of social relations, namely the deployment of interactive processes between emotionally engaged participants in contextually dynamic environments. A promising avenue of development for the field is immanent in the principles of two-person neuroscience (Schilbach et al. 2013), which suggests that interpersonal understanding is primarily a matter of social interaction and emotional engagement with others. This approach seeks to bridge "the spectatorial gap" by exploring inter-brain communication in multi-participant experimental settings, as shown in a number of studies (Garcia and Ibanez 2014). Supporting this approach, recent methodological advances (e.g., Redcay et al. 2013) have favored increased ecological validity through the study of social cognition processes in real time, looking at how people actively engage and interact with one another in social encounters.

In consequence, future studies in psychiatric and neurological populations should strictly control for context-dependent levels in social cognition tasks, ranging from context-free to context-rich paradigms with varied manipulations of situational cues. Ecological validity could be increased through methods assessing social cognition processes in real-time (e.g., Redcay et al. 2013) and spontaneous interactions between socially engaged participants (Garcia and Ibanez 2014; Schilbach et al. 2013). Ideally, protocols should also explore possible dissociations between social and nonsocial domains. In this sense, two key issues to be addressed in future research are the role of contextual information in social interactions and predictions, and the neural basis of mechanisms integrating information from social context frames. Methodologically speaking, challenges include the identification of extant social cognition tests which prove sensitive to contextual disturbances across neuropsychiatric conditions, and the development of paradigms aimed to test the three components of the SCNM. This would improve the operationalization of the model's hypotheses to be tested in psychiatric and neurological disorders compromising frontal, insular, and temporal regions. Breakthroughs in these directions could afford a robust framework to assess contextual social cognition in a wide range of populations (Ibanez and Manes 2012).

6 Conclusions

Contextual effects are inherent in daily-life social situations. The SCNM proposes a fronto-temporo-insular network responsible for processing social contextual effects. Patients with bvFTD and ASD clearly illustrate how the social cognition deficits observed in psychiatric and neurological disorders may be explained by a general social context-processing impairment triggered by abnormalities in the network postulated by the model. However, the interpretation proposed by the SCNM may be extended to other neurologic and psychiatric disorders such as stroke, Huntington's disease, schizophrenia, and bipolar disorder, among others.

Although context-processing impairments occur similarly across neurological and psychiatric conditions, most current tasks fail to capture the influence of implicit contextual information on social cognitive processes. Evidence suggests that tasks involving real-life social scenarios are more sensitive for the clinical assessment of both types of populations. This observation highlights the importance of assessing social cognition by means of ecological instruments tapping contextual sensitivity.

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