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NEUROPRAGMATICS

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1. Definition

The term neuropragmatics indicates an emerging interdisciplinary field devoted to the study of the neural basis of pragmatic abilities, i.e. the neural underpinnings of the mental processes involved in communication. In other words, neuropragmatics revolves around the mind/brain processes underlying the construction of context-appropriate meanings for the purpose of the communicative exchange. By taking into account the contextual dimension, neuropragmatics focuses on the activity of communicating, and deals with how communicative agents' minds brains represent and share intentions, beliefs, situations and the various components of context in order to construct a shared meaning and to engage in successful communication.

On the one hand, neuropragmatics draws on notions and frameworks put forward by philosophers, linguists and psychologists in modelling the linguistic, cognitive and social aspects of communicative interaction. On the other hand, it is strongly connected with the wider domains of the neurosciences of language and social cognition, encompassing research in both healthy and pathological conditions, and applying different techniques – from neuropsychological observations to functional neuroimaging. At the intersection of these many traditions lays the aim of finding theoretically refined and neurally plausible models of pragmatic processes.

Special test-beds in neuropragmatics are communicative events where context plays a pivotal role in completing implicit and linguistically underspecified meanings, namely complex speech acts, figurative meanings and discourse phenomena. The choice of testing especially demanding processes reflects both a research tradition – as indirect speech acts and non-literal meanings are well-established topics in the pragmatic literature – and an experimental strategy, devoted to better isolate and measure the cognitive demands posed by the recognition of the intended meaning in the communicative context.[1] Indeed, pragmatic processes are not limited to specific and complex kinds of exchange but apply automatically to fine-tune the interpretation of virtually every word (Wilson 2003) and every communicative action (Bara 2010, 2011). The ultimate goal of neuropragmatics is thus to describe the neuro-functional architecture of pragmatics as a system underpinning the whole domain of appropriate communicative behaviour in natural contexts of use. Accordingly, in the last years innovative protocols that closely mirror everyday communicative situations are being designed and employed, in the direction of potentiating the ecological validity of the neuropragmatic enterprise.

2. Historical notes

A profile of neuropragmatics cannot but start from the recognition of two historical facts. First, while patients with disruptions in the structural aspects of language were extensively studied since the late 1800s, pragmatic deficits started to be reported only a few decades ago. Second, while aphasiology could count on famous and relatively clear-cut cases such as Broca's patient "Tan", pragmatic deficits were initially described very generically, as pertaining to high-level language processing, lacking a precise classification. The reason for this scenario is two-fold. One the one hand, pragmatics as a fully developed discipline is a recent achievement, as compared to other domains of language and cognition. On the other hand, pragmatic impairments are less apparent to clinicians, as many patients with such deficits either retain the main linguistic abilities or have such profound deficits in the structural components of language that the inability of communicating follows as a secondary effect. However, despite the compressed time lapse, the study of the relation between pragmatics and the brain has rapidly emerged by absorbing leading methods and models from neuropsychology and cognitive neuroscience. After a couple of decades based primarily on clinical observations, neuropragmatics has expanded to functional neuroimaging, and – as it is happening in neurolinguistics – models are moving from a more localistic perspective, assuming the selective role of the right hemisphere, to widely and bilaterally distributed networks.

Traditionally, the first reports of pragmatic impairments are traced back to the late 1960, with the description of linguistic deficits not captured by an aphasic profile, related to "supra-ordinal" and "subtle" aspects of language (see Eisenson 1959, 1962; Critchley 1962; quoted in Joanette et al. 1990). More structured insights into the neural bases of pragmatics arose in the late 1970s, when clinicians began to notice that, in contrast with patients with left hemisphere damages, patients with lesions to the right hemisphere demonstrated systematic linguistic and communicative impairments that could not be classified as aphasic. A cornucopia of studies flourished in a large spectrum of phenomena, mainly dealing with the comprehension of non-literal meanings (Winner & Gardner 1977; Brownell et al. 1983) and the production of discourse and conversation (Joanette & Brownell 1990). By the end of the 1980s, these domains were grouped under the umbrella of pragmatics, and the hypothesis of the selective involvement of the right hemisphere imposed itself throughout the 1990s (Joanette et al. 1990; Tompkins 1995; Beeman & Chiarello 1998). It is in this period that early uses of the term neuropragmatics are found in the literature (Bara & Tirassa 2000; Stemmer & Schönle 2000).

In more recent times, the advent of functional neuroimaging techniques has led to a radical revision of the right hemisphere hypothesis. Although early studies reported right hemisphere activations (Bottini et al. 1994; Nichelli et al. 1995; St. George et al. 1999), probably due to methodological limitations, later investigation clearly evidenced the involvement of multiple brain networks devoted to pragmatic processing, not confined to the right hemisphere, but rather encompassing regions in the left hemisphere (Bookheimer 2002; Mason & Just 2006): it seems that mostly frontal and temporal regions are recruited, bilaterally. There is evidence that the right hemisphere is indeed involved in pragmatic tasks, but crucially along with other regions: the precise role of the right hemisphere is still a matter of debate, and some assume two different processing styles for the two hemispheres (Jung-Beeman 2005), but the two hemispheres seem to cooperate in supporting pragmatically appropriate behavior.

Furthermore, functional neuroimaging has brought to light that pragmatic processes are especially well captured by the network model put forward in cognitive neuroscience (Bressler & Menon 2010): pragmatic behavior results from the mutual engagement of multiple centers, linked to different cognitive abilities, from semantic/

conceptual elaboration to the capacity of mind-reading (Theory of Mind). The available results suggest that pragmatics cannot indeed be described as a monolithic component in neurofunctional terms, but emerges from the interplay of separate yet integrated systems, differently modulated according to the specific contextual coordinates. In this respect, much information comes also from neurophysiological techniques, which are able to unravel the time course of pragmatic processing and are providing crucial information of how the brain integrates context through time (Van Berkum 2009).

In parallel with the adoption of functional neuroimaging, the last decades also witnessed refinements in clinical investigations concerning pragmatic impairments, expanding to pathological populations other than right-hemisphere damaged patients, including neurodegenerative and psychiatric diseases and developmental syndromes (Stemmer 1999; Cummings 2009). More articulated proposals have been put forward to account for the multiplicity of clinical conditions that can exhibit pragmatic deficit: it is widely acknowledged that the same deficit might be motivated differently across pathologies, selectively involving specific cognitive components, either attention, working memory, or mind-reading abilities (Martin & Mac Donald 2003). Again, this points in the direction of multiple neurofunctional components supporting pragmatic processes.

Importantly, clinical practice is showing increasing efforts to include pragmatics in the neuropsychological assessment (Adams 2002). New tests are being produced and standardized which deeply explore and evaluate aspects such as speech act recognition (e.g., The Awareness of Social Inference Test, TASIT, McDonald et al. 2003; the Assessment Battery for Communication, ABaCo, Angeleri et al. 2008) and communicative effectiveness (Paul et al. 2004; Long et al. 2008). This reflects increasing awareness of the social aspects of communication as an important component in determining the patients' quality of life, and further legitimates neuropragmatics as a research field.

Overall, nowadays neuropragmatics can count on a considerable and growing amount of data (Bambini ed. 2010): in addition to a well-established tradition of lesion studies (often called "clinical pragmatics"; Perkins ed. 2005; Perkins 2007; Cummings 2009), insights into the neural basis of pragmatics appear in brain imaging maps on specific topics (e.g. the brain basis of metaphor) or under more general rubrics such as social neuroscience, neuroscience of discourse, including more context-oriented studies on the conceptual system organization. It is now time to unify these approaches into a concerted enterprise converging on interaction-centered and context-aware processes rather than artificially isolated ones (Bara & Tirassa 2000), strengthening the current experimental turn in pragmatics (cf. the research field of experimental pragmatics; Noveck & Reboul 2008) and adhering to the widely sought after study of the ecology of the language/brain relations (Small & Nusbaum 2004; Kutas 2006). In this sense, neuropragmatics represents a very lively expansion of the neuroscience of language, in a more socially oriented perspective.

3. Research domains

There are currently three pragmatic domains that especially attract the interest of researchers: (a) the recognition of communicative intention and speech act force; (b) the construction of non-literal meanings and (c) the managing of discourse. These domains have been extensively accounted for in the pragmatic tradition (Levinson 1983), and accordingly are major topics in exploring pragmatics in the brain, both through neuropsychological and imaging approaches (Stemmer 2008; Bambini 2010). Also, they are included in the most common checklists and tests for the assessment of pragmatic abilities, suggesting that they identify three main aspects of pragmatic competence (e.g. Bryan 1995; Joanette et al. 2004).[2] In what follows the main achievements in the three domains are sketched along with some representative references.[3]

3.1 Communicative intentions and speech acts

One of the main aspects contributing to the derivation of intended meaning is the force of the speech act, through which the speaker can communicate more than what she is saying in terms of content (Searle 1983), and convey her intent indirectly, generating many possible nuances at the social level (Pinker et al. 2008). Understanding speech acts relies on contextual cues to represent the partner's mental states and intentions, and the inferential load increases with the complexity of the representations involved. Cognitive pragmatics has pointed out that what makes the difference in speech act recognition is not only the direct-indirect dichotomy, but also and rather the length of the inferential chain required to derive the speaker's communicative intention. On this basis, simple and complex acts can be distinguished, related to different cognitive loads (Bara 2010, 2011).

The ideas put forward in cognitive pragmatics found empirical support in clinical investigations: difficulties in processing complex speech acts (e.g. certain instances of irony, requiring several inferential steps) have been observed in developmental syndromes such as autism (Bara, Bucciarelli & Colle 2001), acquired pathologies such as closed head injuries (Bara, Cutica & Tirassa 2001; Cutica et al. 2006) and dementia (Bara, Bucciarelli & Geminiani 2000). The pragmatic disruptions at play here are generally linked to Theory of Mind mechanisms, namely the ability to attribute mental states to others.

In terms of brain correlates, many attempts have been made to isolate the brain network responsible for mind-reading. Neuroimaging results describe a widely distributed neural system, including the medial prefrontal cortex (i.e. prefrontal areas located towards the imaginary midline dividing the two hemispheres), the right and the left temporo-parietal juncture, and the precuneus (an area in the postero-medial parietal lobe). Other regions frequently implicated in Theory of Mind tasks are the superior temporal sulcus and the temporal poles (Van Overwalle 2009).

One research line especially aims at disentangling how this network behaves in recognizing intentions, and especially communicative intentions. The Intentional Network proposed by Bara's research team (Walter et al. 2004; Ciaramidaro et al. 2007; Bara & Ciaramidaro 2010; Bara et al. 2011) consists in a dynamical activation of four major areas involved in mind-reading, modulated according to the individual/social dimension and the present/future one (see Figure 1). This network, active in a third person perspective, is able to represent other people' intentions from the observation of their actions. The types of intentions studied are:

a. Individual intention, that refers to the representation of a private goal (e.g. A opens the fridge in order to get a coke). Its recognition is realized by the right temporo-parietal juncture and the precuneus.
b. Prospective social intention, that refers to the representation of a social goal in the future (e.g. A enwraps a present for B, but the two agents are not currently interacting). Its recognition is realized by the right temporo-parietal juncture, the precuneus and the medial prefrontal cortex.
c. Communicative intention, that refers to a social intention in the present, with its recursive feature (e.g. A points at a bottle of water in front of B, in order to obtain it from him). Its comprehension requires the recruitment of the entire neural network: the temporo-pariental juncture bilaterally, the precuneus and the medial prefrontal cortex.

The Intentional Network suffers predictable pathological dysfunctions: paranoid schizophrenics show hyperintentionality with respect to normal subjects, i.e. tend to over-attribute intention not only to persons but also to objects. (Walter et al. 2009). On the contrary, autistic subjects suffer from hypointentionality, in that they do not attribute intentions to people (Bara 2010).

Importantly for pragmatics, the case in (c) underlies communication as intended by Grice (1975): A communicates to B that p, in order to share with B that p, plus the intention that the communicative intention itself should be recognized. This type of intention clearly has special status in the mind/brain, engaging a large network of regions which is likely to be responsible for the very core of the communicative exchange. Successful interactions depend upon our capacity to experience other people as goal-directed, intentional agents. Noteworthy, the brain network recruited for the comprehension of communicative intentions does not depend on the modality through which they are conveyed, and responds equally to the recognition of linguistic and extralinguistic (gestural) communicative contents (Enrici et al. 2011).

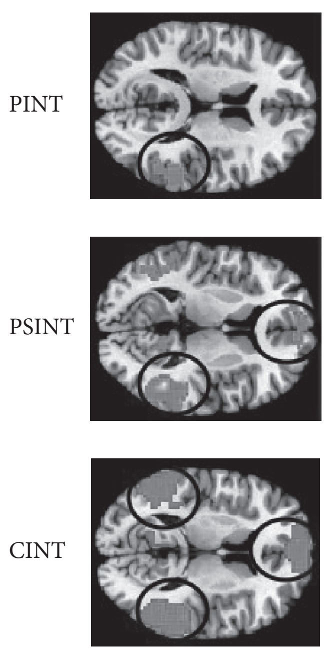

Figure 1. *The Intentional Network for private intention (PInt), prospective social intention (PSInt), communicative intention (CInt) (axial view of the brain). Adapted from Bara and Ciaramidaro (2010)*

3.2 Non-literal meanings

Lexical material is largely underspecified with respect to the meaning that speakers intend to convey. Pragmatic theorizing has brought to the fore that communicators make sense of words by supplementing linguistic decoding by contextually driven inferences, operating upon the conceptual dimension and integrating ingredients from co-text, situation, and beliefs about the world (Carston 2002). Context-based processes become especially eminent when the intended meaning seems not to actually feature in the coded material, as in the case of non-literal expressions: metaphors, idioms, humour, ironic statements and different kinds of implicatures.

It is now well-established that context-based interpretation is vulnerable to several neurological conditions. The clinical literature on metaphor, for instance, ranges from focal lesions (Gagnon et al. 2003; Rinaldi et al. 2004) to Alzheimer's disease (Papagno 2001, Monetta & Pell 2007; Amanzio et al. 2008; Rapp & Wild 2011) and schizophrenia (Iakimova et al. 2006), as well as developmental disorders such as autism (Wearing 2010) and Wiliam's syndrome (Annaz et al. 2009). The variety of clinical populations supports the idea that metaphor resolution capitalizes upon the interplay of different systems, which can be differently damaged across pathologies (Martin & MacDonald 2003). Specifically, difficulties in Alzheimer patients have been explained in terms of poor executive functions in the prefrontal cortex (Amanzio et al. 2008). Similarly impairments in Parkinson patients are probably due to a deficit in the fronto-striatal system for working memory (Monetta & Pell 2007). The difficulties experienced by schizophrenic patients may lie in the semantic domain located in the frontal regions, whose disruption may produce concretism and difficulties in pragmatic enrichment (Kirchner et al. 2007), although alternative explanations related to poor Theory of Mind and poor executive functions are also possible. In the case of autistic patients, the problem is likely to be linked to the lack of Theory of Mind (Happé 1993). Noteworthy, Theory of Mind is a necessary but not sufficient prerequisite for metaphor interpretation, as difficulty experienced by autistic patients may be as well motivated by a poor semantic-conceptual system (Norbury 2005).

Brain mapping findings are providing deeper insights into the delicate neural circuitry supporting the comprehension of nonliteral meaning (Eviatar & Just 2006; Giora 2007). Comparative studies conducted on the results of a large number of studies on figurative language highlight a bilateral network in which frontal and temporal areas stand out in particular (Bohrn et al. 2012). Keeping the focus on metaphor, it is possible to decompose the functional network of brain regions in several components: it is likely that frontal areas participate in conceptual activity (along with the angular gyrus), by integrating linguistic material and world knowledge in order to fine-tune contextually appropriate meaning, while prefrontal regions and the cingulate cortex are responsible for the attentional mechanisms filtering the relevant aspects of context, and the superior temporal sulcus supports the mindreading mechanisms in deriving the speaker's meaning (Bambini et al. 2011; Figure 2).

One important aspect emerging from the literature is that the brain network underlying metaphor processing is dynamically activated depending on the linguistic and contextual properties of the materials: one parameter capable of sensibly influencing brain activity is the conventionality vs. novelty of the metaphorical expressions, which seems to modulate brain activity especially at the level of the right hemisphere (Schmidt et al. 2010). Also, subject-related factors, such as age, can modulate the extension of the network of brain areas recruited for metaphor comprehension, which seems to be wider in older than in younger individuals (Mejía-Constaín et al. 2010).

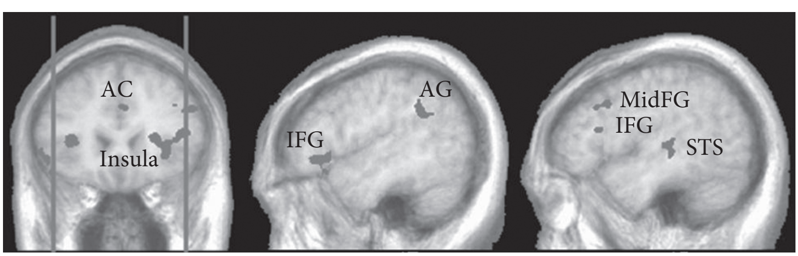

Figure 2. *Brain areas activated for metaphor comprehension as compared to literal sentences. Coronal (on the left) and sagittal view of the left hemisphere (center) and of the right hemisphere (right); the lines in the coronal image correspond to the location of the sagittal slices. AC: anterior cingulate; IFG: inferior frontal gyrus; MidFG: middle frontal gyrus; STS: superior temporal sulcus; AG: angular gyrus. Adapted from Bambini et al. (2011)*

Similar neurofunctional architectures are reported for other types of non-literal meaning, namely idiomatic expressions. Results suggest that there is not a right hemisphere prevalence, but rather a bilateral (especially left) prefrontal and temporal involvement. Frontal regions are responsible for retrieving and maintaining competing meanings from semantic memory (in temporal areas) while the selection of the appropriate interpretation is supported by prefrontal areas (Papagno & Romero Lauro 2010).

3.3 Discourse phenomena

Communication runs in units larger than isolated sentences, unfolding in stories, dialogues, texts, where part of the intended meaning emerges from both local and global properties of the text (Kintsch & Van Dijk 1978; Brown & Yule 1983). The construction and maintenance of discourse require not only the ability of mastering the appropriate meaning of each word and sentence at the microstructural level, but also the ability of organizing sentences at the macrostructural level, by establishing cohesive links and by using thematic and topical knowledge to understand the gist of the story being told or the general content of a discourse.

A wide variety of clinical populations exhibits poor control over discourse, delivering verbose, non-informative, unconnected, tangential, repetitive speech. Right hemisphere brain damaged patients have been extensively studied (Johns et al. 2008), as well as aphasics (Marini et al. 2011) and schizophrenic patients (Ditman & Kuperberg 2010). Tests are often based on the elicitation of descriptions of standardized pictures, where both local and global features of the discourse are evaluated (production of ambiguous referents, topic switching, etc.).

These abilities have also been the issue of a number of neuroimaging studies since the early 2000s, targeting for instance the brain response to manipulation of cohesive devices (e.g. by varying the degree of textual and logical properties between passages) or the neural activations elicited when deriving the general content of a text or the moral of a story (i.e. by comparing text with and without title) (Bookheimer 2002; Gernsbacher & Kaschak 2003). Overall, results show that making sense of discourse – just as is the case for the extraction of intended meaning from figurative expressions – relies upon a set of high-order abilities, mainly implemented in inferior frontal and temporal cortex bilaterally (Mason & Just 2006; Schmalhofer & Perfetti 2007; Perfetti & Frishkoff 2008). Recent comparative analyses have produced systematic proposals on how brain activation might be organized in specific components. The Extended Language

Network proposed by Ferst put special emphasis on the dorso-medial prefrontal cortex for what concerns inference and coherence building, on the parieto-medial cortex for the updating of situational and discourse representation, and on the anterior temporal lobes for integrating clausal information (Ferstl et al. 2008; Ferstl 2010).

3.4 Temporal issues

Pragmatic facts possess not only spatial boundaries in the brain, but also temporal ones. A very promising research line addresses the temporal signature of pragmatic processing: traditional behavioral measures are now supported by neurophysiological techniques such as the use of electroencephalogram (EEG) and event-related brain potentials (ERPs), which can measure the postsynaptic electrical activity of large neural populations with a millisecond accuracy (Coulson 2004). The importance of this research line lies in revealing whether there are specific processing phases for pragmatic elaboration, whether pragmatics elicits effects different from those reported for syntax and semantics. Besides, neurophysiological techniques are of major importance in solving the long-standing debate over the priority of literal meaning, i.e. whether there is an initial literal elaboration preceding the pragmatic one, as the Gricean model would predict when translated in processing terms. The topic has quite a long history in the psycholinguistic tradition, where a large quantity of behavioural data on figurative meaning and scalar implicature has been produced. We have learned that, given an equal amount of context, pragmatic meanings take more time and more effort than encoded meanings (McElree & Nordlie 1999; Bott & Noveck 2004), but we have also learned that supportive context can drastically reduce the difference between literal and non-literal interpretation (Gibbs 1994; Breheny et al. 2006), as do several other lexico-semantic variables (Giora 2003).

A quite robust result in ERP studies on the resolution of figurative expressions is the amplitude modulation of the component known as N400, i.e., a negativity peaking around 400 ms after the stimulus onset. For instance, Coulson and Van Petten (2002) compared sentences such as (a) *He knows that whiskey is a strong intoxicant* vs. (b) *He knows that power is a strong intoxicant*. A more negative N400 effect occurred in (b) than in (a), similar in amplitude and scalp distribution to the classic N400 wave registered for semantic anomalies in sentence context.

Similar effects have been registered for other cases of deviation from literal meanings, e.g. jokes (Coulson & Kutas 2001). These results suggest that the brain does not proceed by first computing meaning in a context-free way and then incorporating contextual information, as a Gricean-inspired model would predict, but rather non-literal meanings are detected as quickly as semantic anomalies.

The N400 component has been described as sensitive also to discourse context manipulations: when considering words that are appropriate in the local sentence context but vary in how they fit the wider discourse, such as *By five in the morning, Jane's brother had already showered and had even gotten dressed. Jane told her brother that he was exceptionally* (a) *quick* vs. (b) *slow*, higher N400 amplitude is registered for discourse-incongruous words with respect to congruous words, e.g. in the case in (b) (Van Berkum et al. 1999). Again, these findings suggest that every incoming word is immediately related to the wider linguistic context, either sentential or discursive.

In addition to N400 modulation, much interest has been directed in recent years to assessing the involvement of a late positive component (LPC or P600) in pragmatic processes. Originally reported for syntactic reanalysis, P600 effects have been observed in a number of context-dependent phenomena, such as metaphor (De Grauwe et al. 2010) metonymies (Schumacher 2011), irony (Regel et al. 2011), including discourse-related phenomena such as information structure (Schumacher 2012). To account for the different processes underlying N400 and P600, it has been proposed that contextual effects are indexed by the N400, while content enrichment and updating based on pragmatic considerations such as speaker's meaning and cooperation principles is reflected in the P600 (Schumacher 2012).

In general, ERP evidence supports the idea of the brain as a highly context-sensitive machine, designed to integrate context, structure and meaning in an incremental fashion (Coulson 2004; Van Berkum 2010). It seems likely that pragmatic operations unfold in different stages, adapting to the contextual and communicative environment (Kutas 2006).

4. Final remarks

From the succinct survey above, the domain of neuropragmatics emerges as extremely vast, which seems to reflect the variety of topics in pragmatics itself

(Verschueren 2009): the areas of investigation range from the neural correlates of irony comprehension to the resolution of anaphora in discourse, and many features of the communicative interactions remain unexplored. The discussion of what specific aspects of pragmatic theory are relevant for the brain is still open (Bertuccelli Papi 2010), as is also the question on how "neuro" we are really going, i.e. how much our models capture brain processes (Van Berkum 2010). Yet the focus of neuropragmatics is quite clear-cut: the neural machinery behind the construction of contextually appropriate meanings for the purpose of communication. Research shows that pragmatic processes are not haphazard: there are regularities in the way of integrating structures (linguistic and extra-linguistic) and context, and regularities in interfacing different cognitive systems for communicative purposes under given environmental constraints. These regularities are probably stored in specific knowledge formats and are likely to form what has been called "pragmatic/communicative competence" (Bara 2011). It is of some importance to briefly comment upon the notion of "pragmatic competence".

Since the advent of formal syntax, a strong distinction was made between "competence" and "performance", where the former refers to the knowledge of our language grammar (mainly syntactic rules) as it is represented in our minds, while the latter refers to the way we access these linguistic representations in our use of language. Most research placed pragmatics in the domain of performance, probably because of its strict correlation with the context of use, thus ruling out the possibility of scientific investigations of pragmatic knowledge. The achievements obtained in neuropragmatics go in the opposite direction, by showing the neurobiological underpinnings of pragmatic processing, i.e. systematic patterns of brain activity in dealing with pragmatic aspects, and also specific developmental trajectories and possibly paths of decay and disruption. In this light, the notion of pragmatic competence gains further consistence, along with the possibility of a theory of communication (Nerlich & Clark 2002; Airenti 2010).

We can expect that major future contributions in neuropragmatics will come from the combination of theoretical refinements and sound experimental designs, in order to achieve a better characterisation of crucial notions such as sharedness, intentionality and, above all, context. Researchers are pioneering these issues in at least two ways. On the one hand, interesting paradigms are being devised which disentangle context in its sub-components (spatio-temporal coordinates, previous discourse, etcetera, up to speaker's identity and personal values) in order to single out specific cognitive imports and neural patterns (Bosco et al. 2004). For instance, Van Berkum and colleagues showed that there is a specific spatio-temporal signature for the integration of the speaker's identity into the ongoing message (Van Berkum et al. 2008), while other paradigms are focusing on world knowledge, how information is checked against a world knowledge background (Menenti et al. 2009). On the other hand, researchers are shaping protocols that tend to preserve the richness of context, in order to describe the dynamical recruitment of brain networks in communication. Along these lines, it is becoming possible to simulate naturalistic situations such as continuous audiovisual stimulation (Hasson et al. 2008; Wilson et al. 2008), co-speech gestures (Dick et al. 2009), the coupling of speaker's and hearer's perspective in dialogue (Noordzij et al. 2010), and possibly to address the emotional and aesthetic effects of language.

When we turn our attention from language to language use, and from structure to communicative intentions, another important domain that deserves to be explored is bodily experience. Despite its not being traditionally included in the repertoire of pragmatic topics, embodiment is rapidly emerging as an important mechanisms underlying the way we construct and represent meanings in communication (Barsalou 2008). Up to now, the embodiment hypothesis has found empirical support especially at the level of the vehicle, i.e. in terms of phonological processing, and at the content level, especially for what concern action semantics (Gallese 2007; Pulvermüller 2012). Promising research lines are exploring whether the sensory-motor system is involved in processing abstract and metaphorical meanings (Cacciari et al. 2011; Desai et al. 2011), in comprehending the narrative scenario (Taylor & Zwaan 2008) and ultimately in understanding communicative intentions (Manera et al. 2011).

Putting together all these mosaic tesserae should lead to a better understanding of how minds brains and bodies interact and communicate, pursuing the Gricean intuition that communication is a complex form of rational behaviour at the interface of language, cognition and social interaction.

Notes

* This entry is the joint work of both authors. V.B. is mainly responsible for Sections 2, 3.2 and 3.3, B.E.B. for Section 3.1.

1. This strategy resembles the violation/anomaly paradigm frequently applied in neuroimaging experiments. This paradigm assesses the effects elicited by semantic and/or syntactic violations, employing words/phrases that fail to meet the semantic expectations and/or the grammatical rules, and comparing them to correct sentences. The underlying assumption is that the violation is taken to produce extra processing specifically disrupted at the linguistic component, and a differential response to two kinds of violation is taken to reflect a distinction between two kinds of processes. Non-literal and discourse-based meanings are assumed to produce a supplementary processing effort in the pragmatic component with respect to literal/sentence based phenomena, and offer an opportunity to observe pragmatically induced modification in the brain activity.
2. Note that in clinical settings speech acts and non literal meanings have been tested mainly with respect to the comprehension modality, while discourse is traditionally evaluated in production; by contrast, most neuroimaging studies address comprehension, including discourse comprehension.
3. Another domain often connected to neuropragmatics is prosody, for its role in the recognition of speech act force. As for other domains of pragmatics, the hypothesis of a right hemisphere prevalence, dominant in the old neuropsychological view, is now being revised on the basis of neuroimaging data (Ross & Mesulam 1979; Kotz et al. 2006), which take into account also wider considerations related to speech perception and the auditory system, as well as emotional processing.

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