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Supplemento n. 6 a «Illuminazioni» n. 18 (ottobre-dicembre 2011)

Alessandra Anastasi

THE SINGING OF PRIMATES

The study of the melodic expressions of other animals arises questions and as many lines of research that help us to understand better, through different (but not necessarily complementary) perspectives of investigation, the origins of the musical ability of our kind. To avoid confusions it is necessary to distinguish the matters inherent in the basic mechanisms involved in the musical ability (evolutionary change, neurophysiological substratum), from those of evolutionary function (adaptive significance) and history (phylogenesis). One of the matters on which the research efforts are assembled is to understand if birds, whales, gibbons and human beings uses same neural network and comparable neurochemical balance when they sing, and in particular if this ability may influence their reproductive performances (fitness) and therefore the propagation of the genes in the generations to follow. Probably, the understanding and the resolution of these issues could lead to a better overall view for the evaluation of the characteristics of the evolutionary history of music systems (Hauser 2001).

A first step in this direction that could provide interesting insights regarding the evolution of music, may be the examination of the vocal repertoire of non-human primates in order to measure both the referential and affective components of the emitted signal. Since the end of 1970, studies in monkeys have revealed the existence

of conceptual tools producing the idea of the presence, in those animals, of a system of referential communication (Premack 1986). In 1980 he made a crucial experiment (Seyfarth et alii 1980) that brought to reconsider the idea that animal vocalizations reflect changes in emotional state, and emotional reasons. The meaning emerging from a study conducted by Struhsaker (1967) is that the vervet monkey (*Cercopithecus aethiops*) produces three different types of alarm in response to three types of predators: the big cats (leopards), raptors (martial eagle) and snakes (pythons, mambas). Exactly the close association between the type of call and the response that follows, suggests that such signals may function as a label for each different type of predation: the animal will climb the highest branches of trees at the presence of leopards or hide under a bush or branches if it is warned of the presence of an eagle, or more if the signal indicates, instead, the proximity of a snake's the response will be to stand bipedally and scan the ground nearby.

Each of the answers is of course the result of the presence of an acoustic division that allows different sounds for each type of predator behavior and then generates a result, the run or the patrol, a general alarm, in fact, would be a failure because it would require the detection of the real nature of the hazard resulting then in a vulnerability (Hauser 2001). Based on these results, Cheney and Seyfarth (1990) gave a more sophisticated function and meaning to the monkey vocalizations. It is clear that some of these are functionally referential vocalizations (Marler, Evans, Hauser 1992), that are salient within the environment, similar kinds of references were also

tested in other species (ring-tailed lemur, macaque rhesus macaque toque), and in the domestic chicken (Zuberbühler et alii 1997). What emerged from these studies is that signals are often associated with food. According to a recent hypothesis supported by Ouattara, Lemasson and Zuberbühler (2009), the signals delivered by a monkey to indicate specific external events show their ability to change sound during the production of the call that is functionally equivalent to the suffixation in human language. This hypothesis is supported by the theory that human language has evolved on a biological substrate that has deep roots in the phylogenetic lineage of primates (Hauser, Chomsky, Fitch 2002). Certainly, fundamental for this thesis has been the study on Campbell's vervet (small arboreal monkey of West Africa) that made possible the identification of form of "words" in the sounds of alarm calls. The three words uttered were: BOOM! To tell the group about the falling branches or the moving into a new corner of the forest; HOK! To indicate the presence of prey eagles; KRAK! To warn of the presence of a leopard. the extraordinary ability of vervets to create different expressions from the three major, by adding a suffix, which resembles the construction of the adverb in our language (which is obtained by adding "mind" at the end of the adjective) is surprising. The suffix in question is "oo", with this trick the monkeys have created several variations: for example, "hok-oo" has the meaning of "Attention! There is something in the trees". Furthermore, the vervets are able to develop even a "sentence" with 25 vocalizations that, combined in

different ways from time to time, provide information on the nature of the risk (Ouattara et alii 2009).

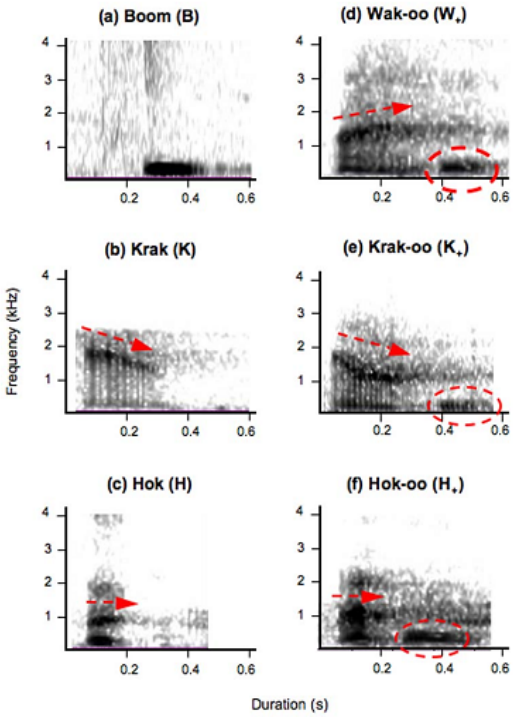

Figure 1: Spectrographic illustrations of the different loud call types produced by Campbell's vervets in different contexts. From Ouattara et alii (2009).

For almost sixty years, research has been conducted on a population of monkeys that live in the *rhesus island* of Cayo Santiago (Puerto Rico). What impressed the researchers was that, when rhesus find food, they give one or more distinct vocal signals: warble, grunts, harmonic vocals. Even if they were fed daily with forage products available in nature such as leaves, fruits, insects, grass, however, they raised the calls. The research carried out in recent years have focused on some interesting questions:

- How does motivational state affect the production of food-associated calls?
- Does each call type refer to something like the kind of food or its relative quality?
- When rhesus monkeys hear the calls, how do they classify them?

Based on a large sample of adult males and females, we examined the change in the production of the recall as a function of food consumption and time available depending on the level of hungry, the food was placed in the dispenser in the morning and then again in the noon the next day was added from 4.00 PM to 8.00 PM. From this evidence it was assumed that they were more hungry in the early morning and late afternoon were full. You can see that the males produced less food-calls than females and that, as in most mammals, males left the group to reach their sexual maturity while females remained in herds. In addition to differences of a sexual nature, it was discovered that the rate of production of food-calls would rise before the peak of food consumption and then fall rapidly after food consumption, suggesting that the percentage of appeals is correlated positively with the level of hunger. To further investigate the relationship between the level of hunger and vocal production, it has also been considered the relationship between the frequency of call signs and the time of an individual to reach the food placed in the dispenser, while the food was placed in the dispenser, one or more groups would sit next to the fence waiting to eat.

From the graphic below we can see the relationship between speed (call / min) of Food-Calls of rhesus monkeys and the latency time (in minutes) to get the dispenser of food (Scherer and Kappas 1988).

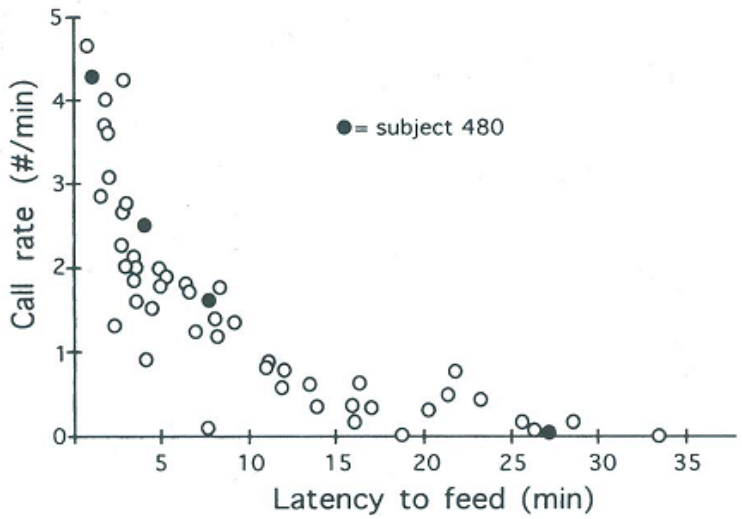

Figure 2: The relationship between rate (number of calls/minute) of food – associated calls and latency (minutes) to arrive and feed at the chow dispensers. From Scherer and Kappas (1988).

To contribute to eventual comparisons with new studies the changes in the acoustic structure of rhesus monkeys during recall at the time of the meal have also been examined, as we see from the chart below there are two common situations reported. Early in the morning the monkey starts moving toward the distributor of food when the staff arrives the monkeys begin to coo (COO) waiting for the food, but everything is done with minimal vocal effort, it is relatively low and its frequency is flat. When food is placed in the machine a morphological change happens and individuals put more effort into the call. Examining spectrographic analysis this changement in the

production seems to cause greater vocal turbulence at the top of the chart, you can analyze the sound made while waiting in front of the machine who is, in fact, without any alteration harmonic.

The second sound of the harmonic structure shows instead a break for a short period of time, while the final part of the harmonic structure is almost completely stopped. These changes are perceptible by the ear. In the second part of the graph we have the representation of a male adult who sees a coconut from a distance and then get closer to it. The first three calls made before and during the sighting of the coconut can be classified as a sort of grunt, but in the phase in which the male grabbed and ate the coconut he produced two harmonics sounds. In contrast with the first box so here we see a change in call type voice generated by the capacity of the structure to implement the changes. The hypothesis at this point would be that the rhesus monkeys implement changes in emotional state when approaching the food, which can lead to more important morphological changes as the switching from one type of calls to another. This would be corroborated by observations of free individuals in nature that showed systematic differences in different contexts producing different types of calls, especially trills and chirps were produced by some individuals when food as rare as a coconut was found. These forms of grunts were sometimes accompanied by other types of calls that were primarily generated as a response to the search of less refined food. The morphological and spectral

characteristics of the types of calls refer then to the found of a rare food by an individual or the type of the food (Hauser 2001).

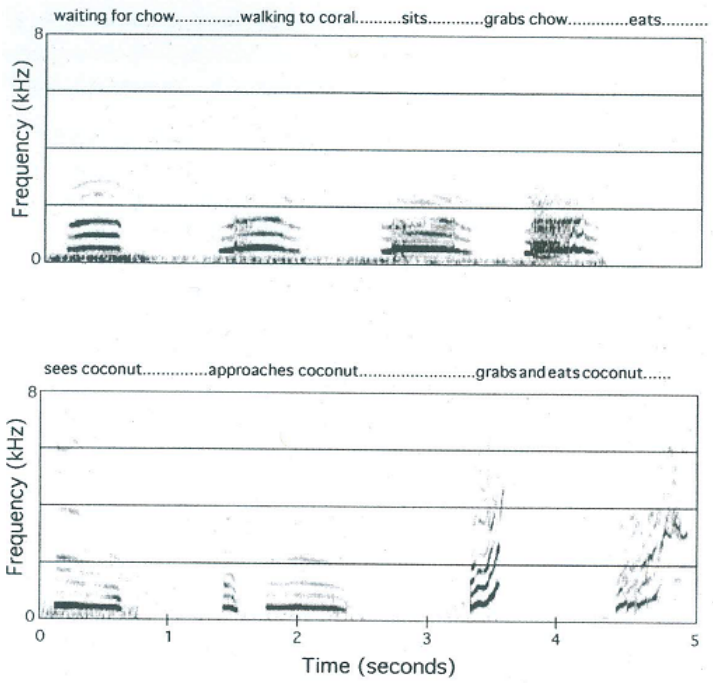

Figure 3: The upper panel shows changes in acoustic morphology of the rhesus coo vocalization as a function of proximity to chow. From Hauser (2001)

Given the understanding of the contexts and functions associated with food recalls, an experiment was set up to determine how these recalls can be classified. A technique employed in the understanding of the developmental processes underlying the development of vocal prelinguistic infants has been borrowed for this purpose, that is a process of habituation and discrimination used to determine if the acoustic morphology was the driving factor in the classification of the calls of rhesus monkeys for his food. This procedure was performed on field upon a group of vervets

monkeys (Cheney and Seyfarth 1990), the experiment focused on three types of calls: warble, harmonic sound, grunt. These sounds are acoustically different but the warble and harmonic sounds are produced in the same context and therefore may have a different meaning from the grunt, although a change in perceived noise level has been observed, the same is not necessarily accompanied by a semantic change. Tested Individuals participated in a session Within-Referent (used to warble and sound harmonic) and Between-Referent (used to warble and grunt and vice versa), the caller's identity was kept constantly hidden during the session. Several specimens with various types of call were used until the tested individual was unable to look in the direction from which the sounds were coming, once used to this environmental context a signal of a specimen with a different type of call has been reproduced. If the individual showed some interest the test session was considered over, if any answer was given instead, the session was repeated but with a new type of call, the second condition could occur either because the animal grouped stimuli in one category by its perception, or because he was accustomed to all the sounds coming from that area. The session Within - Referent individuals showed a greater response in the case of harmonic sounds among trills made them heard, all the participants failed the test in two consecutive trials as evidence in the trial were not able to respond suggesting that trills and harmonic sounds were grouped in one category, even if they were acoustically different (Figure 4). Coherent responses have been obtained whithin a session of Between – Referent even if the answer has been subordinated by the

presence of pre-stimulus during the habituation phase, especially when the subjects were accustomed to the grunts they showed a significant response to trills and harmonic sound. When they were accustomed to warble their responses to the growl were instead low.

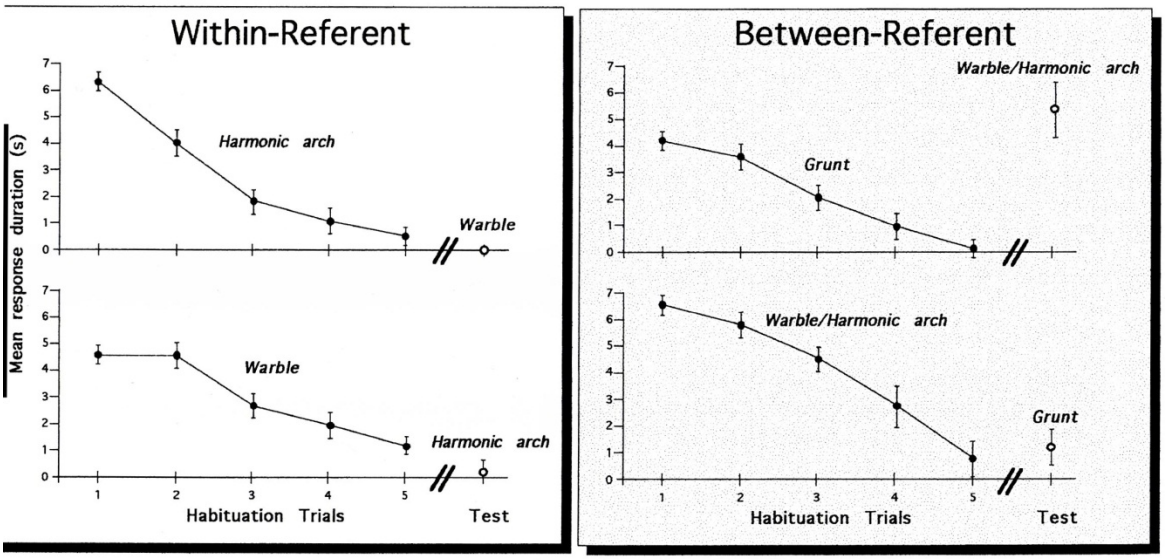

Figure 4: Results from Within- and Between-Referent sessions. From Hauser (2001)

What remains then to understand is why three different sounds are used to refer to the food. data suggest that in some animals the morphology of the acoustic repertoire consists of several components that question the status of calls and other emotional components that relate to objects and events in the external environment. The most radical idea about this matter is if the animal vocalizations can't approach the referential power of our words, both in objective terms than instates of mind, it may nevertheless be sufficiently advanced to justify the classification as a precursor. Before to deal with these issues it would be appropriate to strengthen our understanding of other animals, because if it is believed that the vocalizations of

primates represent a form of proto-language, then this implies a more precise conceptualization of the morphogenetic instruments of human primates as well as the type of selection pressures that occurred during the evolutionary history of humans and nonhuman primates.

An interesting example of vocalization (and maybe the most complete) is produced by gibbons, whose main specialization are, in fact, the vocalizations emitted especially in the morning, gibbons produce long and high sound that differs by species and environment it has a duration ranging from 10 to 30 minutes, although there was a continuous sound emitted by a male Hylobates lasting 86 minutes. The songs are preferably articulated early in the morning while there are others produced in specific times of day, these are stereotyped and species - specific. The species can be identified through their songs and their vocal characterizations used to establish systematic relations among Hylobatids and reconstruct their phylogeny. Another, further specialization is the accuracy of all the singing duet with the exception of gibbons Hylobatids Kloss and Hylobatids Moloch. The duets are sang by a couple of mates, they usually combine their music with a certain rigidity in order to arrive at clear voice interaction to produce a good duet. The males of many species of gibbons produce one ore different types of phrases that often become progressively more complex (by the number of notes, number of distinct types of notes, modulation frequency), as a song procedees. During the execution of the song the contribution of the male sex in the exhibition shows a form of gradual development that goes from

the expression of simple phrases to most complex ones; the contribution of females is given with a strong call of stereotyped type and shows a form of locomotion to the apex of the call. In many species instead, the male contributes with a "tail" in order to follow the call of the female and can also participate in his show (Geissman 1993).

For more or less regular intervals, we can have specific phrases usually produced by female exemplary that may affect the degree of relationship, in many species the call of relational degree consists in a particular series of rhythms made of from long notes with an increment of duration in peak frequency. Males usually stop when vocalization began a recall of kinship and reproduce a sound response (tail) to the relational degree call, before starting to sing their "common phrase". In addition, one or both partners may exhibit movements as violently shaking the branches of trees, the call of kinship by the female and the subsequent tail of the male will be repeated many times during a single short-singing. This is obviously a simplified description of the duet of the gibbon, but we must also consider the fact that the species of gibbons also produce other singing sequences, the females of many species in fact help with sentences as the duet of the call of kinship is considered stereotyped. In Siamangs (Hylobatids syndactylus) and Hoolock (hoolock Hylobatids), interactions whithin duets are much more complex and even the recall of sequences in the degree of relationship and the corresponding tail, includes several phrases and vocal interactions between males and females. At present time, the duet of siamangs is

probably the most complex musical singing made by a terrestrial vertebrate further the human (Hauser 2001).

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Valentina Cardella

DELUSIONS AND HALLUCINATIONS: THE ROLE OF METACOGNITION

1. Introduction

As delusions and hallucinations express the detachment from reality characteristic of major mental disorders, they are the core features of psychosis. Since Kraepelin's works (1904) those symptoms was used to identify one of the most severe mental illness': schizophrenia. When entering the schizophrenic *Lebensform*, delusions and hallucinations assume peculiar traits: the former specifing in bizarre themes , the latter becoming *voices* which inhabit and violate the individual intimacy. In this paper, I'll try to show that the best way to investigate these symptoms is to highlight their shared mechanisms, focussing on metacognitive factors which form and maintain them. When examining these factors, the believes seem to be weaken in both cases, even if considering auditory hallucinations as pathologies of belief could seem counterintuitive. Voices don't seem to belong to the area of believes but to that of perception. Nontheless, analizing the most recent literature on auditory hallucinations, one can notice that a growing space is given to top down processes (believes and expectations on own cognitive processes that would concur to feed and maintain the symptoms), rather than to bottom up processes (brain damages or neurological deficits that would cause psychotic symptoms, e.g. anomalous perceptual experiences).

2. Delusions

Delusion, according to the APA definition, is a false belief that is firmly sustained despite what almost everyone else believes and despite what constitutes incontrovertible and obvious proof or evidence to the contrary (APA 1994). Depending on the topic, delusions can be bizarre or non-bizarre: the first ones, characteristic of schizophrenia, are completely implausible, while the second ones have a possible content. For example, one of the most common delusions, that of persecution, is a non-bizarre one, since refers (even if in a peculiar way) to experiences that everyone can live in his life (feeling victimized by someone, persecuted by enemies or institutions and so on). On the contrary, delusion of control, whose content is the belief that our own actions are controlled by external forces, is a bizarre delusion; he who holds this delusion thinks to be a sort of puppet manipulated by someone else ("it isn't me that acts this way, but someone else that moves my body"). Even more unusual to people that don't have to do with schizophrenia are the delusions of thought withdrawal, broadcasting or insertion. A schizophrenic patient can believe the others think his own thoughts, or insert their thoughts in his mind, and he can describe his thoughts being broadcast to others or withdrawn by others. Kurt Schneider (1959) considered the delusions of thought withdrawal, insertion and broadcasting as the most important diagnostic indicators of schizophrenia, and for that reason he included them, together with hearing voices, in the first rank

symptoms. In other words, if a patient tells the psychiatrist that he sometimes hears voices or feels as though his thoughts are not his own, he is very likely a schizophrenic.

According to Maher (1992, 1999) delusions are rational responses to abnormal experiences. It means that there's nothing wrong on delusion itself, since it is nothing but an attempt to rationalize what the patient perceives as unusual. Therefore, the core factor of the genesis of delusions would be *bottom up*, since it consists for Maher in a neuropsychological deficit which in turn would cause an abnormal experience.

So, what are these abnormal experiences? Stone e Young (1997) focus on monothematic delusions, which are circumscribed to one topic, because, from a theoretical point of view, it would be easier to find the abnormality that leads to their genesis, abnormality that would be much harder to recognize in polythematic and florid delusions; the authors argue that monothematic delusions are based on atypical perceptual experiences occasioned by a wide set of neuropsychological anomalies.

One of the first delusions which has been analyzed that way is the Capgras syndrome, also known as the illusion of doubles, since he who suffers this delusion believe that a person or people close to him (the partner in most cases) have been replaced with duplicates. According to Maher (1999), this delusion is due to a deficit in the ability of recognize faces; more precisely, faces are recognized, but there is an impairment of the automatic emotional arousal response which is usually associated

with them. Therefore, patients recognize faces, but they don't feel the matching emotional responses, the feeling of familiarity, and so they face two opposite pieces of information: one saying for example "It is your wife", and the other, the emotional one, saying the opposite. The delusion makes the rationalization arise: "It seems my wife, but she's not"; for that reason Maher claims that the delusion would be nothing but the attempt to make sense of a peculiar experience. The same would go for the other kinds of delusion, also for the schizophrenic ones, like the delusion of control described above, whose deficit would consist in the alteration of the internal monitoring of actions, that would lead to perceive the actions as controlled by other agents.

According to Stone and Young, one can identify such neuropsychological anomalies in any other forms of monothematic delusion, and so the core factor for the genesis of delusion would be just some kind of anomalous perceptive experience. And Maher goes beyond claiming that the anomalous experience is the *only* factor causing the delusion, delusion which, apart from that, isn't different from normal believes:

> Delusional beliefs, like normal beliefs, arise from an attempt to explain experience. The processes by which deluded persons reason from experience to belief are not significantly different from the processes by which non-deluded persons do. (Maher 1999, pp. 550-1).

This theory has been yet criticized on numerous fronts. First of all, no one has proved the existence of the deficits the authors talk about, and this clearly invalidates their view, because they seem to postulate *ad hoc* impairments which fit each kind of delusion. Moreover, one can notice that while some of these delusions (like the Capgras syndrome) are due to brain damages, and a neuropsychological anomaly is therefore supposable, for other kinds of delusion a similar origin must be ruled out, since for example a brain damage hasn't been proved yet in schizophrenia, and according to many authors every attempt to find this kind of damage in this mental disorder is bound to fail. Secondly, according to other authors the anomalous experiences would neither be necessary to form a delusion; Bell and coll. (2008) used an experiment to test the anomalous perceptual experiences in a control group, a group of subjects with delusions and a group of subjects with both delusions and hallucinations, and results showed that delusional patients didn't exhibit a significantly different level of anomalous experiences, compared with controls.

Other authors showed that the anomalous perceptual experiences, far from being necessary, would neither be sufficient to create a delusion. Davies and coll. (2001) proved that, in some cases, there are people who feel anomalous experiences without having a delusion. For example, patients with frontal lobes' damages fail to discriminate familiar faces, but they don't develop the Capgras syndrome, moreover, patients suffering from depersonalization disorder lack the sense of agency for their own actions, but they claim to feel *as if* someone is controlling their actions, and they

don't develop a delusion of control. For that reason, many researchers began to search for a second factor, which is not of the *bottom up* kind, but it refers to peculiar cognitive styles. These cognitive factors, rather than supposed (and never proved correct) anomalous experiences would form and maintain delusional believes.

And at this point, we have to face several hypotheses.

3. Metacognition and delusions

Garety and al., for example, started with a number of studies on deficits in probabilistic reasoning which are supposed to characterize people who suffer from persecutory delusion (Garety *et al.* 1991; Warman *et al.* 2007; Freeman 2008). More precisely, these subjects seem to be ready to believe something without having sufficient evidence, they show in other words a tendency to jump to conclusions. The *jumping to conclusions* bias would explain why paranoids usually jump from the experience (anomalous or not) to the delusional belief.

In line with these studies, many authors aim to explain persecutory delusions through referring to the "attributional styles" of subjects; paranoids seem to have, besides the jumping to conclusions bias, a further tendency to blame the others when things go wrong, and to take too much credit for success (Bentall 1994). Nonetheless, these hypotheses seem to be really controversial. If paranoids have actually the tendency to jump to conclusions, why, in front of opposite evidences, they don't jump immediately to the opposite belief? Moreover, following studies (Sharp *et al.*

1997, McKay *et al.* 2005) showed no association between persecutory delusions and the tendency to externalize the blame, and the same goes for the tendency, in paranoids, to take the credit for positive events. Finally, one can hardly apply this theory to the delusions of non-paranoids, like, for example, to the bizarre delusions of schizophrenics.

Actually, researchers must solve the mistery of the incorrigibility of delusion, rather than its first appearance; how can we explain, from a cognitive point of view, the fact that, once born, the delusional idea is so strongly mantained? Many authors refer to a generic deficit in the believes revision's mechanism (Bell et al. 2006b; Stone e Young 1997, Davies e Coltheart 2000, Davies *et al.* 2001), which has not been identified yet.

It is probably more useful to refer to metacognitive factors, in other words, to top down factors, which could have a feedback effect on psychotic symptoms. For example, Bentall (1990) and Morrison (2001) stressed how believes and expectations about the self and the external world can produce bias, that is systematic preferences guiding ambiguous experiences'interpretation (Stirling *et al.* 2007). More precisely, the role of some kind of metacognitions (thoughts about one's own cognitive processes) in the formation and the maintenance of neurotic and psychotic symptoms has been highlighted; the vulnerability towards mental disorder is due, according to these authors, to different mechanisms, e.g. heightened self-focused attention, threat monitoring, ruminative processing, activation of both dysfunctional beliefs and

strategies that fail to modify maladaptive self-knowledge (Wells and Matthews 1994; Morrison e Wells 2003). Such a cognitive system makes the jump from experience to belief to delusion much easier: for example, if someone having believes like "I can trust no one, let alone the institutions", receives a visit by an inspector checking the licence fee AE's payment, for his meta cognitive bias he can focus on this event, make it particularly meaningful and salient, attach it with negative emotions and come to believe that the visit of the inspector is the proof of a governative conspiration against him (Morrison 2001). Depending on the events the different subjects live, these jumps from experiences to beliefs to delusions can be extremely varied, as described here:

> Examples […] would include an individual interpreting intrusive thoughts as evidence of alien thought insertion; interpreting intrusive impulses as evidence of alien control over one's body; […]interpreting the mention of one's first name on television as evidence that everyone is talking about you or that the media are communicating directly with you. (Morrison 2001, p. 260)

Theories like this, which stresses the role of metacognitive factors, seem to be more "parsimonious" than those previously mentioned, since they don't need to postulate *ad hoc* mechanisms, like the *jumping to conclusions* or anomalies of the attributional style.

Once the delusional belief is born, it is firmly held through the same mechanisms: selective attention makes stimulus more salient than they actually are, and these

stimulus, expecially when referring to the delusional theme, cause an arousal which feed it, and lessen the accessibility of possible counterexamples. In other words, once the delusion is generated, it maintains itself because an emotive hyper activation towards topics related to the delusion, which are actually neutral, encourages to the activation of heuristics, i.e. reasoning strategies which speed up the process of finding a solution, and that are intuitive, guided by habit, but not really accurate (Speechley, Ngan 2008).

In the last decades the idea that psychotic symptoms, however serious, place themselves on a *continuum*, is beginning to spread over; in this perspective, the boundary between sanity and madness doesn't lie in one jump, but in a series of small and continuous transitions. This *continuum* seems to apply to delusions (Verdoux, van Os 2002; Freeman 2010), insight (Shad 2006), hallucinations (Johns 2005), paranoia (Ellett *et al.* 2003, Freeman *et al*. 2005), and, as we'll see hereinafter, voices (Johns *et al.* 2002; Beck, Rector 2003). With regard to delusion, hypothesis like those described above are consistent with the *continuum* perspective, since the difference between delusional and normal beliefs doesn't rely on anomalous perceptual experiences, that would occur in one case and would not in the other, but rather on metacognitive factors that, taken individually, are not at all mysterious, but that, when combined together and fed on certain kinds of beliefs, lead to the development of a delusional system.

4. The auditory hallucinations

Just as the delusion takes typical topics and structure in schizophrenia, in the same way the hallucinations are distributed in a peculiar way inside the schizophrenic spectrum. Schneider (1959), which assigned auditory hallucinations a very important role in schizophrenia, identified three kinds of hallucinations as absolutely distinguishing: hearing comments about one's own behavior, hearing voices speaking of oneself in the third person, and hearing voices speaking one's thoughts (the so-called thought echo, that has a high diagnostic value for schizophrenia). In other words, voices, in all their forms, seem to rule the schizophrenic world.

The voices can be very different. They can be remarks, criticisms, orders, ruminations, worries, questions, they can be continuous one day, and disappear the next, they can be barely audible or at full volume. The voice can belong to a stranger, or to relatives, persecutors, lovers, gods, angels, devils, machines, radio, TV. At first sight, auditory hallucinations, just like delusions, or even more, seem to be something equivalent to mental disorder. To speak in a brutal way, if someone hears voices, it is *obvious* that he's mad. Nevertheless, some elements seem to suggest that this phenomenon is not limited to madness, but that in this case, just like the delusion's one, it is more proper to talk of a *continuum*. For example, there are people that hear voices without being psychotic (Beck, Rector 2003), like widows, which, in a survey of Rees, show an unusually high incidence of either visual or auditory hallucinations of the dead spouse, especially in the period immediately subsequent the loss (Rees,

1971). These voices don't seem to be qualitatively different from the psychotic ones. In line with this *continuum* hypothesis, voices, and hallucinations in general, appear more easily when subjects, both normal and psychotics, go through particularly stressful periods.

The onset situations of hallucinations are usually two, and opposite: they appear when subjects are alone, focusing on their own thoughts (the same situation as the delusion), but also when, on the contrary, there are many people. For this reason, one who experiences voices can adopt some strategies to reduce their onset, e.g. avoiding to be alone or to go to crowded places. Once closely related with delusions, hallucinations are maintained just in the same way: they establish themselves as real (it is hard indeed to doubt the existence of a voice shouting inside our mind) and they are judged as coming from the outside; moreover, the emotive responses they produce to the subject (which usually calms down if the voices are good, and gets anxious if they are evil) confirm their existence and their coming from the outside.

But what causes the auditory hallucinations according to the cognitive perspective? One of the major theories involves a deficit in the monitoring system. According to this hypothesis (also applied to delusions, as we noticed above), the voices would be self-generated, but not recognized, and so they are externalized. Shergill, Cameron e Brammer (2001) noticed for example that the activation patterns detected with fMRI during auditory hallucinations are very similar to those observed in normal subjects when they imagine that someone is speaking to them. This would mean that voices

are a sort of "internal speech" which, for some defect in the monitoring capacity, would be imputed to the external world. So, there would be a tendency to externalize the cause of self-generated actions.

But this theory of the *externalizing bias* has some weak points. It is not clear, for example, why a mistake in the monitoring capacity should cause only the bias to impute some internal events to external causes, and not the opposite tendency, to impute internal causes to external events. If there were this kind of deficit, in the differentiation between internal and external causes, the subjects should often be uncertain about the origin of the events, rather than regularly impute internal events to external causes, unless we assume, in addition to the monitoring deficit, also this tendency to externalize, and if so this theory will end up complicating without actually explaining anything.

More generally, the scientific consensus about the existence of a deficit which would make people judge as external voices actually self-generated, doesn't seem to stand the test of concrete. As highlighted by Stinson and coll. (2010), a bias in the self-monitoring capacity not only hasn't been proved yet, but in some cases doesn't seem to be connected with hallucinations (cfr. John *et al.* 2006, Versmissen *et al.* 2007). For this reason, in his survey Stinson can claim that the mechanisms underlying auditory hallucinations are still a black box (Stinson *et al.* 2010, p.179).

5. Metacognition and auditory hallucinations

Van Os and coll. made an interesting remark upon voices (van Os, Krabbendam 2002; Krabbendam *et al*. 2004). The authors pointed out that is the development of beliefs and delusions which are relative to hallucinations (e.g. giving them a special meaning, or believing that they come from an external source) to lead to psychosis, rather than the experience of hallucinations itself. It seems then that, even for hallucinations, psychosis is trigged by the beliefs, rather than by perceptual experiences.

Thus, many authors are beginning to highlight the role played by metacognitive factors, which are the same implicated in delusions. The vulnerability to hallucinations is ascribed to specific mechanisms, such as excess of self-focused attention, ruminative processing, dysfunctional self beliefs and hypervigilance to idiosyncratic threat cues (Ensum & Morrison 2004; Lobban *et al.* 2002; Morrison *et al.* 2000; Cangas *et al.* 2006). In other words, people who experience auditory hallucinations are more inclined to reflect and to judge their cognitive processes, and to have thoughts such as "I need to worry, in order to work well", "It's bad to have certain thoughts", "This worrying will make me sick", "I must control my thoughts" and so on (Morrison 2001). According to Larøi (Larøi *et al*. 2005), when intrusive thoughts (persistent and unwanted) are not admitted, a cognitive dissonance results, which the person tries to escape by externalising the intrusive thoughts. This would explain why these subjects don't externalize all of their actions (as we would expect

if it were a deficit *in toto* in the self-monitoring capacity), but only some of their thoughts.

Once again, the beliefs referred to certain events lead to auditory hallucinations, rather than the events themselves. Thus, it will be the initial interpretation of an event, be it an intrusive thought or a real hallucination (which is an event more common than previously thought), to determine the reactions to the event itself.

> […] if someone interprets an auditory hallucination as the result of stress or sleep deprivation, he may reduce arousal or get some sleep but not give the hallucination any further thought. However, if the same person were to interpret it as being a sign of madness or indicative of their neighbour's attempts to harm them, they may engage in hypervigilance for similar experiences, attempt to suppress the experience, punish themselves for it or adopt safety behaviours to prevent the feared outcome, all of which may contribute to the maintenance of further hallucinations. (Morrison 2001, p. 264)

Through developing an hypervigilance for similar experiences, punishing oneself for them, considering them highly dangerous for being signs of madness, one will only make them more likely, and create a vicious circle which is impossible to escape from. Focusing on the voices in order to make them stop, these subjects will give special attention to them, making them more powerful and persistent. The subject's attitude towards his hallucinations is crucial since the very first episode, as described by this patient:

> On a Sunday morning at 10 o'clock, it suddenly was as if I received a totally unexpected enormous blow on my head. I was alone and there was a message—a message at which even the dogs would turn up their noses. I instantly panicked and couldn't prevent terrible events from happening. My first reaction was: What on earth is happening? The second was: I'm probably just imagining things. Then I thought: No, you're not imagining it; you have to take this seriously. (Beck, Rector 2003, p. 23)

In this example, it's the thought "you have to take this seriously" to trigger the "hallucinations – delusions – hallucinations" vicious circle.

Finally, also the emotions, such as anxiety and fear, play a crucial role in auditory hallucinations, since they attach greater importance to neutral stimuli, and they concur to maintain the belief on the reality of voices and their coming from an external source. Thus, the auditory hallucinations seem to be a phenomenon more complex than expected, because it arises from the linking of beliefs, expectations, emotions, hypervigilance, ruminations. Nevertheless, I think that, in this perspective, a leading role must be given to beliefs, for they contribute to interpret, trigger, confirm and maintain the voices.

6. Pathologies of belief

Hallucinations and delusions are closely related phenomena. They are connected not just because, in the majority of cases, the two symptoms confirm each other, e.g. the persecutory delusion can be supported by voices with negative content, which in turn are supported by the delusion itself, that consider them as belonging to the persecutor.

In my opinion, there is a deeper reason why we cannot deal with delusions and voices separately. They are both pathologies of belief. In the former case, the belief area seems to be obviously involved. It is a belief, be it plausible (in paranoia) or implausible (in schizophrenia), which is sustained beyond all evidence and that becomes the main focus of a person's life, who can't help but interpret everything basing on the delusion. In the latter, it is the way voices are judged, interpreted, and the related beliefs, rather than hallucinatory experience itself, to turn a phenomenon belonging to a continuum into a proper psychotic symptom.

Even if the mechanisms underlying these symptom are still unsolved, I think that the attempts of explanations which are more plausible are those involving common factors, and, more precisely, the role played by beliefs and *top-down* factors.

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BIOLOGICAL CONSTRAINTS ON LANGUAGE: NEW DATA FROM HUMAN AUDITORY CORTEX

1. Preliminary remarks: from foundations to biological constraints of language

One of the classical perspectives among the studies on language, beginning with the aristotelic naturalism, considers the anatomical components as correlates, structures that allow the function. This stance gave birth to opposite positions during the last century: if, on one hand, those who reflected on language in a philosophical-linguistic perspective focused only in its functional aspects (ruling out the biological structures in a more or less explicit way, e.g. the chomskyan thesis, Saussure and the structuralism followers), on the other hand some multidisciplinary researchers favoured the structural analysis, regarded as an evolutionary mark of the linguistic function, some sort of guarantee of the language's unique presence in *sapiens* (LENNEBERG 1967, LIEBERMAN 1975, etc).

The cognitive sciences' point of view within the debate on human language's nature and function was unambiguous and rather extreme: putting aside the formalizing and dephysicalizating hopes of the cognitivistic first generation, the cognitive sciences focused on neuroanatomical structures, thanks to a growing amount of data about the working of the central nervous system during the execution of selected behaviours. For the cognitive paradigm of second generation, biological

structures were the actual object of study, and the explanation of the function took sometimes a second place compared to the location of cerebral loci which are active during the execution of cognitive tasks (SWAAB 2010), the linguistic ones above all, that already had a specific neuroanatomical location. The essence of the linguistic function thus came down to the use of language central structures. The model suggested by an emergent part of the second generation's cognitive sciences was based on the brain primacy in the explanation of functions, without considering the link with the remaining organism: brain was regarded as a special organ ("brain is special") and the functions it controls, language first of all, were assigned a special position (PENNISI-FALZONE, 2011).

Evolutionary (cfr. JOHANSSON 2005, BOTHA-KNIGHT 2009a, BOTHA-KNIGHT 2009b) and comparative (FITCH 2010, HAUSER 1997) studies changed this setting turning the attention from the description of the event-related brain activity to the meaning of this activity for its adaptive and ecological role (GOULD, 2002): according to this perspective, language would be not only a complex cognitive function which cannot came down to the brain activity either to the communicative ability alone, but also a central and a species-specific function for the *sapiens*. Language, in other words, would be a central function since it influences human cognitive activities to such an extent to form a constrain, a functional and representational coercion, rather than being one among the various functions of human cognition that can be studied irrespective of its adaptive role.

The human language anatomical structures set up the way this constraint materializes screening the information about the world and allowing our typical modality of building representations of the world. *Sapiens*' sensory canals (like, *mutatis mutandis*, those of the other species) are built in such a way that they can be hit only by specific stimuli and these stimuli are recognized, categorized and processed on the basis of the typical human cognitive structures. We are cognitively blind to infrared, just as we are cognitively oriented to classify the objects we recognize as similar in shape or use as belonging to the same category, or to learn culturally driven information on the basis of the daily experiences in a specific linguistic community (HAGOORT et al. 2004).

We don't choose, we are forced to know the world on the basis of the biological-cognitive constraints the evolutionary history gave us. These constraints set the *Ümwelt* of each animal species (von UEXKÜLL 2010), making them different not only in a biological way but also in a cognitive one.

In this study we want to claim that the language's biological constraints, in the sense described above of biological-cognitive influences, allow the *sapiens* typical modality of using language to build and decode the representations of the material and relational environment. This would mean that the linguistic function is species-specific for the *sapiens*, a capacity that the human being can't help showing and that influences other cognitive activities. This constraint already appears in the biological structures which specifically decode auditory stimuli, and that are specific for

linguistic and cognitively complex tasks. Auditory cortex would show indeed a species-specific setting for the *sapiens* which would make it sensitive to linguistic information in a number of different levels of competence.

1.1. Linguistic and auditory species-specificity

Before carrying on the description of the reasons in favor of the human auditory cortex's species-specificity, it is necessary to clarify that the species-specificity's "technical" notion we refer to in this work belongs to the classical ethology's tradition, according to which is species-specific a behavior that an individual, insofar as belonging to a species, can't help showing. No estimation about a behavior's spectacularity or exclusivity can be inferred by its species-specificity: formulated in the area of biological sciences, this concept would indicate that some organisms would be active only toward a specific animal or vegetal species (just think of those parasites that live only in specific animal species or plant). Lorenz borrowed this biological concept and he assigned it to a sphere that was higher than the simple chemical compatibility, the behavioral one, which follows working rules that are very different from those of the animal or vegetal biology.

The core component of the specificity's notion Lorenz intended to apply to the animal behavior was the constrictive element: the parasites that can't choose which plant to infest, rather they can, indeed they must, for their survival and reproduction, attack one and only species, show *Speziesspezifität*.

The founding father of ethology used thus this notion of functional coercion through applying it to the animal behavior. In the contemporary ethology, in fact, one must assume that "the behavior is largely driven by phylogenetic adaptations in the form of hereditary coordinations and innate release mechanisms" (EIBL-EIBESFELDT 1987: 382): this meaning specify the technical use of the "species-specificity" term.

Thus, the behavioral natural component lies in the species-specificity gradient an animal species shows: the higher the gradient, the more the behaviors of every member are constrained, and the more their execution, given a specific environmental condition, looks unstoppable. It is of course a general definition that can be applied to every behavior, but we have to take into account the functional complexity of the behavior we consider. If a behavior is species-specific it means that it materializes through selective filters which influence its execution.

In the case of human language it becomes clear that these filters are nothing but the language's central and peripheral biological structures that, as showed by a large amount of scientific data, influence the way we represent the world, both in the achievement of the communicative function and in the relations that language has with the other functions it relates to (HAGOORT 2003).

Studies that show the involvement of Broca's area both in tasks about visual perception with description of actions (PAPAFRAGOU et al. 2006 e 2008), and in complex cognitive tasks are well known. According to the most recent interactionist

perspectives, Broca's area would be the place of integration of information about semantics, syntax and world knowledge. It would thus form the center of confluence and integration among meanings that are acquired and stored in the long term memory and the new ones, arising from the continuous interaction between the subject and the world. Broca's area would be a sort of multimodal neuroprocessor, a "super-area" of association, which would be able to keep the info coming from the different sensorial elaborations on line, in order to allow their categorization and integration in one own's encyclopedic knowledge. This view would highlight the Broca's area's role of representations' and linguistic procedure's maker, a role which influences and codetermine the achievement of the other high functions (actions' planning, objects' categorization, life experiences' storaging, and so on), binding the whole human cognition to language.

The data we'll show in this work, on the contrary, concern a cortical structure with linguistic-perceptual roles: the auditory cortex. A specific role for this area seems to arise from these data: it would present a functional specialization in recognizing linguistic sounds, in other words it would show a greater activity in the presence of stimuli belonging to spoken language. More precisely, recent studies seem to show the specialization of a specific part of the auditory cortex for such a highly adaptive task as the identification of single individuals on the basis of the emission of vocal sounds. These data, together with the classic behavioral works about the hearing and voice synergy in the building of primary relationships (MEHLER-DUPOUX, 2006),

would suggest the specialization of the auditory cortex for the building of primary social relationships.

2. Adaptivity and specialization of the auditory cortex

The human auditory cortex presents a specific functional organization, with a tonotopic sensitivity: the primary cortex is thus organized in columns of associations that respond in a specific way to the heard frequencies, with a specialization in the posterior regions for the higher frequencies, and in the anterior regions for the lower ones (HUDSPETH 2003). This tonotopical maps represent the whole spectrum of the audible frequencies.

But linguistic stimuli represent a sort of "privileged input" for the human auditory cortex. Some studies (cf. FECTEAU et al. 2004, ZATORRE et al. 1996, ZATORRE in press) highlighted that the human auditory cortex is particularly sensitive to linguistic sounds, rather than to non-linguistic ones (e.g. music) or to other animals' sounds. More precisely, there would be a large amount of experimental proofs about the species-specificity of a particular portion of the auditory cortex, the Superior Temporal Sulcus, which shows a medium-level activation for non linguistic or belonging to other species' stimuli, while would show a very high activation (almost twice the BOLD activity) when in presence of human vocalizations.

From an ethologic point of view this element is relevant: this area seems to be sensitive to language in a species-specific way, for its activation is high for linguistic

sounds and mild even for stimuli that are ecologically relevant, like sounds related to dangers. The greater sensitivity of the Superior Temporal Sulcus for linguistic sounds than to sounds that reveal dangers (like sudden or very loud noises) would suggest the specialization of a part of the auditory cortex for the species-specific vocalizations, which are also crucial for the survival of the species (cf. ANDREW 1963, ALTMANNN 1967, , PETERSEN 1982, SEYFARTH et al. 1980, TIAN-RAUSCHECKER 1998, van LAWICK-GOODALL 1968). In other words, a portion of the cerebral structures which process the auditory data would be selectively sensitive to human vocalizations: a species-specific structure that screens the information from the outside world and direct our "preference" towards linguistic inputs. Moreover, studies conducted on seven-months old's infants show a preference in the structures of the temporal planum for linguistic sounds belonging to the mother tongue (GROSSMANN et al. 2010), with a typical activation for the consonant-vocal units and for words of the mother tongue. Infants have a greater interest in linguistic auditory stimuli, more than the other sensory stimuli (e.g. visual or tactile ones) if these are made by the mother or by people they have primary relationships with (ZATORRE-GANDOUR 2008).

There would be thus a specific portion of auditory areas dedicated to vocal production. When we change to linguistic stimuli belonging to a specific language the evidences about the auditory cortex's specialization become even more convincing. Human auditory system is not only highly specialized in the perception

of the auditory frequencies that are typical of the human language (one can think of the cochlea's tonotopical organization and its accuracy in the translation of the analogical auditory information to the electrical signals through the auditory nerve) but is also characterized to the central level by its ability to perceive and decode linguistic sounds. More precisely, it is the auditory cortex itself to integrate the information that are lacking in the peripheral auditory level: the ability to perceive the words of a language despite of the production's inaccuracy (according to a "cybernetic" model the smallest segmental unit of speech would be the phoneme, a model that slumped because of the data coming from the articulatory phonetics, cf. MAN e GOLDSTEIN 2000) would be allowed by the auditory cortex and by the integration's processes that are biologically guaranteed.

In order to assess the human auditory cortex's species-specificity we can refer to different studies by BELIN and coll. (2004) according to which the human voice not only is the vehicle of speech but it is also a sort of "auditory face" that gives important emotional and identity's information and also data about the relation between the speaker and the listener. Those information would be processed in a specific way by specialized areas (the so called Temporal Voice Area, made up by the central and the anterior components of the Superior Temporal Sulcus) and would have the same adaptive role than those of the cortical structures assigned to faces recognition (Face Area, cf. BRUCE-YOUNG 1986). BELIN et al. (2011) suggest an interesting model of interaction between the Temporal Voice Area and the Face Area

in order to recognize conspecific that, in the case of human being, are "talking conspecific".

Well strengthened studies found the auditory cortex of the left hemisphere, more specifically the posterior part of the Superior Temporal Gyrus and the Superior Temporal Sulcus, particularly sensitive to sounds that are linguistic comprehensible (SAMSON et al. 2011), in other words to words belonging to a specific language. Articulated language, on the contrary, is linked to a greater sensitivity of the auditory areas that are not primary (BA 22, Wernicke'area), the associative areas (BA 29), the Superior Temporal Gyrus of the STS and the temporal planum of the left hemisphere.

These recent data on the specialization of the secondary auditory cortex for linguistic tasks are no news for neuropsychologists of language: the areas that are specialized for sounds which are linguistically intelligible, would consist in structures that are known for their involvement in the classic model of the neuroanatomical functioning of language. More specifically, Heschl's gyrus and the posterior part of the BA22 (Wernicke's area) would work for the linguistic decoding and their alteration involves a damage in the ability of understand language (the aphasia of Wernicke).

It is interesting that these areas are part of a network that links the auditory and the prefrontal areas. More precisely, it has been found a network of activation that links auditory and non auditory areas: a large hierarchic model of the language processing that comes from the primary auditory cortex and extends to non auditory regions,

mainly in the frontal cortex, and to a series of motor, premotor and prefrontal regions (DAVIS-JOHNSRUDE 2007, HICKOK-POEPPEL 2007, RAUSCHECKER-SCOTT 2009). The most corroborate neuroscientific models tend to detect a functioning network with functional epicenters (MESULAM 1998), rather than finding a single area as responsible for a specific function, as postulated in the classic modularist hypothesis (cf. FODOR 1983). These epicenters would be "nodes" where the data take an amodal format and are cathegorized and recognized. In the case of auditory cortex, too, especially in the secondary auditory cortex where the Wernicke's area is located, it is possible to find myelinated circuits of activation. More specifically some studies (RAUSCHECKER-TIAN 2000; ROMANSKI et al. 1999) tried to detect, in the auditory cortex, two ways of processing: a ventral stream, the "what pathway" that processes what the sounds indicate (i.e. the decoding process and the word's reference to elements of the outside world), and a dorsal stream, the "where pathway" (i.e. spatial location of the inputs).

Moreover, these data about the secondary auditory cortex's specialization for linguistic "qualitative" information (referring to the content) would assign the Wernicke's area a crucial cognitive role: that of processing the information referring to the outside world in a multimodal way, processing essential properties of language of an abstract kind. This would explain in part the activation of the Wernicke's area for the decoding of linguistic information even in born-deaf subjects (PETITTO et al. 2000).

These findings would show the specialization of the human auditory cortex for the linguistic sounds with a great preference for word-made stimuli already in infants, and a generic preference for the voice in the primary relationships. Studies conducted with brain imaging techniques, moreover, would show a specific competence of the Superior Temporal Sulcus and the Superior Temporal Gyrus of the left hemisphere for words and the activation of a temporal-frontal circuit that links the secondary auditory cortex (Wernicke's area) with two circuits that are functionally different.

These data could make us assume that the decoding of sounds and the typical organization of the auditory cortex are "special" for the *sapiens.* Rather the ethological comparison, unmerciful with every form of anthropocentrism, showed that this preference for the production of vocalizations and the resulting activation of the auditory cortex is far from being a human specialty.

It is indeed sure that the human auditory system is characterized by elements which are homologue to those of the non human primates, but it is interesting to note that these features are present only in specific animal species, where the vocal production is used to communicative aims within social groups. The organization of the non human primates' cortex, more complex than those of the other mammals, seems in fact to be fit to the perception of the complex vocal sounds that are peculiar to verbal communication.

3. Conclusions: exaptation of language's cerebral circuits

These data would then support the idea that the auditory cortical structures, phylogenetically inherited from previous species, has been exapted in *sapiens* for linguistic purposes, an exaptation occurred on a anatomical structure that was first selected for adaptive-communicative purposes. In humans, on the contrary, it seems to be present already in the cortical level a specialization for the human language's prosodic components and for linguistic sounds both meaningless and meaningful. Thus, the idea that there is a formal model of language production which is unrelated to the speaker's (and hearer's) biology rules out an explanation that is crucial and well grounded about how the human being produces language.

The hearing and the auditory cortex would be regarded as a constraint that qualitatively influences the functional and evolutionary realization of language (both in the individual and in the community), rather than simple "biological foundation" of the linguistic function.

In humans this biological constraint doesn't concern only the ability to recognize the subject's identity from his vocal production or the possibility to detect an emotive level through voice, but it concerns also the sequential decoding of linguistic structures. There would be a specific sensitivity to types of phonemes, even if the studies' results are controversial, and it is well known that the posterior part of the BA22 in the primary auditory cortex decodes linguistic process in a specific way: it is the Wernicke's area, which is classically viewed as the area of linguistic decoding,

and is nowadays an interesting object of study for its ability to decode the categorizations of world-knowledge and the relationships the subjects entertain with it. It is still not clear whether it is possible to assign the Wernicke's area the competences that concern complex tasks as the decoding of categorized information and not only linguistic-decoding tasks. But it is clear that auditory cortex (more specifically STG, STS, and temporal planum) and the posterior frontal cortex are biological constraints that influence the way the sapiens build representations, a modality that phylogenetically evolved for intraspecific communicative aspects, and has been exapted for linguistic-representational purposes.

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Consuelo Luverà

RETHINKING ABOUT FREE WILL AFTER THE COMING OF NEUROSCIENCE: IS IT WELL-GROUNDED FEAR?

Before the coming of brain science, the problem of free will was investigated by conceptual analysis and theoretical assumptions. But these speculations weren't borne out of the facts. The possibility of experimental evidence about those questions did not exist yet. Since our knowledge about human nature is also the result of studies in the neuroscience field, the way of facing many conceptual questions considerably changed. Now the philosophers too have to face the naturalistic-reductionist perspective of the world. From this viewpoint all concepts need to be included into the natural science ontology. So if you can't include a notion in this field, it means that it is an irreducible concept and, for this reason, you have to eliminate it. According with this perspective, the discussion about the problem of free will includes also an account of neuroscientific investigations that are made to discover what happens in our brain when we are making a decision.

Since Benjamin Libet made his first experiments about conscious actions, the intuition about our freedom was called into question. The idea of people as free decision makers was attacked by several studies suggesting the illusion of free will. So, the common sense intuition of free will isn't up to date any more and, perhaps, it's going to be revised or even eliminated, as well as closely moral responsibility concept. In fact he fear about the end of free will notion is linked with the concern

about the concept of moral responsibility: we usually look at people as moral responsible, only if we believe in freedom of their actions. If neuroscience proves that performed actions are out of our control, this means that we can't keep considering ourselves as free and moral responsible agents because our neural processes, without our free volition, make the decisions. It's nevertheless too early to declare the end of free will and moral responsibility: these neuroscientific investigations are criticized because of methodological and conceptual problems. Although those whom supporting this neuroscientific perspective above all, think that the discussion about free will is settled, the debate is still open. It's worthwhile highlighting that the free will question is actually very complex. It needs not only philosophical and neuroscientific research, but also studies from humanities and social science. Even though neuroscience show that we are not free, we don't know our possible reaction, we can't imagine our hypothetical ways to face the new reality and the relationship with others. Someone, like Saul Smilansky (2002), thinks that, if we will stop to believe in free will, we could give up our moral behavior. On the other side there is someone, like Peter F. Strawson (1962), who thinks that discovering the illusion of freedom, won't have any consequences in our way of living and thinking about ourselves as free and responsible from a moral point of view.

It's a given that nowadays we can't discuss about free will without considering the neuroscientific perspective. But we need to play the question safe, to avoid a

conjectural apocalyptic view of the future world, with neither freedom or moral responsibility.

Experimental investigations

In the naturalistic-reductionist perspective of free will notion, Libet's pioneering experimental investigations about the connection between conscious decisions and underlying neural processes are actually crucial: in fact they mark a turning point in conceptualizing the issue. It was the first time neuroscientific research was involved in philosophical debate about free will.

During his investigations, Libet asked subjects to perform a basic action, like a movement of the wrist or finger. This action had to be performed in a totally free way: subjects didn't think about decision making, they had to move only when they felt the urge to do it. At the same time they looked at a special, really precise, clock. So they could remember the precise moment of the intention, that is the moment when they decided to move, according with the position of the clock pointer. They had to tell experimenter this record at the end of the task. This was the system to estimate the moment in which awareness aroused, compared to the motor action. At the same time electrical brain activity was measured at their scalp surface. It turned out that the time of intention typically precedes the movement by approximately 200 milliseconds. Nothing weird, 200 milliseconds is a due period of time for putting to use a movement. Unexpected was the recording of an evoked potential (the readiness

potential, or RP) by the electroencephalogram. This activity preceded the awareness of intention by approximately 350 milliseconds, and, so, also preceded the motor activity by about 550 milliseconds. According to Libet's interpretation of data, considering that the beginning of the process leading to perform a free action starts unconsciously in the brain, by 350 milliseconds before the awareness coming, this means that the decision-making is not due to subject's volition, but depends on neural unconscious processes. This, in Libet's interpretation, means also that we can't go on thinking about our decisions as free deliberations, because the real decision maker is the brain. Thus, free will does exist no more, at least in the common sense meaning. This account of neural processes coming before our awareness poses a real challenge to our common sense intuitions about our own autonomy, leading us to believe that free will is actually just an illusion. Although Libet poses a challenge to common concept of free will, he also attempts to save human freedom. In fact he holds that we have veto power over our automatically generated actions. During that 200 milliseconds between awareness and the motor action we can abort the movement and, so, we can be the ultimate free decision-maker of the action. Actually this is not free will, rather it is free veto or, as called by Libet, *free won't*. The start of a decision lies in our neural processes, but it is our consciousness the real decision-maker (Libet, 2004).

Libet's investigations are most assuredly of great importance in analysis of the free will problem, also because his studies have paved the way to other experimental

investigations about this topic. But it would be premature to think that these findings unequivocally show the end of the common free will notion.

Although Libet's studies are really important for the study of the relation between action and awareness, those who hold that his findings are less important in the free will debate made several objections. A well-known remark to Libet's interpretation comes from Daniel Dennett. According to Dennett, Libet's interpretation leaves us to think that consciousness is only an observer looking at what happens in our mind: as if consciousness lays in some place of the brain waiting to know what others parts of brain are doing. This is, according to Dennett, an erroneous interpretation, corrupted by an outdated dualistic conception of consciousness. In his opinion, Libet didn't show that consciousness is late compared to decision-making, but just that conscious decisions need such a time to be made. (Dennett, 2004). Also Mario De Caro makes some methodological objections to Libet's discovery: he maintains that there are some perplexities about the evaluation criteria about subjective timing of consciousness and, above all, about the correlation between timing measurement and objective timing of neural processes measured by technical equipment. Moreover, another question exposes Libet to attacks. During his experiments Libet registered the moment in which the subjects were aware of their urge to move. Here the problem is just about the word *urge*: we can't consider the action led up to urge as typical of the whole class of free actions. The urge is not a necessary condition for voluntary actions and neither a sufficient one. During our lives we often perform free actions as

the effect of a long deliberation, rather than a urge. At the same way we often perform action caused by urge that we can't call free, like sneezing. So we can't use the account of impulsive actions as a typical example of free action and, above all, we need to pay attention in drawing conclusions about free will based on this wrong assumption (De Caro, 2009). The same opinion is held up by Alfred Mele: he thinks that it's not the case of filling us with enthusiasm and neither worrying about Libet's findings about the urge to move as preceded by unconscious processes. In fact feeling the urge to move doesn't mean necessary to perform a free action (Mele, 2007). Another critical remark is about the first moment the subjects make their decisions. Before sitting in front of the clock to perform the task, subjects have to make an important decision: that, as a part of the experimental task. According to many researchers this is an important moment in the whole decisional causal chain that will lead to the final motor action of the wrist or finger. But Libet's interpretation doesn't take this moment in account and considers decisional process as a chain of events that, maybe, started before the performance in the experimental task (De Caro, 2009).

In line with Libet's investigations, Soon *et al.* recently made another experiment that leads to more drastic conclusions (2008). In this case the action preformed by the experimental subjects had two possible choices: pushing the button under right index finger, or pushing the button under left index finger. Subjects had to act in absolutely freedom, just when they felt the urge to do so, as well in Libet's task. The experimental room was settled in this way: the subjects sat in front of a monitor,

while a series of alphabetical letters turned up on the screen. They should remember the letter presented when their motor decision was consciously made. So, at the end of the task, they could tell researchers what letter was on the screen at the precise moment of the decision. Their brain activity was measured using functional magnetic resonance imaging (fMRI). It turned out that, alike in Libet's experiment, the subjects felt awareness of the action's intention only after the brain activity. Also in this study the brain looks like the decision maker while our intuition of free volition appears to be just an illusion. An interesting aspect of this research is about the time span between brain activity and entering awareness. Soon *et al*. claim that the outcome of the decision can be encoded in brain activity up to ten seconds before it enters awareness (Soon *et al.,* 2008). It's worthwhile noting that ten seconds is a very long period speaking about brain activity timing. This experiment was planned in order to guard them against the same remarks made to Libet. An important difference is the technical equipment used by Soon compared to Libet's one. Soon, in fact use fMRI because he judges it better in measuring brain timing than the electroencephalogram used by Libet, with also a better spatial resolution. Another difference is about how the system estimates the moment in which awareness enters. In the Libet's task there was a clock, so the subjects could have systematic preference about the position of the clock's hand. That is, they could decide to move when the pointer of the clock was indicating a particular time. With the use of a monitor and alphabetical letters this was no more possible. A randomized succession of letters made impossible any

prevision about the moment when pushing the button: there was an updating in the letters sequence every thirty seconds, so the subjects couldn't preview what letters would appear later. Moreover the task had two possible choices, not only one. This was a way to guard Soon *et al*. against the objection about the first moment subjects make their decisions. In fact, in this case, the subject could push the button under his right index finger, or that under his left one. So at the moment in which the subject decided to be involved in the experiment, he didn't start the whole decisional process. The decision, in fact, is about right or left, and not about moving or not, or the time of the movement. The causal chain leading one to take the final decision starts just when he's sitting in front of the screen, not before (Haynes, 2010).

Maybe Soon's experiment is less objectionable compared to Libet's one, but maybe is not. Some criticism can be evaded, but some of the remarks made previously to Libet are also valid for this experiment. Those cautions, in fact, are not enough to stand up for Soon against the Dennett's remark about the use of an outdated dualistic conception of consciousness. Moreover, in this experiment we can criticize the evaluation criteria about subjective timing of consciousness and its correlation between that and objective timing of neural processes by technical equipment. And finally, the use of the word *urge* referred to the impulse to act is present in this investigation too. But we have just considered the problem concerning the impulse to act as not typical of the whole class of free actions. Another remark by De Caro pertains to the classical theory of decisions. According to theory of decisions,

in order to have a real decision we must have a hierarchy of preferences. In the typical situation of decision-making, the subject assesses the potential implications of all the options and he chooses only one according to this valuation. During Soon's task, when the subject pushed the button under his right index finger, or that under his left one, he had no preference for one or another, he chose in a random way. Therefore that was a decision wherein there wasn't a hierarchy of preferences, so maybe not even a real decision, at least according to classical decision theory (De Caro, 2009). It seems that an experiment aimed to show that our decisions aren't free, maybe, was testing not even real authentic decisions.

In the reductionist analysis of free will problem, Daniel Wegner's *Illusion of conscious will* (2002) aroused many people's interest. In his *theory of apparent mental causation* he holds that people experience conscious will when they look at their thoughts as the cause of the actions. But, actually, that experience is not about a real causal connection between thought and action. According to Wegner we mislead the question thinking that we are the cause of our own actions because causation is only about neural processes, that is processes of which we can't be aware. In fact "this theory of apparent mental causation depends on idea that consciousness doesn't know how conscious mental processes work" (*ibidem*, p.67). Wegner calls to his support several examples and argues that conscious will is just an illusion resulted of a self-perceived apparent mental causation. Actually we can't access directly to the causes of our decisions: "unconscious and inscrutable mechanism create both

conscious thought about action and action, and so produce the sense of will experience by perceiving the thought as cause of the action" (*ibidem*, 2002 p.98). As noted by De Caro, although Wegner uses several examples to support his theory, his phenomenological arguments for agency and intention in determining action are not definitely demonstrative of the illusion of conscious will. We can't judge about the freedom of our decisions basing on the reports of consciousness, because we perform many actions without awareness, but certainly in a free way. For example when we are driving the car we always perform actions automatically to avoid obstacles, but this doesn't mean that the performed actions weren't free. Moreover, when Wegner holds that: "we can't know, let alone keep track of, the tremendous number of mechanical influences on our behavior because we inhabit an extraordinarily complicated machine" (*ibidem*, 2002 p.27), Dennett asks himself who is that "we" inhabiting in our brain. In fact Dennett maintains that Wegner can also be criticized for his use of a dualistic Cartesian notion of consciousness (Dennett, 2004 p.326).

Summarizing previous analysis of reductionist studies about the question of free will, we can assert that, at the moment, neuroscience didn't solve the free will problem. Experimental investigations are without any doubt fundamental in the analysis of the issue, above all considering that nowadays we can't face the problem of freedom regardless of neuroscience, as well any other philosophical matters. But, as we have seen previously, we need to dampen enthusiasm before declaring human freedom just an illusion.

The pseudo-threat of neuroscience to free will

It's interesting to point out that different interpretations of the same neuroscientific experiment with implications in free will can be used to support discording theories about this issue, as noted by De Caro (2009). For example illusionists and skeptics can call on neuroscientific discoveries to support their theories, and so, to affirm that the intuition of free will is just an illusion. But illusionists and skeptics aren't the only ones trying to bring grist to their mill through the outcomes of neuroscience. Also the compatibilists and hard determinists can do the same, and they effectively do it so. In a compatibilist view, free will is compatible with the truth of causal determinism, so causal determination isn't at all a problem in freedom execution. They maintain that freedom can be determinate, but absolutely neither forced nor compelled. As things stand, neurobiological determination postulated by Libet doesn't show that we aren't free, quite the opposite, freedom needs that determination. Moreover, also the hard determinist, which holds that free will doesn't exist because it isn't compatible with determinism, can use neuroscience in his favor: he claims that science proved the illusion of free will just because it shows determination of neural events. At last, even a libertarian as Robert Kane can maintain that the indeterministic event allowing freedom could lay just in those 200 milliseconds in which we can abort the action through veto or choose to go on it (De Caro, 2009).

Those who are afraid of neuroscientific findings about free will can also reassuring themselves looking at several data coming from experimental philosophy. In this field people common intuitions are investigated in order to discovery their natural tendency to be compatibilist or incompatibilist. Some experiments ran by Nahmias *et al.* (2005) show that ordinary people are naturally compatibilist. As things stand, if neuroscience will prove that we are determined in our decisions, our intuition of freedom won't result undermined. It seems that the end of free will intuition isn't going to come. Until now we can continue to think ourselves as the real decision-makers of our lives.

We considered the possible challenge posed by neuroscientific discoveries to some of the fundamental concepts of our lives, as the existence of free will and the possibility of blaming or praising people for their actions. We also analyzed the remarks of who claims that we need to dampen enthusiasm before declaring human freedom just an illusion. As things stand, it's worthwhile mentioning Adina Roskies's arguments for showing that fear about free will and moral responsibility is not well grounded (Roskies 2006, 2010). She seems actually encouraging in her ideas about the grounding of free will intuition. Roskies claims that neuroscience today is not in a position to resolve the debate, and more importantly, neither is any foreseeable neuroscience. Nonetheless, she holds that neuroscience may be able to influence our philosophical positions about free will in important ways. And more, she maintains

that we shouldn't worry about neuroscientific demonstration of the inexistence of a unitary-self, because our common sense intuition of freedom doesn't depend on that.

Normally during decision-making processes the agent is aware of his intention and, above all, of his reasons to act, this is really important in order to say that he's actively participating to deliberation process. But, as pointed out by Roskies, it doesn't need that the subject is aware of his intention and his reasons during the whole decision-action process. Intuition of freedom is not the same of intuition of a unitary-self, rather it is correlated with the possibility of being an active part during the decisional processes (Roskies, 2010). So, neuroscientific investigations regarding the moment in which awareness enters during a decision to move a finger are not really relevant for the philosophical problem of free will. About freedom and determinism Roskies claims also that what neuroscience told us about determinism and indeterminism problem isn't enough. In fact she holds that it will be theoretical physics, not neuroscience, that we must ultimately appeal to, in order to answer the question of indeterminacy. Neuroscientific technology is not able to tell us if a system is definitely deterministic: apparently indeterministic behavior at one level can be the result of indeterministic or deterministic behavior at a lower level and, in the same manner, apparently deterministic behavior at one level can be the result of indeterministic or deterministic behavior at a lower level. Regardless the truth of deterministic theory, as the majority of authors maintain at least at a macroscopic level, Roskies claims that neuroscience is not able to tell us how things stand at all

the levels of description. Maybe a better physics theory could tell us how the things stand, but not brain sciences: "no evidence for indeterminism at the level of neurons or regions of activation will have bearing on the fundamental question of whether or not the universe is deterministic" (Roskies, 2006 p.421).

So, if the answer to the question "are we free?" relies on the state of the world, maybe we shouldn't search that answer in the neuroscientific field. Rather it is actually useful a better theoretical analysis, because the issue is more worrying if we consider the possible conceptual compatibility of free will with determinism or with indeterminism. In fact both compatibilists and incompatibilists have to face the problem about the difficulties in conciliating both theories with the notion of free will. An ancient debate is just about this issue. As Roskies points out, the problem of free will exists independently of neuroscientific advances, that is, it is primarily a conceptual problem: "if the universe is deterministic, then everything, including our actions and the brain activity that causes them, is as it is, only because of the initial state of the universe and neural law. Is this is the case, then we cannot do other than we do, and so we are not free" (Roskies, 2006 p.419). And she goes on about the problem of linking freedom with indeterminism: "if our actions are not determined, but instead due to these chance events, then it is chance, and not our will, that leads us to act as we do" (*ibidem*). Probably Roskies is right when she claims that a better comprehension of mechanisms underlying decision-making process and physics

theory is the way to reach a better comprehension of the question of free will (Roskies 2010).

Neuroscientific studies considered up to here are mostly focused on investigations of voluntary actions. In those experiments, in fact, the subjects usually perform basic voluntary movements of the wrist or finger. But when we think about free will we usually think about more complex actions than moving a finger. The typical moments of life in which we experience our free will are those in which we take time to deliberate: the decision is the outcome of thinking about the reasons to make a choice. For example we think about what candidate vote for, or about the way of investing next years of our lives. These are typical moments in which we feel that we have free will and that we are exercising it. Neuroscience can't investigate this kind of phenomenon, but it limits itself to investigate simple voluntary decisions connected with the motor system. Obviously this is the only way to deal with a very hard problem. In fact the problem of free will is such a complicated issue that, at the present time, it doesn't seem threatened by neuroscience.

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THE BIOLINGUISTIC APPROACH TO THE STUDY OF LANGUAGE NATURE

Dominant linguistics paradigms in the past several decades were focused exclusively on the surface forms of language, the product of human behavior, rather than on internal processes that underlie and shape that behavior. According to this studies the nature of language can be understood studying the external language, the set of expressions produced by speakers, the external forms of language: sounds, morphological units, words, utterances, texts, that exist apart from any individual (Anderson and Lightfoot 2002).

The biolinguistic perspective, in the broad sense, began to delineate almost half century ago when, on the path of Chomsky, the linguistics was mainly considered as the study of the system of rules and representations present in the speaker's mind. Nevertheless, in the famous article written with Hauser e Fitch (Hauser et al 2002), Chomsky still promote a research program that will enable a productive interchange between biologists and linguistics:

> One aim of this essay is to promote a stronger connection between biology and linguistics by identifying points of contact and agreement between the fields. Although this interdisciplinarity marriage was inaugurated more than 50 years ago, it has not yet been fully consummated. We hope to further this goal by, first, helping to clarify the biolinguistic perspective on language and its evolution (Hauser et al 2002:1570).

In order to determine the distinctive features of human language and their evolution we need a comparative approach with a collaborative effort among linguists, biologists, psychologists, anthropologists and neuroscience. The faculty of language, according to Chomsky, must be studied in the same way that visual system, immune system, circulatory system, and any other organ.

> The approach is "mentalistic" […] it is concerned with "mental aspects of the world", which stand alongside its mechanical, chemical, optical and other aspects. It undertakes to study a real object in the natural world – the brain, its states, and his functions – and thus to move the study of the mind towards eventual integration with the biological sciences. (Chomsky 2000:5-6).

In contemporary research there is both a weak and a strong sense to the term "biolinguistics": the weak sense of the term refers to the extent of linguistics that are engaged in discovering the properties of grammar, carrying out the research program Chomsky initiated in *Syntactic Structures* (1957) e culminated, after various revisions and reviews in the *Minimalist Program* (1995); a strong sense that refers to a research program that requires the combination of linguistic insights and insights from evolutionary biology, genetics, neurology and psychology (Boeckx e Grohmann 2007).

The best example of biolinguistics in the strong sense is E. Lenneberg's book (1967) *Biological Foundations of Language*[1], in which many topics that will be discussed in the successive years are anticipated: evolution and acquisition of language, impairment in linguistic function. The biolinguistics develops thanks to this book and the debate which has grown upon its contents.

[1] Trad. it 1971, *Fondamenti biologici del linguaggio*, Torino: Bollati Boringhieri.

The term “biolinguisitcs” is coined just in 1974 by Piattelli-Palmarini in a interdisciplinary meeting that involves evolutionary biology, neuroscience and linguistics. Through an interdisciplinary approach it has been tried to give an explanation of the human capacity to acquire and use language. The biolinguistics perspective deals with the component of human biology that occurs in the use and acquisition of language. The development of our linguistic capacities can’t be explained only in terms of learning, rather the faculty of language develops and must be studied as any other organ of human body. The main goal of the biolinguisitcs is to delineate a precise framework of biological and neural mechanisms that underlie human behavior.

The focus of the bioliguistics inquiry can be broken down into five precise questions: how can we describe the knowledge of language? How is that knowledge acquired and put in use? How did this knowledge implement in the human brain? How did that knowledge emerge in our species? (Boeckx 2010).

The aim of Chomsky, in the biolinguisitcs perspective, is to search the three factors that play a role in the development of language: genetic endowment, universal for all the individual of the species, the topic of the Universal grammar; the experience, which selects one or another language; principles not specific to the language faculty, principles of structural architecture and efficient computation, principles which are independent from the different languages (Chomsky 2010).

According to Chomsky there is a innate knowledge, the universal grammar, which represents the initial state of the faculty of language and determines all the possible

languages. The universal grammar has some syntactic principles, one of this is the principle of structure-dependency, this principle asserts that knowledge of language relies on structural relationship in the sentence rather than on the words' sequence. This knowledge is not derived from experience, but is innate of the faculty of language, part of universal grammar, a set of abstract principles that regulate the acquisition of language.

Chomsky doesn't study the ways in which we use language in daily interactions with others, the language seen from a social/cultural perspective, that he calls E-language, but studies the language as a natural object, a I-language, where I means internal, individual and intensional. The faculty of language is internal in that it deals with an inner state of mind, is individual in that it deals with one individual and with language communities only derivatively, it is intensional in the sense that is a function specified in intension, not extension (its extension is the set of linguistic expressions) (Chomsky 1995). To Chomsky, the term "language" means internal language, a state of the computational system of the mind/brain that generates structured expressions. These expressions, generated by computational system are connected to the interface systems: conceptual/intentional (semantic/pragmatic) system that uses linguistic expressions to reason, interpretate and organize action; sensorimotor system that externalizes expressions in production and constructs them from sensory data in perception (Chomsky 2009). According to Chomsky the only uniquely human component of the faculty of language is the recursive rule: the capacity to yield with a finite set of elements a potentially infinite array of discrete

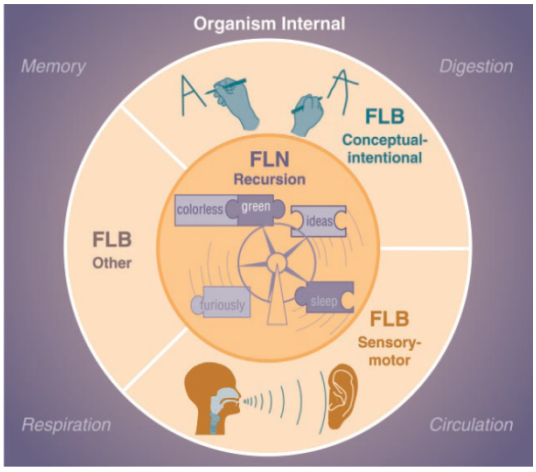
expressions. It's the creative aspect that differs the human language from any other animal communication system.

Having mastered a language, one is able to understand an indefinite number of expressions that are new to one's experience, that bear no simple physical resemblance and are in no simple way analogous to the expressions that constitute one's linguistic experience; and one is able, with greater or less facility, to produce such expressions on an appropriate occasion, despite their novelty and independently of detectable stimulus configurations, and to be understood by others who share this still mysterious ability. The normal use of language is, in this sense, a creative activity. This creative aspect of normal language use is one fundamental factor that distinguishes human language from any known system of animal communication (Chomsky 2006:88).

The identification of the hallmark of the human language leads Chomsky to delineate two conceptions of the faculty of language: one broader and more inclusive – FLB (*faculty of language - broad sense*) the other more restricted and narrow - FLN - (*faculty of language - narrow sense*). The faculty of language in broad sense includes an internal computational system combined with at least two other systems, the sensory-motor and conceptual-intentional systems. FLB includes the biological capacity of human that allows to readily master any language and excludes other organism-internal systems that are necessary but not sufficient for language: memory, respiration, digestion, circulation. The faculty of language in narrow sense includes

instead only the computational system, independent of the other systems it interacts and interfaces with.

FLN takes a finite set of elements and yields a potentially infinite array of discrete expressions. This capacity of FLN yields discrete infinity (a property that also characterized the natural numbers). Each of these discrete expressions is then passed to the sensory-motor and conceptual-intentional system, which process and elaborate this information in the use of language (Hauser *et al.* 2002:1571).



There are also many organism-internal factors, but external to FLB and FLN, that impose practical limits on the usage of the infinite combinatorial capacity of the human language. For example, lung capacity imposes limits on the length of actual spoken sentences.

Therefore the peripheral components of the faculty of language in broad sense are shared to some extent with other vertebrates, with differences in quantity rather than type, the faculty of language in narrow sense and the internal operation whereby this

interfaces with the other faculty of language in broad sense's systems are instead the only uniquely component of the human language.

The human language possess the ability to generate, starting from a finite set of elements, new combinations of grammatical elements, by applying certain syntactic rules, in a potentially infinite number of times. The combinatorial property of human language is attributable to complex syntactic rules. Every individual can understand and produce the infinity of linguistic expressions thanks to the syntax. Chomsky attributes to syntax a central role, omitting the importance of the other linguistic levels, including pragmatic level. The pragmatic level has a central role in processes of language interpretation. It is proved, in neuroscience, by Hagoort's studies (Hagoort 2009) of Broca's region, but it is already showed by Jackendoff, a linguist student of Chomsky that criticizes his teacher for the lack of recognition of the pragmatic level's importance.

Jackendoff

Jackendoff stands in sharp contrast with some of the chomskian generative grammar key points. Jackendoff gives up some of this key points: in his later study there is a rejection of syntactic movement and accordingly of the deep structure's existence[2]. It's very interesting the review of the syntactic component's status: he presents an hypothesis that is deeply in conflicts with the idea of syntax developed within the chomskian generative grammar. All linguistic theories assume the

[2] Per una discussione dettagliata si rimanda a Culicover e Jackendoff 2005.

existence of three representation's levels: phonological structure, syntactic structure and semantic structure. Differences between the various theories reside in the identification of additional layers, for example the morphological layer or pragmatic layer; in the way of conceiving the internal articulation of each level and the interaction between the different levels; in the role ascribed to individual levels. Despite the considerable changes that have characterized the generative grammar, during the different versions, some aspects remained constant: the idea of "hidden" syntactic levels, the idea that syntax is the only source of the compositionality, the idea that the lexicon (fixed elements) is separated by grammar (rules that allow the infinitive linguistic productivity). In the generative grammar, the syntax is the central object of study, the part of language faculty that includes the rules that govern the grammatical organization of words and phrases. The syntax is seen as the distinctive feature of the human language, the only component that allows the creative properties. The problem of language's acquisition is therefore discussed in terms of syntax.

Instead in Jackendoff's parallel architecture theory (Culicover e Jackendoff 2005) the combinatory complexity arises independently in fonology, syntax and semantic. It is no longer recognized the primacy of syntax on phonology and semantic: these components have their own independent combinatorial character. Each of linguistic structure's component is the result of an independent generative system. The syntax is just a language component like other, each of which helps to create creativity, complexity and astraction. The syntax is central only "geographically", as represents

the connection between semantic and phonology. The grammar consists of parallels generative components, each of which creates its own combinatorial complexity. Phonology, syntax and semantic are independent components, divided in levels or subcomponents. The grammar also includes a set of rules that determine the connection between the independent components. The language (*narrow sense*) includes syntactic and phonological structures, the interface that correlates syntax with phonology, the interface that correlates syntax and phonology with conceptual structure (conceptual-intentional interface), with perceptive input and motor output (sensory-motor interface). The conceptual structure is epistemologically prior to linguistic structure: it's a system of mental representation that codifies the way the world is filled, a mental structure in which present experience, episodic memory and planning for future actions are stored and correlated with each other, a structure which includes pragmatic considerations and "world knowledge", basic processes of reasoning and logical heuristic. The conceptual structure is the mind's central system: it's not considered part of language rather is the mental structure whereby language encodes communicable shape (Jackendoff 1999). Since the conceptual structure is considered an autonomous component, there is no need for any aspect to be reflected in syntax.

Another point of rupture with generative grammar is the refusal of the clear distinction between lexicon and grammar, which is replaced by the idea of a multidimensional continuum, ranging from particular, the idiosincracy of the words, to general, the grammatical rules. In generative grammar the lexicon is part of syntax

and is interpreted phonologically and semantically. Instead in Jackendoff's parallel architecture the lexicon is part of, or better is a essential part, interface components: a word is conceived as part of interface between syntax, semantic and phonology. The lexicon sets the connections between the parallel structures. The lexical items are placed simultaneously in the three structures and a connection is established between them.

In the parallel architecture, the linguistic structure is viewed as a collection of independent but linked levels of structure (phonology, syntax and semantic). Each level of structure is characterized by its own set of primitives and combinatorial principles. So it is rejected the classical distinction between phonology, syntax and semantic: according to the parallel architecture this division is based on generative components of phonology, syntax and semantic. Within this organization, the syntax is only one among several generative components. The parallel architecture is non-directional: in each component, starting from any part of the structure you can build a larger coherent structure. Starting from phonology, through interfaces, you can build the correspondent syntax and semantic or starting from semantic you can build the correspondent phonology and syntax.

We try to understand better how the parallel architecture is divided, so we can understand what are the unification processes that, as demonstrated by Hagoort (2009), requires the contribution of Broca's area. We take the Jackendoff's example (2002):

The little star's beside a big star

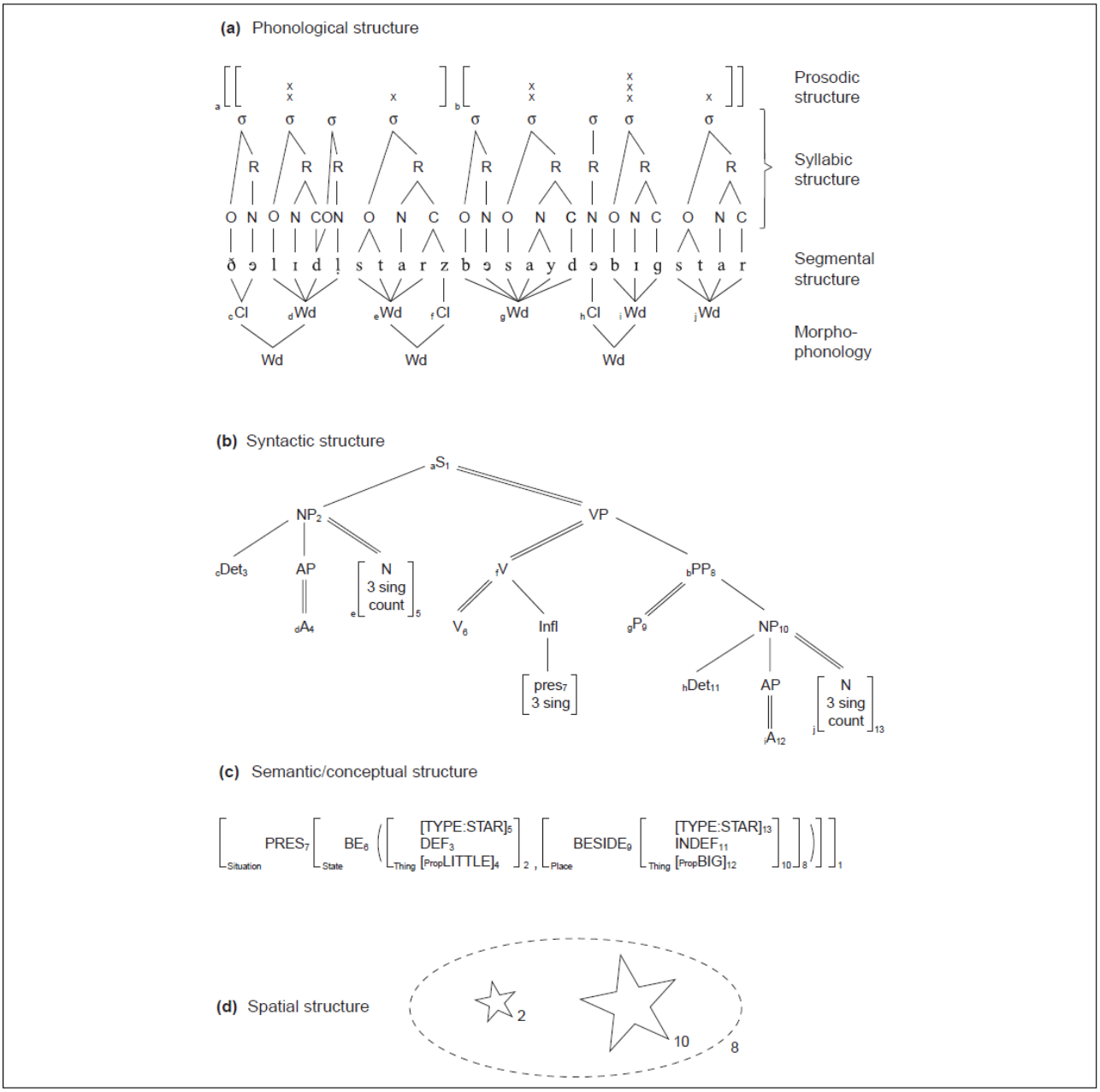


Figura 1. Struttura di The little star's beside a big star

The structure of the sentence *The little star's beside a big star* is organized into four levels, each one has a characteristic formal structure. The phonological structure consists of four subcomponents or tiers, one of this is the segmental structure, the string of phonemes. A phoneme is a phonic segment that can't be decomposed, characterized by distinctive traits that define the phoneme in opposition to all the others. The phonological structure is not simply a sequence of phonemes, there is

another subcomponent which brings together the sounds of spoken syllables. Above the syllabic structure is the tier of prosodic structure: the brackets indicate the organization of the syllables into intonational phrases. Below the phonological string there is the morphophonological structure, that combines the speech stream into words (indicated by Wd).

In syntactic structure the tree diagram represents the hierarchical structure of the sentence, that is the sintagms that make it and the different levels at which the compositions operates. The sentence (S) divides into a noun phrase (NP) and a verb phrase (VP). The noun phrase divides into a determiner, a modifying adjective phrase and a head noun. The verb phrase divides into a head verb and a prepositional phrase (PP). the prepositional phrase divides into a preposition and its NP object , and the NP divides as the subject NP. Attached to the V is an inflection with includes present tense plus the feature 3rd person singular, which agrees with the subject.

If phonology and syntax are fairly well settled, there is less agreement about the proper formulation of semantic/conceptual structure. The conceptual structure represents the descriptive, informative tier: it says that there is a situation in the present, consisting of a state. This state is an object located in a place. The function BE maps the object and the place into this state. The brackets surround the conceptual constituents. There are two kinds of relation among conceptual constituents. The first is the function-argument structure: F is a function that maps a constituent of type Y and a constituent of type Z into a constituent of type X.

$[_x F ([_y \ldots], [_z \ldots])]$

The second kind of relation is modification: there is a constituent of type X, in which the inner constituent, of type Y, specifies a further characteristic of the outer constituent.

$$\begin{pmatrix} \cdots \end{pmatrix}$$
$$_{x}[_{y} \cdots]$$

The object, first argument of BE, has three pieces of structure. The first designates the object as belonging to the category STAR, the second piece is a marker DEF, which indicates that the identity of the object can be fixed by either the previous discourse or the context, the third piece is a modifying constituent of the type Property, which designates the object as having the characteristic LITTLE. LITTLE has further internal structure: it says that the overall size of the object in question is smaller than a pragmatically determined norm. This norm in turn may be chosen from the average size of members of the category in question, the average size of stars in the contextual environment, the average size of all comparable objects in the contextual environment. The same is true for the other object, A BIG STAR, argument of the function BESIDE, that maps the object into a Place.

Finally, the spatial structure can be seen as an image of the scene that the sentence describes, a schema that must be compared to the world in order to verify the truth conditions of the sentence. In this case there are required two star-shaped objects, in the configuration must appear in some way the features of BESIDE, to represents the "beside-ness".

When we produce or perceive a sentence, this mental structure must be connected with each other: this operations are the problem of *binding.* A sentence have four independent structures, each one has multiple levels that must be connected, and also the four structure must be connected together. Correspondences between the levels are not obtained between primitive elements of any of the levels but between composite units. The primitive units of phonological structure such as distinctive features and syllables are completely invisible to syntax and semantic. Only the assembly of a number of speech sounds into a word has a connection to syntax and/or meaning. Similarly, the primitive units of syntax, the word's syntactic categories such a Noun, are invisible to phonology. Also, not every aspect of syntax corresponds to something in meaning. The units that are connected between phonology and syntax are not always the same units that are connected between syntax and conceptual structure. The mapping between phonology and syntax preserves linear order, while the mapping between syntax and meaning tends to preserve the relative embedding of arguments and modifiers. In turn, some parts of semantic/conceptual structure, but not all them, correspond to spatial structure, some parts of conceptual structure are harder to be represented directly in any spatial format: for example, LITTLE and BIG raise the problem of how to notate relative size in spatial structure.

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