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Brain and the Lexicon

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An international conference organized by the Center for Logic, Language and Cognition of the University of Turin took place in on of the great historical buildings of the city, the Rectorate Palace (Palazzo del Rettorato).

The event, that saw the partecipation of some of the most famous experts in lexical processing and brain mechanisms, was part of a project, "The role of visual imagery in lexical processing", funded by Compagnia di Sanpaolo, that investigates the role of perception and association mechanisms in lexical processing and conceptualisation. The project is coordinated by Diego Marconi, full professor at the University of Turin.

The conference developed in two days, counting six talks. Each speaker presented the development of the research carried on in the last few years, focusing on his/her area of expertise and interest. The result was a well-organised, stimulating event, where the debates after each talk allowed to see how the various disciplines (experts in lexico-semantics and psycholinguistics, neurologists and philosophers were present) interact as far as the research on language and the brain mechanisms work. Moreover, several concurring views were presented, allowing to have a dynamic and complete picture of the current debate and a clear view on the varied positions regarding language use. The first part of this report will be dedicated to a overview concerning the event and the topics that have been presented during the two days of the conference. In the second part, I will focus on two talks in particular, namely Professor Vigliocco's and Professor Pulvermüller's ones, as I believe they can be representative both of the event and of the current state of the research.

On the first day, after the greetings by the Rector of the University, Prof. Gianmaria Ajani and an introduction by Prof. Marconi, the opening lecture was given by Prof. Gabriella Vigliocco, by University College London, who is currently co-director of the Deafness Cognition and Language Research Center in London. Her talk was focused on the role of emotional valence in the representation of abstract concepts

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and words, work that she has been carried on during the last six years of research.

Professor Matthew Lambon Ralph is currently associate vice-president and director of the Manchester Doctoral College at the University of Manchester and professor at the same university. He is also Senior Investigator Emeritus for the NIHR, and awarded the BPS President's Award in 2015. He presented his talk, *The role of anterior temporal regions in semantic cognition: convergent clinical and neuroscience data* that focused on the contribution of the anterior temporal regions in various semantic mechanisms, both verbal and non verbal. The talk focused on the impairments in Semantic Dementia, which is a neurodegenerative condition characterised by anomia and poor verbal comprehension. Part of Professor's Lambon Ralph's focused on the exploration of the nature of the semantic deficits that are not verbal (Bozeat et al, 2000) and in other studies he explored the deficits in Wernicke's aphasia (Thompson et al, 2015). Particular attention was given to the role of generalization of the ATP, as both overgeneralization and undergeneralization were registred (Lambon Ralph et al, 2009) in patients with semantic dementia.

In the afternoon, Professor Friedemann Pulvermüller gave his lecture, *From concepts to lexical semantics: is there a benefit?*. Pulvermüller, a well known name in the cognitive science panorama, is currently Chair in Neuroscience of Language and Pragmatics at the Freie Universität Berlin, in the Brain Language Laboratory. His experiences includes being Honorary Professorship at University of Malaga and of Sain Petersburg University, after a postdoc at Max Planck Institute for Biological Cybernetics.

Diego Marconi is professor of Philosophy of Language at the University of Torino. He previously taught at the University of Cagliari and at University of Eastern Piedmont at Vercelli, along with Pittsburgh, Geneva and Barcellona. He was also president of the Italian Society for Analytic Philosophy (SIFA) and one of the founders of European Society of Analytic Philosophy. His talk, *Work on the dual structure of lexical semantic competence*, closed the conference on the first day. Starting from the exposition of the classic Searle's Chinese room dilemma (Searle, 1980), Marconi introduced the problem of referential abilities in human language. Marconi subsequently presented data regarding the dissociation between inferential abilities and referential abilities as far as semantic processing is concerned. The data (Marconi, 2013) supported the dual picture of human lexical competence that Marconi proposes (Marconi, 2003) and that, if adopted, would facilitate artificial systems in replicating natural-language understanding, according to the author. The fMRI showed that while inferential tasks are correlated with an activation of left hemispheric language areas involved in lexical retrieval, referential ones are associated with nonverbal conceptual and structural object processing in the right hemisphere's areas. All of this is compatible with double dissociations in patients and therefore confirms the predictions of Marconi's model.

Guido Gainotti opened the second day of the conference with his lecture *Is the*

abstraction capacity due to the amodal format of conceptual representations or to the power of language?. Guido Gainotti is currently neurology professor at the Catholic University of Rome. Member of many neurological societies, Gainotti has been Secretary General of the Research Group on Aphasia of the World Federation of Neurology and member of the Task Force for Dementia and Cognitive Disorders of the European Federation of the Neurological Societies. In his talk, Gainotti presented a review of experimental results, addressing the semantic hub hypothesis, according to which the amodal format of the conceptual representations can explain abstraction capacity. The model of Patterson and colleagues is based on results on semantic dementia. To this picture, Gainotti opposes several data regarding the differences that seem to emerge in the processing of abstract and concrete concepts, that do not seem therefore to be processed by the same semantic amodal system. Moreover, literature seem to suggest that double dissociations exist between concepts characterised by different modalities. The strong left lateralization of abstract words activation proved by several studies, however, and the linkage between the processing of these words and the language areas suggest that the capacity to abstract away from surface similarity could be do due to different functions of language, such as the capacity to shape informations coming from the external mileau and the fact that encyclopedic information acquired through propositional language allow us to reach high and abstract level of conceptualization.

Professor David Kemmerer is currently full professor at Purdue University in West Lafayette. He is also adjunct professor in Behavioral Neurology and Cognitive Neuroscience at the University of Iowa. He has been General Editor for Language and Cognition since it was launched in 2009. In his talk, Professor Kemmerer challenged an assumption that is currently found in many models of cognition, naming that concepts encoded by words are the same ones used for various non-linguistic purposes, assuming therefore an overlapping between linguistic tasks and not linguistic ones. Kemmerer stresses how this assumption has to deal with an important fact: there is an incredible high number of human languages (about 6000) in the world and how they differ as far as categorization and taxonomies are concerned. Once acknowledged this, it is clear that interlinguistic variance has to be taken in consideration, in order to see whether differences in language reflect on linguistic tasks and non linguistic tasks alike. Kemmerer presented a series of interesting data regarding differences in taxonomies across languages, as far as aspects of actions, objects parts, opening events, spatial relationships and other domains are concerned. In an interesting study of 2008 Kemmerer and colleagues (Kemmerer et al, 2008) used fMRI to scan brain activity during semantic judgements for five classes of verbs that vary according to five distinct semantic components, namely action, motion, contact, change of state and tool use. The core assumption was that action components depended on primary motor and premotor cortices, the motion component was dependent on the posterolateral temporal cortex, the contact one

on the intraparietal sulcus and inferior parietal lobule, the change of state on the ventral temporal cortex and the tool use on the tempora, parietal, frontal regions. As the results were confirmed, the study allowed a mapping of aspects of verb meaning.

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Contents

1 *On the representation of abstract concepts and words*

Gabriella Vigliocco (University College London)

In her lecture, Vigliocco presented the work of her research group during the last six years. Their work focused on abstract concepts, mainly considered "hard words", as they are more difficult to learn and to process, longer and less frequent in languages. What is interesting, however, is that even in experimental contexts where frequency and length are controlled, there seem to be a delay in their processing compared to concrete words. This has led to the hypothesis of abstract words being processed through mechanisms that are mainly verbally based in contrast with concrete words, which might relay in their processing on more imaginability based mechanisms: this is the Dual Coding theory. According to other hypotheses, such as Contextual Availability Theory, abstract words have less verbal associations with possible contexts than concrete ones and are therefore less easy to process. More generally, the role of language has been advocated as central for the processing and use of abstract words. Lexical decisions studies have been conduced where the so called concreteness effect has been registered, with an apparent facilitation for the processing of concrete words that was correlated with either context availability or imageability. More recently, other hypotheses have been put forward, as for instance semantic diversity: abstract words are more heterogeneous and used in more varied sentential contexts. Another hypothesis is that they require logical operations to compute the meaning.

Something that the various proposals have in common is the reliance of language on verbal information, to an extent that it is greater or different from concrete ones. Similarly, explanations of why abstract concepts are not only processed more slowly but also learnt later tend to attribute this feature to linguistic and verbal information. The predominant view is that abstract words are harder to acquire because concrete words have to be learnt before: subsequently, sentence structure has to become familiar and, finally, this knowledge allows to make inferences regarding the meaning of abstract words.

Abstract concepts are thought to be acquired mainly after four years old, and there seems to be a jump around eight years old. However, it is not always the case that abstract concepts are disadvantaged, as it has famously been proved by

Vigliocco and Kousta's group that an advantage can also be registered (Kousta et al, 2009). In a lexical decision study, controlling different variables, when familiarity (subjective one) is controlled, along with imageability, abstract words are processed faster, which goes against both CAT and DC theories. Note that usually imageability is identified in a great deal of studies with concreteness: however, disentangling the two variables can lead to interesting results. The so called "abstractness effect" is surely in contrast with the assumptions that drove most of the research in the last years.

By looking at the stimuli, the research group noticed that emotional valence might have been a interesting variable to look at in order to explain the advantage, considering both positive and negative valence. Indeed, there is a statistical tendency for abstract words to have more emotional associations than concrete words, that tend to be more neutral. Valence is regarded here as a general property that can be applied to any word in language: so, not only emotion words were considered. Excluding emotion words, however, the same results were achieved.

This statistical relation between abstract words and emotions was then investigated during the research. All the lexical variables were controlled a part from valence: results showed that the advantage was absent. This drove the research team to consider the abstractness effect as an indirect effect of valence. So, valenced words are processed faster. This led the team to think that there is an effect of "emotion in disguise", which is importantly related to the statistical predominance of affective associations.

An fMRI experiment with a lexical decision task (Vigliocco et al. 2013) was designed, where different variables were controlled, excluding valence. Abstract items had therefore more affective associations. Controlling any possible element that would have resulted in an advantage for concrete words, it was not surprising to see that no differences in activation was present in the scanning. A cluster of activation for abstract over concrete words was on the other hand registered for the rostral anterior cingulate, an area considered to be part of the system that involves emotional information and has been argued to play an important role in regulating the activity of the limbic system, in particular the amigdala. A difference for abstract concepts was then seen again, as an indirect measure due to the statistical preponderance of affective associations.

All of this was however not sufficient to answer to an important question: why would emotion matter for abstract concepts, and what is its exact role?

The hypothesis was that the ontological distinction between abstract and concrete meanings would turn out to be a distinction between meanings that are primarily grounded in sensory-motor experience and those grounded in inner experience. The difference can be read as a difference between abstract emotional words produced by caregivers and bound to internal states and words referring to objects that are perceivable, in this way creating a distinction between entities in the outside

world and entities in the mind. This might provide a bootstrapping mechanism for the acquisition of abstract concepts. Moreover, it has to be noticed that this hypothesis has the advantage of defining abstract words in positive terms, as grounded in internal experience and states, and not in negative terms as compared to concrete ones. As a result, according to Vigliocco and her team, the role of language has to be reconsidered; linguistic information might still have an important role to play, but affective information has to be taken into account as well.

A more general hypothesis carried on by the group is that, in the semantic system, in order to characterise the representation of both concrete and abstract words, it is necessary to integrate sensory-motor information, internal experience (such as the affective one) and linguistic experience. An optimal system takes advantage of the statistical experience derived from both the world and the language.

A starting point in thinking about the issue was to carry on a fMRI study in order to see what else contributes to grounding of abstract concepts, as the group did. Words were varying along a continuum from negative to positive valence and vary as much as possible in terms of imageability, in order to see the effect of the two variables. A regression was applied, trying to understand whether the variable were modulating activation once the other factors (frequency, age of acquisition and such) we>re taken into account. Based on the previous work, the expectation was that the emotional system was going to be engaged for abstract words concerning activation in the rostral area. If valence is important, one strong hypothesis is that valence plays a greater role for abstract ones compared to concrete ones. The results, replicating previous studies' ones, showed an activation in the rostral ACC. The following question was to see whether imageability was the variable modulating the activation, but the analysis shown it was not.

The effect of valence was similar across the board for more concrete and abstract words: valence, then, was statistically linked to abstraction but not to be considered "special". The statistical predominance of emotional features for abstract concepts does not bring along a special role for valence.

Shallice and Cooper's (Shallice and Cooper, 2013) idea is that abstract words require more logical computation compared to concrete words and this logical computations are carried out within frontal areas, in particular within the left inferior frontal areas. Hoffman (Hoffman, 2015), in a different way, also has argued that abstract concepts, because more semantic diverse among themselves, require more executive control functions, that are carried by neuronal populations within the left inferior frontal area. What should be observed, according to these predictions, is that less imageable concepts correlate with more activation in these areas of the frontal lobe. However, what has been found is that no such a difference was present, as there was no cluster in the inferior frontal area for the more abstract words in a lexical decision task. Obviously, the control functions might be then necessary only for deeper tasks, being lexical decision too shallow. However, at least it can

be concluded that these processes are not inherent in the representation of abstract concepts.

Abstract words, in conclusion, tend to be valenced, and concrete ones tend to be more neutral. Also, there is a processing advantage for abstract words, but it is actually a faster processing for valenced words ("abstract in disguise"). The affective system, according to the results, is more engaged in abstract processing by virtue of this statistical preponderance of emotional features of abstract words, but not because of a link between emotion and abstraction.

Another part of the research focused on the acquisition of abstract words. The idea is that emotions might provide a bootstrapping mechanism: children might learn that the word happy refers to something internal by looking at the caregiver that use the word and having all the emotional cues related to this internal state, working as pointer to the shared emotional experience. According to the hypothsis, they subsequently understand the referent of the words and begin to build the distinction between words that refer to objects in the world and objects that refer to internal experience. If this is indeed the case, emotional abstract words should be learnt earlier than the others. Vigliocco pointed out that, looking at normative data for age of acquisition, what can be found, indeed, is that positive and negative words are acquired earlier than neutral ones, with a bias for positive valenced ones. What is clear, then, is that emotional abstract vocabulary is learnt earlier.

Another study was carried on for lexical decision tasks and others. Monolingual children were selected of three age groups. What emerged is that children were better with valenced words, both positive and negative ones, whereas the pattern changes with the last age group, where the effect of emotions was reduced. Up to nine years old, the children seemed to use the valence of words; they were better at recognising the abstract valenced words and the concrete neutral ones. The pattern changes with older children, with there is much less of a role of emotions, especially for the abstract words: the conclusion is that at this age, children are integrating two different strategies, namely the one based on extracting information from language or other mechanisms and the one based on emotion. In a sense, this means according to the authors that there might be an interesting period right before they enter into the teen years in which they pass from a more grounded strategy to a less grounded one, switching between two kind of lexical processing. This might be explored further, especially because around this age there is a interesting development in frontal functions.

The group also tested atypical populations, studying children with specific language impairment and children with autism spectrum disorder. Abstract concepts are based on linguistic and emotional information: a clear population to test the hypothesis on is that of children that have specific language impairments. If you need language in order to learn abstract concepts, you should be especially impaired in learning abstract concepts if there are difficulties with verbal information. Another

Rivista Italiana di Filosofia Analitica Junior 6:2 (2015)

interesting group is that of children with Autism Spectrum Disorder, as these children are described as having problems with a specific type of abstract concepts, namely those related to theory of mind. If language development is foundational, children with both ASD and language impairment should be especially impaired in their knowledge of abstract concepts. If emotional information is foundational though, the impairment might be relevant for ASD but not for specific language impairment children. Note, however, that ASD have often language impairments, so autistic disorder children were separated in two different groups. Results shown overall lower control, but no difference between the concrete and the abstract words. Children with language impairment only had the same difficulties of children that had also autism spectrum. Children with ASD without language disorder performed better than those with linguistic disorder and ASD symptoms, but there was no difference between the ASD without language impairment group and the control one. Consequently, no specific impairment for abstract concepts, and no specific impairment for valenced words emerged for ASD children. As a result, language impairment does not seem to include a specific impairment for abstract words.

Although recognising that a lot of data needs thinking and that a great number of questions still have to be answered, Vigliocco maintains that some important, negative conclusions can be drawn. Traditional views put emphasis on what makes abstract concepts harder and on the role of verbal information and memory for learning and use of abstract words. But the presented results shown the things can be seen in another way. Abstract concepts are not always harder; furthermore, some logic operations are not intrinsic to the processing of abstract concepts Moreover, children with language impairments do not have specific impairments with abstract concepts. As a results, traditional views should definitely take all of this data into account. Emotion might provide a grounding point for abstract words in virtue of the statistical predominance of valence in the abstract domain and this can bring about a processing advantage in adulthood and could bring a developmental advantage in children.

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2 *From concepts to lexical semantics: is there a benefit?*

Friedemann Pulvermüller (Freie Universität, Berlin)

Pulvermüller talked about the link between actions, perceptions, words and linguistic symbols. The talk focused on how is the meaning of symbols organized in the brain and which computational and eveolutionary advantages does this organization entail. One of the main query at the bottom of the presented research was which neuronal connectivity would casually determine the processes of representations.

Lots of semantic theories focus on how explaining meaning in a cognitive model, the most established of which entails closed encapsulated systems in which the concepts, of amodal nature, are stored and related to each other. However, Pulvermüller underlines, it has been argued that such a system cannot be sufficient for semantics, as a link between the symbols and the objects, the actual perceptions in the world, as well as the actions is missing and still has to be explained. As a result, these amodal symbolic system theories have been challenged for theoretical reasons. In particular, according to the speaker, what is especially missed by people interested in neurobiological mechanisms is a neurobiological mechanism that would underpin conceptual and semantic representations in such as symbolic system.

According to Pulvermüller, then, the query of semantic processing is mainly neurobiological. Given this assumption, what is necessary in cognitive models of language is an explanation of why certain brain areas should be adapt to meaning and, generally, language mechanisms. As a result of these assumptions, then, Pulvermüller argues for the need of well-established symptoms documented in neuroscience, coupled with a set of basic axioms that derive from them and, consequently, the demonstration that neuro-simulations can underpin what the models of language cognition suggest. This is, as a matter of fact, the core assumption underneath his research.

As Pulvermüller underlines, it is well known that there are strong local connections in the cortex. However, also more sparse long-distance connectivity is possible, that allows the neural substrate to build associations and links between distant neurons and therefore distinctive cognitive functional clusters. This is the core assumption underneath the idea of multimodal representations: links between

different neurons in different areas might lead to binding between different neural populations, so that multimodal representation emerge, as it has been postulated by neuroanatomists stressing the possibility of the cortex to have associative memory. This "Information mixing" is also supported by the discovery of mirror neurons ((Rizzolatti, Gentilucci, et al. 1987; Rizzolatti and Gentilucci 1988). The human brain seems to be especially well-suited to information mixing as far as language is concerned, as it is proven by the circuits linking perception of the words to speech articulation-dedicated neurons in the motor cortex, in the left hemisphere. Also, the hebbian principles establish that if neurons fire together, they wire together; that is to say that repetitive firing of two neurons brings to the formation of an associative link between the two. Thus, it is reasonable to assume that the formation of links between motor circuits related to the articulation of words and their perception emerges in development, when first words are articulated by children learning how to speak; the correlated activation of circuits allowing articulation of sound and the hearing of the same sound patterns is likely to be what allows the perception-motor circuits to be formed. Therefore, these circuits are assumed to have a relevant role as far as lexical representation is concerned. Moreover, they can be extended to the idea of sensory-motor circuits being related to the comprehension and use of concepts related to modal action words, leading to the formation of distributed cell circuits linking information. New symbols correlate with meaningful symbols.

The perception of an object and of a word relating to the object might cause the activation of the ventral stream of visual object perception and at the same time an activation in the areas dedicated to the language, thus forming a connection between the two areas. Also, context is supposed to play a meaningful role: if I hear a new word along with several words I already know, associative links might be formed between the semantic information of the known words and the new lexical form I am learning. This is sometime called parasitic semantic learning.

At the same time, it is supposed that visual input associated with auditory stimuli (so, for instance seeing an image of a crocodile, or an actual one, and hearing the word "crocodile" at the same time) can form modal circuits relating the visual information and the word, forming a semantic circuit that will activate when the semantic representation is recruited. According to Pulvermüller and colleagues' proposal, the possibility to build distributed neuronal assemblies is the key mechanism for linguistic and conceptual capacities, because they allow for differentiating a vocabulary of actions, symbols and concepts. Higher-order circuits develop thanks to the possibility of hebbian-like links between brain areas, providing the cortical representations and the mechanisms for the processing of meaningful words, linking verbal representation to modal information. These assumptions are, as a matter of fact, confirmed by several findings related to somatotopic activation of the motor cortex in relation to verbs related to arms, legs and face. One of the most influential studies regarding this topic is Hauk and colleagues work (Hauk et al, 2004).

Rivista Italiana di Filosofia Analitica Junior 6:2 (2015)

In a fMRI experiement, activation was checked during the processing of words related to verbs describing actions to be performed by hand, arm and face. Subjects were submitted to a stimulus they only had to read: face words activated inferior frontal premotor areas bilaterally, activation for arm words was found in the middle frontal gyrus, bilaterally, and in the percentile gyrus of the left hemisphere, whereas leg words elicited activation in pre and post central gyri in dorsal area. All of these is consistent with the somatotopic organization of the cortex. This shows that processing of the words related to action triggers activity in the motor cortex in a somatotopic way. These findings have been confirmed by several other studies (Tettamanti, Marco et al. (2005). "Listening to action-related sentences activates the fronto- parietal motor circuits". In: Journal of Cognitive Neuroscience 17.2, pp. 273-281.) and furthermore correlated by results in TMS studies, such as Pulvermüller, Hauk, et al. (2005). In the experiment, transcranic magnetic stimulation was applied after 150 ms from the stimulus on the the motor "hand area" and "leg area" while subjects were reading words related to arm-actions and leg-actions. The results showed a word-specific effect of the TMS; if it was applied on the motor arm-area, reaction times were lower for arm-related words compared to leg-related ones, and viceversa.

Another question arises whether the activation is context dependent: this was explored in a study where the same phonological forms in different contexts, where the same words acted either as verbs or nouns (for instance "the kick" or "to kick"). It was observed that neural activity depended on the probability of the word to be either a verb or a noun and on the sentential context.

Pulvermüller also presented a relatively controversial issue; if what described seems to work straightforward for action verbs and meanings, it has to be explored what can be said about internal states and emotions. However, emotional meanings are reconnected to action semantics according to his view, being just a special case in this category.

At the same time, abstract concepts are also supposed to be explainable by the theory. As abstract words do not have a perceivable referent, whose visual stimuli can be related to motor circuits, their case seems to be more difficult: beauty is not instantiated in the same straightforward way than crocodile, as the word is used in a variety of contexts that can largely differ from each other and does not have a concrete perceivable referent. As a matter of fact, the word can used to describe a sculpture as well as a face or a cake. However, patterns of family resemblance can be found between different instantiations of beauty (for instance, harmonious lines, round forms), which could contribute to the formation of modal circuits, albeit not strong as in the concrete concepts case. Note that also Pulvermüller and colleagues do recognise some role to emotional grounding of abstract concepts, as they do cite Vigliocco's and colleagues work in some of their studies (Pulvermüller, 2013).

Generally speaking, Pulvermüller points out how it is important to focus on

Rivista Italiana di Filosofia Analitica Junior 6:2 (2015)

subset of abstract words in order to understand how abstract words are grounded, and he focuses on abstract emotion words, just right Vigliocco and colleagues. Abstract emotion words are internal states; one assumption is that these words can be learnt only because they are expressed in actions. Good mood, for instance, can be understood only if someone is that condition and it expresses it someway. The motor activation would serve as a link between meaning and symbols; grounding in action is supposed, so processing of abstract words is expected to trigger motor cortex activity. This was confirmed by studies such as Moseley's one, where the processing of abstract words elicited activity in the motor hand representation area of the cortex (Moseley et al, 2012).

The final problem issue that Pulvermüller introduced is that of the functional role: does the identified motor activation has one, or is it just a byproduct? The question to be asked, according to Pulvermüller, is whether the activation is fast and automatic; fast, because we might secondary think about actions or objects epiphenomenally, after the processing, and therefore having motor activation as just a byproduct of the semantic task, thus losing its functional role. The immediate understanding process is to be distinguished by the epiphenomenal effects. Also, it has to be automatic, as it has to be independent by attention. Finally, the casual role has to be proved. Some answers to these questions have been given; a series of experiment has been carried on, where it has been verified that activation is fast and present even in absence of attention, as the participants were distracted by other stimuli . As far as the casual role is concerned, TMS studies have shown that electric stimulation of the motor areas semantically related to the words in the task has influence on the task performance. Also, this has been supported by findings related to patients that have lesions in the relevant brain areas. For instance, patients with small tumours in the motor cortex were found to have specific impairments for abstract words processing and tool words processing as well.

The motor system, in conclusion, seems to contribute to semantic understanding, as the activations are automatic and immediate. Also, the functional relevance seems to be confirmed by TMS studies. In a nutshell, modality preferential areas seem to be important for semantic understanding.

However, there is still the possibility that, even though activation of motor system is present, it is epiphenomenal. Is there a strong evidence from the perspective of experimental neurolinguistics? Is it possible to agree on a semantic index everybody would be happy with? So the question to be asked is whether there is meaning in the motor system, and this requires an index of semantic process, which is to be based on semantic priming. The semantic priming effect has physiological basis, and it might be asked whether the motor system supports semantic priming in the sense that it shows its brain correlates. A recent experiment has been done in order to address the issue, and the results confimed a semantic priming effect, suggesting that activity in sensory and motor areas during conceptual processing

can also occur unconsciously and it is not necessarily caused by a vivid conscious experience (Trumpp et al, 2013).

According to the data presented, Pulvermüller concluded, the motor system is an example of modal system that is active and necessary for category semantic processing, and it also reflects semantic priming. A range of semantic hub areas are active and necessary for general semantic processes and also reflect semantic priming, so both semantic hubs and category specificity have to be explained. Such a model relies, as it should be according to the premises that were given, on basic neuroscience established principles.

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