

The boomerang tic*

0. *Background*

The strong coupling of gestures and speech has led researches to hypothesize that they belong to one integrated system of communication (Kendon, 2004; McNeill, 1992). This hypothesis has encouraged research into the neural basis of gesture and, in a broader perspective, into the relation between language and action in general.

The divide between cognition and bodily action, a traditional reflection of Cartesian cognitive science, contrasts with an embodied cognition viewpoint that, with more or less radical proposals, stresses the importance of connections between bodily actions and cognition and, specifically, between action and language, probably reflected in overlap of brain processes supporting language and action.

In this perspective we assumed that the study of the Tourette's Syndrome (TS) can be central as well as (i) studies investigating the neural representations of speech sound during comprehension, arguing that these neural representations during comprehension involve structures in the motor cortex used during production (Wilson *et al.*, 2004; Pulvermüller *et al.*, 2006; Wilson and Iacoboni, 2006); (ii) the neural representations of action-related language that support the meaning of an action word (at least partially) represented in the cortical motor system, arguing a crucial role of the motor system in understanding action-related language (Hauk *et al.*, 2004; Pulvermüller *et al.*, 2005; Vigliocco *et al.*, 2006); (iii) the overlap between neural processes of understanding sign language and spoken language (Newman *et al.*, 2002; Levanen *et al.*, 2001; Rizzolatti *et al.*, 2001; Emmorey *et al.*, 2004; Rizzolatti and Craighero, 2004); (iv) the neural basis of comprehension of speech and speech gestures (Gunter and Bach, 2004; Kelly *et al.*, 2004; Gallese and Lakoff, 2005; Kelly *et al.*, 2007; Willems *et al.*, 2006; Özyürek *et al.*, 2007; Skipper *et al.*, 2007).

Tourette's Syndrome seems a very intriguing disorder; it is an interesting neurobiologic condition because its tics are involuntary muscles contractions that produce stereotyped movements (motor tics) or sound (vocal tics): the vocal tics begin as inarticulate barks or grunts and later assume a verbal form (often coprolalic and sometimes echolalic). The analysis of the syntactic and

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semantic determinants of verbal tics shows that the verbal tics tend to occur at points of low information, especially probable before conjunction and pronouns, before longer words and words of low transitional probabilities. Tic strings occur in an environment of pauses and filled pauses, mainly syntactically determined¹.

Thus, linguistic considerations can be articulated with theories concerning the neural basis of Tourette's Syndrome, in an attempt to design a neurolinguistic model of the syndrome. Current conceptualization of TS have been shaped by advances in neuroscience and the emerging understanding of the role of the basal ganglia in implicit learning and habit formation (Peterson, 2001; Singer, 2005).

There is evidence that the basal ganglia are involved in language processes (such as fluency, sentence-level comprehension, grammar) (Lieberman, 2000, 2003). However the spectrum of involvement of the basal ganglia in behaviour includes higher cognitive functions. A growing body of evidence indicates that an abnormality in corticostriatalthalamocortical circuits and their neurotransmitter system is likely to underlie tic and coexisting problems in TS.

Walenski *et al.* (2007)² represents a very interesting attempt to formulate a neurolinguistic model of TS. In this experimental study, TS children are significantly faster than typically-developing control children at producing rule-governed past-tenses but not irregular and other unpredictable past tenses. They are also faster than controls at naming pictures of manipulated but not non-manipulated items. The results suggest that the processing of procedurally-based knowledge, both of grammar and of manipulated objects, is particularly speeded in TS children. The authors conclude that the frontal/basal ganglia abnormalities may thus lead not only to tics, but to a wider range of rapid behaviours, including in the cognitive processing of rules-governed forms in language and other types of procedural knowledge.

In our opinion Tourette's Syndrome represents an important issue in the debate about the relation between language and action and, in a broader perspective, about the embodiment theory³.

¹ Cf. MARTINDALE (1976), but a comprehensive profile of language in the Tourette's Syndrome is still lacking (LEGG *et al.*, 2005).

² According to dual-system model, known as the *Declarative/Procedural Model* (ULLMAN, 1999, 2001a, 2001b, 2004), the mental lexicon and the mental grammar are linked to distinct neurocognitive systems, each of which subserves non-language functions. Specifically, the mental grammar relies on the procedural memory system, which is rooted in frontal/basal-ganglia circuits. This system underlies the implicit learning of new motor and cognitive skills and habits, especially involving sequences, such as riding a bicycle or using tools.

³ For more discussion about Tourette's Syndrome from our point of view, see NICOLAI (2009).

1. Introduction

Tourette's Syndrome is a serious neurologic pathology characterized by different kinds of tic, which can affect the arms, the legs or the phonatory apparatus. The tics can be classified as motor, when an irregular and unexpected movement is produced, or as phonic, when the tic is represented by an uncontrollable vocalization. Every Tourette patient has his/her own tic "inventory". In other words, each subject has his/her own tic(s), which can consequently differ in form. Moreover, the tics can vary in form and intensity over the years. A fundamental characteristic of Tourette Syndrome is the *premonitory sensation*, that is, a physical or psychological urge which the patient feels just a few seconds before the tic occurs (Banaschewski *et al.*, 2003). In this case the tic seems to have a mitigating function which relieves the physical or the psychological sensation.

Notwithstanding the presence of some other symptoms, such as obsessive-compulsive behavior (OCB) or attention and hyperactive deficit (ADHD), the most evident and debilitating sign is the tic (Black *et al.*, 2006; Cath *et al.*, 2001). Although some tics can be made imperceptible, most tics are very visible because of their forms and jerky rhythm. The difficulty in passing unnoticed causes much discomfort for the Tourette patient, who experiences a feeling of embarrassment in public. In fact the Tourette patient suffers more from others' perception of the tic than from the tic itself.

However, the patient can try and manage his/her tic(s) if he/she feels the *premonitory sensation* coming on. If he/she feels this, he/she can find a strategy to manage the tic. Recently O'Connor (2005) has in fact identified three tic management strategies: *containment*, *masking* and *correction*. The *containment* strategy uses the momentary suppression of the tic through the tension of the tic antagonist muscle. This strategy is very frequent but increases the patient's anxiety. The *masking* strategy involves the physical covering of the area affected by the tic. For example, the Tourette patient can cover the most-often tic-affected area with large clothing or use the least-often tic affected limbs. The *correction* strategy is the most complex and elaborate. The tic is diverted into a gesture or an action modifying its course or adding components. The correction strategy is very effective: in fact a skilful Tourette patient can deceive the observer's eyes who can mistake the tic for a gesture. Thus it seems that the tic has acquired a new form.

In this research we shall underline the importance of this strategy and its implications for tic transformation and for variation of the patient's tic inventory. As mentioned above, every Tourette patient has his/her own tic inventory: a tic can change form, disappear, acquire components and an explanation for these mutations could be the use of the correction strategy. Repetition seems to

be the fundamental requirement for the transformation of a tic. In fact, the findings in this study suggest that only by the patient repeatedly correcting the tic does this correction lose its voluntary character and acquire the involuntary nature typical of a tic. This research will describe the correction strategy produced by two Tourette patients and will underline the importance of repetition as a fundamental requirement for the insertion of the corrected tic into the patient's tic inventory.

2. The research

This qualitative study is based on the analysis of two subjects affected by Tourette Syndrome. It aims to underline the regularities of tic manifestation and to analyze tic management strategies. In particular the way the tic has been corrected is investigated, how it has become part of the tic inventory, and, lastly, how it acquires meaning according to the patient's context and life experience.

3. The Analysis

In this section three cases of correction strategy in two Tourette's patients will be described and discussed.

Case 1

The first case, a 28 year-old male subject, OP, has been affected by Tourette syndrome since he was 8 years old. He underwent a drug therapy which was interrupted after three months because of the side effects of sleepiness and loss of energy. During the period of research and video recording the subject had not yet begun the drug therapy. The patient was video-recorded for three hours in a familiar setting in artificial light with a Sharp mini DV video camera. The voice is comprehensible even if there was no external microphone. The choice of a familiar setting was determined by the belief that it would help the patient feel at ease. OP was asked to talk freely about relevant personal events or situations - two car accidents and some photographs. The choice of the topic was completely up to him and the interlocutor intervened as little as possible.

Phases:

1) OP moves his right arm forward with his right forefinger up. The rhythm is irregular and the muscular tension is high. The timing of the movement from the preparation to the returning phase is 2.20 sec.



Figure 1. A case of a “fake deictic gesture”

2) OP moves his right arm forward with his right forefinger pointing straight ahead. The rhythm is jerky. The timing of the movement from the preparation to the returning phase is 6.00 sec.

These are only two of the numerous cases belonging to what we define as a “fake deictic gesture”. The tic affecting the right or the left arm was always produced with the forefinger straight as if it were a deictic gesture, but, notwithstanding the presence of all the formal parameters of a deictic gesture, the deixis referent was absent. Moreover, the timing of the tic simulating a deixis was compared with the timing of 9 deictic gestures produced during the video recordings. This comparison revealed that the execution time of the deictic gestures had an average of 1.36 sec., while that of the fake deictic gestures had an average of 2.36 sec.

The fake deictic gesture acquires a meaning only by considering what the observer witnesses. After the video recordings the observer, deceived by this tic, asked OP if he wanted to point to something or if the movement was simply a tic. OP explained that most of his tics affected the upper limbs and during adolescence he had felt extremely embarrassed by these uncontrollable movements. Thus he had devised a way of correcting this tic so that observers would mistake it for a deixis⁴. To sum up, the initial tic affecting only the arm was modified by the adding of a component, the straight on forefinger so that the observer would think it was a deictic gesture. But now every time the tic affects the arm the forefinger is always pointing straight ahead, even if there is no observer, as another video clip with a hidden camera showed.

Summing up, at the beginning the tic involved only the arm, while now it also involves the forefinger. Therefore, it is probable that the added forefinger

⁴ The self-reported patient’s memory could be a post-hoc rationalization. This possibility doesn’t change our interpretation.

was so frequently produced together with the tic during adolescence as to become an automatic movement and then, as time passed, a tic itself. In other terms, the new tic component, voluntary created by the patient, was transformed into an automatic response.

Case 2

The second subject analyzed in this research was a 33 year-old female, TA, who has been affected by the syndrome since she was 10 years old. The subject didn't take any medication for the treatment of the syndrome. She was video-recorded using the natural light in the hospital with a Sharp mini DV camera that had an internal microphone. The video recordings lasted 1 hour. At the beginning of the video-recording the subject was clearly embarrassed and the conversation was forced, but after a while the subject was more talkative and the frequency of the motor tics increased. The topic of the conversation was the patient's daily life and her job in a pen factory. Her tics mostly affect the mouth and the eye area of the face and both hands. The tics on the facial area produce many grimaces which distort the face. The tics affecting the hands involve the fingers, which become tense and produce many hasty movements in front of the nose and the mouth affected by the tics as well.

Phases:

The left fingers are ticcing. The nose tics too. The fingers touch the nose covering almost the whole facial area. After the finger tic, the fingers and the hand caress the left cheek. In the meantime, the nose tic has finished.

1) The left fingers are ticcing. The nose tics too. Her fingers touch the nose covering almost the whole facial area. After the finger tic, the fingers and the hand caress her left cheek. In the meantime, her nose tic has finished.



2) The left fingers affected by the tic touch the ticcing nose. The hand closes itself in a fist, which covers the facial area affected by the tics.



These tics are very frequent for TA. Every time a tic affects her facial area, her hand and fingers (also affected by tics) cover her face. Hypothesizing a process similar to that described in the first case, it is probable that the covering gesture belongs to a strategy aimed at covering the area with a tic. Thus, TA has created this covering gesture in order to make the tic less visible. Over time, this covering gesture has been inserted into her tic inventory and modified the initial tic. At first the tic only affected her face, and then it also involved her hand and fingers. Repetition has contributed to make the covering gesture automatic. To sum up, the repetition of a movement or a gesture could produce an automatism with tic qualities.

Case 3

During the video-recordings, the previously described subject, OP, produced a kind of correction which could signal the beginning of the correction process. Let us consider the following example:

1) OP has a tic in which he bends the torso on the right and then down. Then he folds the trunk towards the floor with his arms straight down. Finally, he arranges his socks and says: "Damn, these socks are always slipping down!". OP repeats the same movement three times during the next 20 minutes.



It is possible that this example shows the beginning of an automatism. When the tic affects the trunk, as OP has his arms straight down, he arranges his socks or jeans in order to "justify" his movement to the observer. We do not

actually know if this gesture will become part of his tic inventory because we cannot foresee the frequency of this tic and, therefore, of the subsequent movement. Longitudinal observations could be useful. However, what we can see is how a tic can be masked or corrected on line in front of an observer.

4. *Conclusions*

This brief case report can offer some insights into the process of tic management strategies. First it is evident that Tourette patients can correct or hide tics, modifying them or adding the parameters of a gesture. The first case shows how a tic can be converted into a deictic gesture thanks to the addition of a component, the forefinger. The second case shows the production of a covering gesture simultaneously with the tic manifestation in the facial area. After the correction or masking phase voluntarily created by the patient, this new gesture is inserted into the patient's tic inventory due to continuous repetition. The addition of the forefinger in the first case or the self-manipulation production in the second case become part of the tic they would disguise, acquiring an irregular rhythm and an uncontrollable character. In other words, movements and/or gestures produced in order to make the tic less visible lose their initially voluntary characteristic.

The transformation of the corrected tic into a tic *tout court* supports the idea that "motority" is a complex interweaving of experiences. We produce tests and errors of motor sequences which are then stored in our memory in a stereotyped form. When the new gesture/movement enters this storage of stereotyped schemes, it automatically becomes a foreseeable movement, a tic. The experience and/or the repetition of the movement/gesture permit the patient to select the movement for rapid involuntary production without constructing it anew. Thus the gesture acquisition of the tic parameters supports that when a Tourette patient produces a tic, the mechanism of sensorial retroaction of predetermined movement sequences is lacking.

In conclusion, if a voluntary gesture which gives the tic an acceptable veneer of a conventional gesture is repeated, it can become one of the most accessible and, therefore, retrievable motor engrammes. It enters into the patient's procedural memory process, the mnemonic system based on the implicit execution of movement. This long-term memory is connected to the subcortical structures (basal ganglia) and dopaminergic circuit which are the most damaged areas in the Tourette system. If the frontal/basal ganglia abnormalities result in unsuppressed behaviour, in decreased inhibition leading to a hyperkinetic behaviour profile and to an inability to suppress tics, if the processing of any procedurally based linguistic and non linguistic knowledge

(Walensky *et al.*, 2007) depends on the basal ganglia, we can suppose that the same procedural system and the same neural mechanisms operate in verbal and motor tics.

References

- BANASCHEWSKI, T., WOERNER, W. and ROTHENBERGER, A. (2003), *Premonitory Sensory Phenomena and Suppressibility of Tics in Tourette Syndrome: Developmental Aspects in Children and Adolescents*, in «Medical Children Neurology», 45, 10, pp. 700-703.
- BLACK, K.J. and WEBBS, H. (2006), *Tourette Syndrome and Other Tic Disorders*, in «Pediatric Neurology», 22, 3, pp. 1-11.
- CATH, D.C., SPINHOVEN, P. and HOOGDUIN, C.A. (2001), *Repetitive Behaviours in Tourette's Syndrome and OCD with and without Tic: What Are the Differences?*, in «Psychiatry Research», 25, 101, 2, pp. 171-185.
- CUMMINGS, J.L. (1993), *Frontal Sub-Cortical Circuits and Human Behavior*, in «Archives of Neurology», 50, pp. 873-880.
- EMMOREY, K., GRABOWSKI, T., MCCULLOUGH, S., DAMASIO, H., PONTO, L., HICHA, R. *et al.* (2004), *Motor-iconicity of sign language does not alter the neural systems underlying tool and action naming*, in «Brain and Language», 89, pp. 27-37.
- GALLESE, V. and LAKOFF, G. (2005), *The brain's concepts: The role of the sensory-motor system in conceptual knowledge*, in «Cognitive Neuropsychology», 22, pp. 455-479.
- GUNTER, T.C. and BACH, P. (2004), *Communicating hands: ERPs elicited by meaningful symbolic hand postures*, in «Neuroscience Letters», 372, pp. 52-56.
- HAUK, O., JOHNSRUDE, I. and PULVERMÜLLER, F. (2004), *Somatotopic representation of action words in human motor and premotor cortex*, in «Neuron», 41, pp. 301-307.
- KELLY, S. D., KRAVITZ, C. and HOPKINS, M. (2004), *Neural correlates of bimodal speech and gesture comprehension*, in «Brain and Language», 89, pp. 253-260.
- KELLY, S. D., WARD, S., CREIGH, P. and BARTOLOTTI, J. (2007), *An intentional stance modulates the integration of gesture and speech during comprehension*, in «Brain and Language», 101, pp. 222-233.
- KENDON, A. (2004), *Gesture: Visible Action as Utterance*, Cambridge University Press, Cambridge.
- LANG, A. E., CONSKY, E. and SANDOR, P. (1993), *Signing Tics – Insight into the Pathophysiology of Symptoms in Tourette's Syndrome*, in «Annals of Neurology», 33, 2, pp. 212-215.

- LEGG, C., PENN, C., TEMLETT, J., SONNENBERG, B. (2005), *Language skills of adolescents with Tourette Syndrome*, in «Clinical Linguistics and Phonetics», 19, pp. 15-33.
- LEVANEN, S., UUTELA, K., SALENIUS, S. and HARI, R. (2001), *Cortical representation of sign language: Comparison of deaf signers and hearing non-signers*, in «Cerebral Cortex», 11, pp. 506-512.
- LIEBERMAN, P. (2000), *Human Language and our Reptilian Brain*, Harvard University Press, Cambridge (MA).
- LIEBERMAN, P. (2003), *Motor control, speech and evolution of human language*, in CHRISTIANSEN, M. H. and KIRBY, S. (2003, eds.), *Language Evolution*, Oxford University Press, Oxford, pp. 255-271.
- MARTINDALE, C. (1976), *The grammar of the tic in Gilles de la Tourette's syndrome*, in «Language and Speech», 19, pp. 266-275.
- MCNEILL, D. (1992), *Hand and Mind: What Gestures Reveal about Thought*, University Press, Chicago.
- NEWMAN, A.J., BAVELIER, D., CORINA, D., JEZZARD, P. and NEVILLE, H.J. (2002), *A critical period for right hemisphere recruitment in American Sign Language processing*, in «Nature Neuroscience», 5, pp. 76-80.
- NICOLAI, F. (2009), *La sindrome di Tourette: i tic della mente*, Edizioni PLUS, Pisa.
- O'CONNOR, K. (2005), *Cognitive-Behavioral Management of Tic Disorder*, John Wiley and Sons, Chichester.
- ÖZYÜREK, A., WILLEMS, R.M., KITA, S. and HAGOORT, P. (2007), *On-line integration of semantic information from speech and gesture: Insights from event-related brain potentials*, in «Journal of Cognitive Neuroscience», 19, pp. 605-616.
- PETERSON, B. (2001), *Neuroimaging Studies of Tourette Syndrome: A Decade Progress*, in «Advances in Neurology», 85, pp. 179-196.
- POGGI, I. (2004), *The Italian Gestionary. Meaning, Representation, Ambiguity and Context*, in ALLWOOD, J. (2004, ed.), *Papers from the Second Nordic Conference an Multimodal Communication*, Goteborg University, Goteborg, pp. 13-36.
- PULVERMÜLLER, F., HAUKE, O., NIKULIN, V.V. and ILMONIEMI, R.J. (2005), *Functional links between motor and language systems*, in «European Journal of Neuroscience», 21, pp. 793-797.
- PULVERMÜLLER, F., HUSS, M., KHERIF, F., MOSCOSO DEL PRADO MARTIN, F., HAUKE, O. and SHTYROV, Y. (2006), *Motor cortex maps articulatory features of speech sounds*, in *Proceedings of the National Academy of Sciences of the United States of America*, 103, pp. 7865-7870.
- RIZZOLATTI, G. and CRAIGHERO, L. (2004). *The mirror-neuron system*, in «Annual Review of Neuroscience», 27, pp. 169-192.

- RIZZOLATTI, G., FOGASSI, L. and GALLESE, V. (2001), *Neurophysiological mechanisms underlying the understanding and imitation of action*, in «Nature Reviews Neuroscience», 2, pp. 661-670.
- SHAPIRO, A.K., SHAPIRO, E.S. and YOUNG, J.G. (1998), *Gilles de la Tourette Syndrome*, Raven Press, New York.
- SINGER, H.S. (2005), *Tourette's Syndrome: from Behaviour to Biology*, in «The Lancet of Neurology», 4, pp. 149-159.
- SKIPPER, J.I., GOLDIN MEADOW, S., NUSBAUM, H.C. and SMALL, S.L. (2007), *Speech associated gestures, Broca's area and the human mirror system*, in «Brain and Language», 101, pp. 260-277.
- ULLMAN, M.T. (1999), *Acceptability ratings of regular and irregular past tense forms: Evidence for a dual-system model of language from word frequency and phonological neighbourhood effects*, in «Language and Cognitive Processes», 14, pp. 47-67.
- ULLMAN, M.T. (2001a), *The declarative/procedural model of lexicon and grammar*, in «Journal of Psycholinguistic Research», 30, pp. 37-69.
- ULLMAN, M.T. (2001b), *A neurocognitive perspective on language: The declarative/procedural model*, in «Nature Reviews Neuroscience», 2, pp. 717-726.
- ULLMAN, M.T. (2004), *Contributions of memory circuits to language: The declarative/procedural model*, in «Cognition», 92, pp. 231-270.
- VIGLIOCCO, G., WARREN, J., SIRI, S., ARCIULI, J., SCOTT, S. and WISE, R. (2006), *The role of semantics and grammatical class in the neural representation of words*, in «Cerebral Cortex», 16, pp. 1790-1796.
- WALENSKY, M., MOSTOFSKY, S.H. and ULLMAN, M.T. (2007), *Speeded processing of grammar and tool knowledge in Tourette's Syndrome*, in «Neuropsychologia», 45, pp. 2247-2460.
- WILLEMS, R.M., ÖZYÜREK, A. and HAGOORT, P. (2006), *When language meets action: The neural integration of gesture and speech*, Cerebral Cortex Advance Access published December 11.
- WILSON, S. M., SAYGIN, A. P., SERENO, M. I. and IACOBONI, M. (2004), *Listening to speech activates motor areas involved in speech production*, in «Nature Neuroscience», 7, pp. 701-702.
- WILSON, S.M., and IACOBONI, M. (2006), *Neural responses to nonnative phonemes varying in producibility: Evidence for the sensorimotor nature of speech perception*, in «Neuroimage», 33, pp. 316-325.

