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► **To cite this version:**

François Osiurak, Didier Le Gall. Apraxia : a gestural or a cognitive disorder ?. *Brain - A Journal of Neurology*, 2015, 138 (3), pp.e333-e333. <10.1093/brain/awu238>. <hal-04686587>

HAL Id: hal-04686587

<https://hal.science/hal-04686587v1>

Submitted on 4 Sep 2024

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APRAXIA: A GESTURAL OR A COGNITIVE DISORDER?

François Osiurak¹ and Didier Le Gall¹

¹Laboratoire d'Etude des Mécanismes Cognitifs (EA 3082), Université de Lyon, France

²Laboratoire de Psychologie des Pays de la Loire (EA 4638), Université d'Angers, France

CORRESPONDENCE

Correspondence concerning this article should be addressed to:

François Osiurak

Laboratoire d'Etude des Mécanismes Cognitifs (EA 3082)

Institut de Psychologie

5, avenue Pierre Mendès-France

69676 Bron Cedex, France.

Email: Francois.Osiurak@univ-lyon2.fr

Sir, We read with great interest the article by Buxbaum *et al.* (in press) about the critical brain regions for tool-related and imitative actions. The authors performed voxel-based lesion-symptom mapping with data from 71 left brain-damaged patients. Three types of actions were examined: (1) pantomime to sight of tools (GestTool), (2) pantomime on imitation (ImTool), and (3) imitation of meaningless gestures (ImNov). Impairments in all three of the gesture tasks were associated with lesions in left middle and inferior temporal and inferior parietal regions. Moreover, tool-related actions (both GestTool and ImTool) were dependent on left middle and inferior temporal lobe, while imitation of meaningless gestures (ImNov) were dependent on left inferior parietal regions. From these findings, the authors drew two conclusions. First, the left inferior parietal lobe might be the basis for the kinematic component of the praxis system, useful for planning movement trajectories in terms of extent, direction and timing. Second, middle and inferior temporal regions might support representational components of the praxis system (e.g., the arm and hand posture associated with the use of a hammer)¹.

The results reported by Buxbaum *et al.* (in press) are of primary interest because, as they stressed, this study is the largest prospective study of apraxia-related lesions to date. Unfortunately, the authors overlook important data that can lead to another interpretation of their findings. First, recent evidence indicates that left inferior parietal regions are critical to both the actual use of familiar tools with the corresponding object (i.e., real tool use) and the use of novel tools to solve mechanical problems (for reviews, see Goldenberg, 2013; Osiurak, 2014; Osiurak *et al.*, 2010). These results are difficult to interpret with the kinematic component hypothesis formulated by Buxbaum *et al.* (in press) since the main difficulty of the left brain-damaged patients that fail to solve mechanical problems is not to plan hand postures, but rather to select the appropriate tools to solve problems (Osiurak *et al.*, 2013). Perhaps, a better interpretation is that the

left inferior parietal lobe is involved in all the tool-use situations by supporting the ability to reason about the physical object properties (i.e., the technical reasoning hypothesis; Osiurak, 2014; Osiurak *et al.*, 2010, 2013; for a somewhat similar interpretation, see Goldenberg, 2013). This hypothesis has also been extended to imitation of meaningless postures. Indeed, mechanical problem solving might also be applied to the multi-part mechanical object that is the human body (Goldenberg, 2013). In sum, the technical reasoning hypothesis can account for why Buxbaum *et al.* (in press) found that left inferior parietal regions were associated with all three of their tasks.

A second issue concerns the involvement of inferior and middle temporal regions in tool-related actions (GestTool and ImTool). Evidence has indicated that patients with a selective deficit of semantic knowledge and, as a result, temporal lobe lesions are able to use familiar tools with the corresponding objects (i.e., real tool use) or to use novel tools to solve mechanical problems (Goldenberg & Spatt, 2009; for a review, see Osiurak, 2014). In line with the aforementioned technical reasoning hypothesis, this can be explained by the integrity of the left inferior parietal lobe in these patients. Interestingly, these patients have been shown to encounter difficulties in demonstrating how to use a tool presented in isolation (e.g., Hodges *et al.*, 2000). To account for this, Osiurak (2014; see also Osiurak *et al.*, 2010) suggested that semantic knowledge stored in temporal regions is critical to determine the social usages associated with tools (e.g., knowing that a hammer is commonly used with nails and can be found in a workshop). In this frame, semantic knowledge is not the basis for understanding the potential mechanical actions, a function specific to technical reasoning. And, temporal regions would be particularly involved when people have to determine how to use a familiar tool presented in isolation, because information is lacking, particularly about the examiner's expectations.

After all, asking someone to show how to use a knife presented in isolation (as in the GesTool task of Buxbaum *et al.*, in press) is relatively ambiguous because the knife can be used for a great number of social usages (e.g., cutting bread, opening an envelope, peeling a fruit). The additional presence of bread can help the subject to understand the examiner's expectations (as in real tool use). But, if the subject demonstrates how to peel a fruit in a pantomime condition (e.g., GesTool) his performance might be viewed as impaired because this is not the action expected by the examiner. Nevertheless, most people can decide to show how to use the knife with "an imaginary piece of bread" because they know that this is the most frequent usage of this tool, and as a result, what is certainly expected by the examiner. Said differently, the ability to perform tool-related gestures when information is lacking (as in GesTool and ImTool) might require social knowledge stored in temporal regions. This is another way of interpreting the data of Buxbaum *et al.* (in press).

In sum, Buxbaum *et al.* (in press) perpetuate the traditional perspective of apraxia, consisting in considering apraxia, first and foremost, as a gestural disorder (e.g., the kinematic versus the representational component of tool gestures). The interpretation offered here provides an alternative by suggesting that apraxia must be rather viewed as "the cognitive side of motor control" (Goldenberg, 2013).

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FOOTNOTE 1

Note that these conclusions lead to a profound revision of the initial Buxbaum's (2001) model. In this model, the left inferior parietal lobe was viewed as critical for storing sensorimotor knowledge about how to manipulate familiar tools, whereas the superior parietal lobes were thought to support imitation of meaningless gestures via a direct route from vision to action.

ACKNOWLEDGMENTS

This work was supported by grants from ANR (Agence Nationale pour la Recherche; Project Démences et Utilisation d'Outils/Dementia and Tool Use, N°ANR 2011 MALZ 006 03), and was performed within the framework of the LABEX CORTEX (ANR-11-LABX-0042) of Université de Lyon, within the program "Investissements d'Avenir" (ANR-11- IDEX-0007; F. Osiurak) operated by the French National Research Agency (ANR).