



Tool use in left brain damage and Alzheimer's disease: What about function and manipulation knowledge?

Christophe Jarry, François Osiurak, Jérémy Besnard, Josselin Baumard,
Mathieu Lesourd, Bernard Croisile, Frédérique Etcharry-Bouyx, Valérie
Chauviré, Didier Le Gall

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ABSTRACT:

Tool use disorders are usually associated with difficulties in retrieving function and manipulation knowledge. Here, we investigate tool use (Real Tool Use, RTU), function (Functional Association, FA) and manipulation knowledge (Gesture Recognition, GR) in 17 Left-Brain Damaged (LBD) patients and 14 AD patients (Alzheimer Disease). LBD group exhibited predicted deficit on RTU but not on FA and GR while AD patients showed deficits on GR and FA with preserved tool use skills. These findings question the role played by function and manipulation knowledge in actual tool use.

Keywords: Tool Use; Apraxia; Function Knowledge; Manipulation Knowledge; Left Brain Damage; Alzheimer's Disease.

1. Introduction

Difficulties to actually use tools (i.e., apraxia of tool use) have traditionally been associated with left brain damage (LBD) and cortical neurodegenerative diseases such as Alzheimer's disease (AD). Actual tool use has been extensively suggested to be supported by two kinds of knowledge, namely, function knowledge and manipulation knowledge. In this frame, evidence indicates that apraxia of tool use in LBD patients might result from a specific impairment of manipulation knowledge (Buxbaum & Saffran, 2002). By contrast, alteration of function knowledge or manipulation knowledge, or both has been invoked to explain tool use disorders in AD patients (Chainay et al., 2006 ; Lesourd et al., 2013). In broad terms, the kind of knowledge underlying apraxia of tool use seems to be less specific in AD patients than in LBD patients, raising the issue of whether tool use disorders are of same nature and severity in LBD and AD patients, as proposed by Rapcsak et al. (1989).

The present study addressed this issue by exploring actual tool use, function knowledge and manipulation knowledge in both LBD and AD patients. Another key purpose of this study is that all three experimental tasks were being constructed from exactly the same item pool to ensure that the data are indeed properly comparable.

2. Method

2.1. Participants

A total of 67 right-handed subjects participated in the study. The 17 LBD patients (7 women; mean age = 68.2 years-old; SD = 9.5) suffered from a first-time unilateral cerebrovascular accident (bleeding: 2/17; ischemia: 15/17) and were tested on their ipsilesional hand (i.e., the left hand). Considering that CT or MRI scans were collected for clinical purposes and using different scanners, patients' brain lesions were only classified for effect on frontal (8), temporal (8), parietal (13) and occipital cortex (2) and subcortical nuclei (8). According to preliminary interview and clinical criteria, aphasia was classified as global in 1, Broca in 5, Wernicke in 5, amnesic in 2, subcortical in 2 and non-classifiable in 2. There were 14 patients (6 women; mean age = 77.2 years-old; SD = 3.8; Mini-Mental State Examination, MMSE = 21.5, SD = 3.2, range: 10-24) with a diagnosis of probable Alzheimer's disease established according to the NINCDS-ADRDA criteria (McKhann et al., 1984). They were tested with their dominant hand (i.e., right hand). Thirty- six age-matched control subjects were also recruited from senior citizens' community associations. They had no previous history of neurological or psychiatric illnesses. Nineteen of them were tested on their left hand (14 women; mean age = 69.4 years-old, SD= 7.7; MMSE = 28.6, SD = 1.2, range: 26-30) and 17 on their right hand (11 women; mean age = 75.9 years-old, SD= 4.1; MMSE = 28.5, SD = 1.4, range: 26-30) to serve as control subjects for the LBD patients (CL)

and for AD patients (CR), respectively. Informed consent was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki.

2.2. Real Tool Use (RTU)

This task consisted of 12 familiar tools (2 practice items and 10 experimental items; e.g. screwdriver) and the corresponding objects (e.g. nail in a wooden board) upon which they could be used. One pair at a time was placed on the table and subjects were asked to do what is typically done with the presented tools and objects (see Jarry et al., 2013). Two points were given if the expected action was directly achieved (i.e., correct grasp and application of tools) within the time limit irrespective of the participant's movement speed. One point was given if the participant performed the action after self-corrections. No points were given when the action was not successfully achieved (maximum = 20 for each condition). The time limit was set to 1 minute for each item.

2.3. Functional Association (FA)

Four images of objects were presented below the picture of a tool (see **Figure 1A**). Subjects were asked to select one out of four objects that best matched the target tool. The target tool (e.g. hammer) and the correct, corresponding object (e.g. nail) were functionally associated. Both tools and corresponding objects were the same as those used for RTU (i.e., two practice items and 10 experimental items). A score of 1 point was given if the correct response was given in 30 sec, totaling a score of 10.

2.4. Gesture Recognition (GR)

This task consisted of twelve sets of four photographs (including 2 practice items; see Jarry et al., 2013; see **Figure 1B**). In each set, one photograph depicted the correct use of the

tool, whereas the remaining three photographs showed the tool incorrectly oriented, inappropriately held or dangerously held. The tools shown on the photographs were the same as those used for RTU and FA. One point was credited for each correct response given in 30 sec, totalling 10 points.

< Insert Figure 1 about here >

3. Results

Because of unequal group sizes and partly unequal variances, non parametric tests were preferred. Mann-Whitney U-tests (**Table 1**) revealed that LBD patients performed worse than control subjects (CL) on RTU ($z = 2.72, p < .01$). However, they did not significantly differ from CL on GR ($z = 0.42, p = .67$) and FA ($z = 1.39, p = .16$). Analyses also indicated that AD patients scored significantly lower than control subjects (CR) on GR ($z = 2.16, p < .05$) and FA ($z = 2.09, p < .05$). No difference was found between AD patients and CR subjects on RTU ($z = 0.82, p = .41$).

< Insert Table 1 about here >

According to Spearman rank order correlations, the only significant correlation observed in LBD patients was between GR and FA ($\rho = .55, p < .01$). No correlation was reported between these two tasks and RTU (all $\rho < .46$, all $p > .05$). By contrast, no

significant correlation was found in AD patients between the three experimental tasks (all $\rho < .31$, all $p > .05$).

As shown in **Table 2**, comparisons between patients' scores (LBD and AD) and controls (CR and CL) were performed using a statistical method for single-case studies in neuropsychology (Crawford and Garthwaite, 2002). According to Fisher's exact test, there were no significant differences in the proportion of patients (LBD or AD) showing a deficit in any of the three experimental tasks. However, the analysis of individual performances according to Crawford and Garthwaite's (2005) revised criteria for classical and strong dissociations provided evidence for dissociations between RTU, FA and GR, particularly in LBD patients.

< Insert Table 2 about here >

4. Discussion.

Our main finding is that LBD patients met difficulties with tool use (RTU) but preserved function (FA) and manipulation knowledge (GR) whereas AD showed deficits in knowledge (FA and GR) but preserved tool use abilities.

Altogether, these results provide additional arguments to question the link between action knowledge (function and manipulation) and actual tool use (Goldenberg and Spatt, 2009; Jarry et al., 2013). It also leads us to question the nature of apraxia of tool use in AD patients suggesting that tool use impairments might stem from different type of disorders in LBD and AD patients – i.e., specific *versus* secondary. Concerning AD (from moderate to mild), results corroborate previous studies demonstrating the role of proprioceptive input (Chainay et al., 2006) and that tool use skills are relatively preserved when the tool is given

with its corresponding object, with no distractor, nor sequential constraint (Lesourd and al., 2013).

Besides, two points deserve further attention. First, our results are at odds with previous studies indicating impaired manipulation and function knowledge in LBD patients (Buxbaum & Saffran, 2002). This discrepancy could be explained by the important variability of our LBD group and the fact that we did not distinguish between apraxic and nonapraxic subjects because of the small group size. Another possibility is that Buxbaum and Saffran (2002) asked subjects to select objects sharing similar function or manipulation. This differs from the testing method presented here (FA and GR), based on complementarities (e.g., saw and piece of wood) rather than similarities (e.g., saw and axe). In this kind of experimental tasks, results of LBD patients are probably very sensitive to material and instructions. Second, the issue of why AD patients failed on GR but not on RTU remains open. A first possibility is that manipulation knowledge would be specifically impaired in AD, reinforcing the idea that manipulation knowledge is not strictly necessary to support tool use. Furthermore, GR (and FA) could be considered as visuospatial tasks and difficulties observed here in AD patients might be due to deficits in higher visuospatial functions that are known to be associated with certain praxis disturbances in Alzheimer's disease (Quental et al., 2013).

Future research with a larger sample of patients is needed to confirm these preliminary results. Nevertheless this study underlines the need for continuation of comparative studies, both in neurodegenerative disorders and left brain damaged patients, perhaps by distinguishing between apraxic and non-apraxic patients.

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Table 1 – Table 1 – Means of Experimental tests. Comparisons between each group of patients (LBD, AD) and its corresponding control group (CL, CR, respectively).

	Max	LBD	CL	LBD vs CL	AD	CR	AD vs CR
RTU	20	16.72 (4.64)	19.84 (0.36)	**	19.54 (0.72)	19.76 (0.42)	ns
FA	10	8.11 (2.81)	9.74 (0.44)	ns	9.14 (0.83)	9.71 (0.46)	*
GR	10	8.72 (1.33)	9.05 (0.94)	ns	7.79 (1.61)	9.12 (1.02)	*

Between-group comparisons were performed with Mann-Whitney U-tests.

ns, non-significant ($p > .05$); * $p < .05$; ** $p < .01$.

Values in parentheses are standard deviations.

RTU, Real Tool Use; FA, Functional Association; GR, Gesture Recognition.

Table 2 – Patients impairments and dissociations according to Crawford and Garthwaite's criteria (2002, 2005).

	Percent of patients showing a deficit ^b			Percent of classical and strong dissociations ^c		
	RTU	FA	GR	RTU-GR	RTU-FA	FA-GR
LBD	9/17	5/17	4/17	8/17	9/17	5/17
	53%	30%	23%	47%	53%	30%
MA	2/14	2/14	7/14	3/14	1/14	4/14
	15%	14%	50%	21%	7%	28%
LBD vs MA ^a	$p=.057$	$p=.412$	$p=.153$	$p=.258$	$p=.009$	$p=1$

^aTwo by two tables analysis were performed with Fisher's exact test.

^bA deficit means that individual's scores are significantly different ($p<.05$) from the control sample (CL for LBD and CR for MA).

^cTo summarize the findings, classical and strong associations were added together.

RTU, Real Tool Use; FA, Functional Association; GR, Gesture Recognition.

Figure legends

Figure 1. Functional Association (A) and Gesture Recognition (B).

Figure 1

