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Object utilization and object usage.

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Abstract

It has been suggested that both conceptual knowledge and the ability to infer function from structure can support use of familiar objects. The present paper proposes an alternative view which is based upon the idea that object use requires solely the ability to reason about technical ends. Technical ends (e.g., cutting, sewing) are not purposes (e.g., eating, dressing), but the technical way to achieve them. This perspective suggests that there is no mutual relationship between technical ends and purposes since the same purpose (e.g., writing) can be achieved thanks to several distinct technical ends (graving, carving, tracing), and, inversely, the same technical end (e.g., tracing) can achieve different purposes (making up, writing, drawing). Consistent with this, it can be postulated that object use would depend upon the ability to reason about technical ends, and conceptual knowledge would not be directly concerned with objects use, but might determine which technical end is usually associated with a given purpose. To contribute to the discussion, the present study describes the behaviour of a female patient with left anterior temporal lobe lesions and bilateral frontal lobe lesions following closed-head injury. Conceptual knowledge of object function was severely impaired. She also encountered difficulties when asked to demonstrate the use of familiar objects in isolation (e.g., demonstrating the use of a screwdriver without the screw). The presence of recipient improved her performance (e.g., demonstrating the use of a screwdriver with the screw). It is important to note that she had a normal performance when asked to perform unusual applications of familiar objects for achieving a goal, without providing the usually applied object (e.g., screwing a screw with a knife). Consistent with the theoretical framework supported here, her performance profile suggests an intact ability to reason about technical ends (i.e., utilization), in the presence of a defective ability to determine the usual relationship between a technical end and a purpose (i.e., usage).

Keywords: Tool use, apraxia, action, conceptual knowledge, object misuse.

1. Introduction

In a seminal paper on object recognition, Warrington (1975) defined the term “semantic memory” as “that system which processes, stores and retrieves information about the meaning of words, concepts and facts”. Warrington’s unitary view of semantic memory was later challenged by evidence that brain lesions can selectively impair knowledge of living or nonliving things (Breedin *et al.*, 1994; Hillis and Caramazza, 1991; Warrington and McCarthy, 1987; Warrington and Shallice, 1984). One account of these impairments is that category specificity reveals the differential weighting of perceptual and functional information in the representations of different kinds of things (e.g., Warrington and Shallice, 1984). Even if alternative theoretical perspectives have been advanced (Caramazza and Shelton, 1998; De Renzi and Lucchelli, 1994; Moss *et al.*, 1997), most of these authors agree that the ability to conceive the appropriate goal for which an object is typically used depends upon knowledge about object function (see Humphreys and Forde, 2001).

Since the early 20th century, impairment of object use has been at the centre of preoccupations of the literature on apraxia (e.g., Liepmann, 1920). Apraxia is a disorder affecting the purposeful execution of learned and voluntary movements, in the absence of elementary sensorimotor deficits and comprehension impairment (De Renzi, 1989). Following the suggestions made by investigators of object recognition, the major contemporary accounts of apraxia attribute object use impairment to loss of conceptual knowledge about object function (Ochipa *et al.*, 1992; Rothi *et al.*, 1991; Roy and Square, 1985). This kind of knowledge has been distinguished from knowledge of object manipulation (see Buxbaum *et al.*, 2000; Buxbaum and Saffran, 2002; Jeannerod, 1997; Sirigu *et al.*, 1991). Furthermore, it has been suggested that object-function knowledge might be particularly useful when objects have to be used in an unfamiliar way (Hodges *et al.*, 2000; Rothi *et al.*, 1991; Roy and Square, 1985; however, for an alternative view, see Bartolo *et al.*, 2007).

The role of semantic memory in object use has been disputed in recent years on the grounds that some patients may name or describe objects that they are unable to use (Fukutake, 2003; Heath *et*

al., 2003; Motomura and Yamadori, 1994; see also Zangwill, 1960). The opposite profile of performance was also found (Buxbaum *et al.*, 1997; Negri *et al.*, 2007). In line with these reports, it has recently been observed that patients with semantic dementia show selective conceptual deficit without impairment in using objects, whereas patients with corticobasal degeneration present the inverse pattern of performance (Hodges *et al.*, 1999; Spatt *et al.*, 2002). Semantic dementia is known to affect the anterior (polar) and inferolateral portions of the temporal lobe (Snowden *et al.*, 1996). Basal ganglia and parietal lobes atrophy is frequently observed in patients with corticobasal degeneration (Gibb *et al.*, 1989). On the basis of these neuroanatomical considerations, Hodges *et al.* (1999) suggested that the temporal lobe system would be necessary to identify “what” an object is, while sensory inputs to a parietal “how” system could trigger the use of objects without reference to object-specific conceptual knowledge.

Consistent with the distinction drawn by Hodges *et al.* (1999), it has been suggested that object use might be supported by the ability to infer function from structure (see Goldenberg and Hagmann, 1998; Pilgrim and Humphreys, 1991; Riddoch *et al.*, 1988; Rothi *et al.*, 1991). Nevertheless, the ability to infer function from structure would only be expected when conceptual knowledge is degraded – or when objects are unfamiliar (Bozeat *et al.*, 2002; Goldenberg and Hagmann, 1998; Hodges *et al.*, 2000). The corollary is that the semantic route remains the route by default.

Conceptual knowledge is still considered as essential for using objects, despite the growing literature showing the opposite (e.g., Buxbaum *et al.*, 1997). One possible reason for this may come from the assumption that semantic memory contains knowledge about perceptual attributes of objects (see Roy and Square, 1985). Thus, Hodges *et al.* (2000) presumed that one would rather choose a coin than a heavy card to drive a screw because of *knowing* that coins are hard and inflexible. As long as semantic memory will be supposed to provide both information about familiar functions of objects and knowledge about perceptual attributes of objects, enabling the unfamiliar use of objects, the role of direct inference in object use will appear limited.

An alternative approach introduced by Gagnepain (1990, 1994; see also Le Gall, 1998; Le Gall and Sabouraud, 1995; Sabouraud, 2006) has risen raised the question whether knowledge about perceptual attributes of objects is “specific” enough to perform actions for which functional knowledge is not available. Indeed, what does “a pencil is light” inform us about possible uses of this object? At a purely sensorimotor level, knowing that a pencil is light enough to be freely manipulated by human beings does not give information about possible actions with other objects. At a purely technical level, this single information is insufficient to determine all ~~the~~ possible actions. Pencils are usually too light to knock a bear out, but heavy enough to crush an ant. Thus, it would be unlikely that the ability to use objects is reliant upon knowledge about perceptual attributes of objects, unless functional and associative knowledge is systematically activated (e.g., heavy enough *to crush an ant*), thereby questioning the relevance of distinguishing between two kinds of conceptual knowledge (perceptual vs. functional).

Taking into consideration these theoretical limits, Gagnepain (1990) proposed a somewhat different view in which human beings are assumed to reason about technical means at the moment they decide to use objects. Technical ends (e.g., cutting, sewing) are not purposes (e.g., eating, dressing), but the technical way to achieve them. This perspective suggests that there is no mutual relationship between technical ends and purposes since the same purpose (e.g., writing) can be achieved thanks to several distinct technical ends (graving, carving, tracing), and, inversely, the same technical end (e.g., tracing) can achieve different purposes (making up, writing, drawing).

That is, the question arises as to why do some technical ends (e.g., tracing) seem more familiar than others (engraving) to achieve a specific goal (writing)? Gagnepain (1990) suggested that these privileged relationships, and the knowledge we have about them, are precisely the manifestation of “usage”. The corollary is that usage is not a universally shared value but it is relative to ~~the~~ social conditions that people experience. When applied to the use of objects, usage can lead individuals from different societies to develop various technical ends to achieve the same goal. That is, for instance, the case of feeding behaviours which are performed in France with cutleries and in Japan

with sticks. In sum, and in contrast to influential accounts asserting that the ability to infer function from structure is only expected when conceptual knowledge is degraded (e.g., Bozeat *et al.*, 2002), Gagnepain's (1990) theoretical framework suggests that any use of objects requires both technical skills – i.e., “utilization” – and knowledge about the technical ends usually used to achieve goals – i.e., “usage”. Gagnepain (1990) also suggested that tasks assessing knowledge about object function would be particularly useful for evaluating the ability to determine usage.

We think that the distinction drawn between utilization and usage can open perspectives to explain object use impairment, notably when selective difficulties are encountered in using objects in isolation (Bozeat *et al.*, 2002; Dumont *et al.*, 1999; Hayakawa *et al.*, 2000; Sirigu *et al.*, 1991). More specifically, we hypothesize that usage is all the more necessary in environmental situations in which all ~~the~~ mechanical constraints for using an object are not available such as when requested to use isolated objects in the absence of goal expressed by the examiner (for a somewhat similar view, see Bozeat *et al.*, 2002; Hodges *et al.*, 2000). At a technical level, a screwdriver placed on a desk is not useful unless being used as a chisel. Even if the comparison can seem mundane, a patient with a usage disorder should behave as a prehistoric man, only just mastering the use of flint, who would attempt to detect, from the technical ends he determines, the intended goal. Furthermore, it would not be appropriate to conceive that this prehistoric man exhibits an object use impairment if he starts to scrape the tabletop of the desk. To contribute to this discussion, we present the observation of a female patient, MJC, who developed profound disturbances in several cognitive domains subsequent to a closed-head injury. Of particular interest was a pronounced impairment in using objects in isolation (e.g., demonstrating the use of a screwdriver without the screw), while the use of objects with recipients¹ was normal (e.g., demonstrating the use of a screwdriver with the screw).

2. Material and methods

2.1. Subject

MJC, a woman who completed 8 years of education, was 74 years old in May 2005 when she suffered a severe closed-head injury due to motor vehicle accident and resulting in a left parietal skull fracture and sub-arachnoid haemorrhage (Glasgow coma scale, 6/15). Coma lasted nine days. A computed tomographic scan two weeks after the accident disclosed haemorrhage contusion of the left anterior temporal and bilateral frontal regions (Fig. 1).

Five months after the accident, MJC was admitted to the neuropsychological rehabilitation service of the Regional Centre for Functional Rehabilitation. Neurological examination found neither elementary sensorimotor deficit, nor evidence of neglect or other forms of spatial deficit. She mainly exhibited severe post-traumatic retrograde amnesia (Galveston Orientation and Amnesia Test, 44/100; Levin *et al.*, 1979). Handedness assessment with the Edinburgh Handedness Inventory (Oldfield, 1971) indicated a marked right hand preference (score of 100%).

Fig. 1 about here

2.2. Preliminary neuropsychological evaluation

Our neuropsychological investigations were carried out in September 2005 and in June 2006, respectively, at the fourth and the thirteenth months following the accident. Table 1 summarizes neuropsychological investigations carried out in September 2005. Performances obtained in June 2006, (not reported), showed that her condition has been fairly stable since the first clinical assessment.

Language assessment was carried out with the MT-86 β Aphasia Battery (Nespoulous *et al.*, 1992). Spontaneous language was fluent, well articulated and not characterized by phonemic and verbal substitutions. Auditory sentence comprehension was near normal, and auditory word

comprehension and object manipulation on verbal command were normal, suggesting that MJC was able to understand simple commands. Relatively spared auditory comprehension for simple commands was also confirmed by her performance on the Token Test (De Renzi and Faglioni, 1978). Indeed, while the first five subtests were normally performed (21.5/23 points) she encountered severe difficulties in the last subtest (5/13 points). Written word and sentence comprehension was largely spared. Verbal repetition and reading were also normal. Besides, the DO80 Naming Test (Deloche and Hannequin, 1997) revealed that MJC had word-finding problem which she did not try to compensate by circumlocutory responses. In sum, language assessment revealed a fluent language, severe anomia, moderately impaired auditory comprehension, and spared written comprehension, reading and repetition, consistent with amnesic aphasia.

Two subtests of the Agnosis Visual Battery (Agniel *et al.*, 1992) and the Bells Test (Gauthier *et al.*, 1989) were used to evaluate visuo-perceptual abilities. MJC's performance of the three tests was normal, suggesting that she did not suffer any visual agnosic deficit. Visuoconstructive abilities, assessed with a copy of the Rey-Osterrieth Complex Figure (Rey, 1959), were severely impaired. The Imitation of Meaningless Gestures Test consisted of ten hand and ten finger postures (see Goldenberg, 1999; Goldenberg and Hagmann, 1997). This test revealed a visuoimitative apraxia, more pronounced for the left hand. Execution of motor sequences (fist-edge-palm) was difficult and characterized by perseverations. General intellectual ability was in the average range (Raven, 1947). Memory function assessment which involved a subtest from the Cognitive Assessment Battery (Signoret *et al.*, 1989), Forward and Backward Digit Span Tests, and the Semantic Knowledge Test (Desgranges *et al.*, 1994), indicated general memory impairment. A dysexecutive syndrome was also found with the Frontal Assessment Battery (Dubois *et al.*, 2000).

Table 1 about here

2.3. Overview of the present study

In order to shed light on the relationship between utilization and usage, the present case report will be discussed in details in three distinct sections. Each section will discuss ~~examining~~ a specific aspect of object use ability: Conceptual knowledge, usual use of objects and unusual use of objects. Forty-one healthy control subjects, nineteen women and twenty-two men, matched with MJC for age ($M = 61.5$ years; $SD = 18.2$ years) and education ($M = 10.5$ years; $SD = 3.4$ years) provided the normative data for ~~the~~ experimental tests. All but three subjects were right-handed. They had normal or corrected-to-normal vision and hearing, and had no history of learning difficulties, central nervous dysfunction, psychiatric disease, drug abuse and/or alcoholism.

To avoid false positive diagnoses we decided to establish, for all tasks, conservative cut-offs as the worst score achieved by controls participating in the present study minus an additional 5% (1 point in tasks whose ranges from 0 to 10 or 20, and 2 points in those up to 48). For example, in the Recognition of Object Utilization Gestures Test the worst control achieved a score of 19/20, so the cut-off was set at 18. Therefore, a performance of 17 or below was considered pathological. Performance was videotaped for later evaluation by the first author.

3. Experiment 1: Conceptual knowledge

In this first experiment, we assessed MJC's ability to retrieve associative and functional knowledge about objects. Since it has been suggested that the use of objects in an unfamiliar way might require conceptual knowledge about objects (e.g., Hodges *et al.*, 2000), MJC was also evaluated on this aspect (Alternative Object Selection Test; see below). The investigation was undertaken in September 2005 and in June 2006.

3.1. Methods

Functional picture matching. MJC completed two subtests of the Visual Gnosis Battery (Agniel *et al.*, 1992), each consisting of ten trials. MJC was asked to choose one of the three alternative responses as the best match to the target. Each subtest was preceded by two practice trials for which feedback on the correctness was given. In the associative condition, the target (e.g., screw) and the correct response (screwdriver) were functionally associated. In contrast, in the categorical condition, the target (e.g., belt) and the correct response (pair of shoulder straps) were functionally equivalent². A score of 1 point was credited if the correct response was given in 30 seconds, totalling a maximum score of 10 points for each condition.

Recognition of object utilization gestures. This test (Bergego *et al.*, 1992) consisted of twenty sets of coloured photographs. Each four-photograph set showed the same actress/actor demonstrating the use of different everyday objects (e.g., saw, cigarette lighter, hammer). In each set, one photograph depicted the correct use of the object, whereas the remaining three photographs showed the objects well positioned in relation to the body part but incorrectly oriented (e.g., knife with the blade upside-down), inappropriately held (e.g., knife held by the blade), or used as if it was another object (e.g., knife as a fork). Three error categories were respectively distinguished (orientation, holding, another object). Each correct choice was credited with a score of 1 point, and the maximum score was thus 20 points.

Alternative object selection. MJC also performed the Alternative Object Selection Test (see Le Gall *et al.*, 2000) in which she was asked to select from a list of four words, via pointing, the name of the object that could be used for carrying out the action spoken by the examiner (“With which of these objects can you comb your hair?”). The test consisted of ten sets of four words. In each set, one word corresponded to an object (e.g., fork) sharing critical physical features of the familiar object (comb) used to perform the intended action (combing hair). The remaining three foils were chosen to be either visually similar to, from the same category as, or unrelated with, the target (e.g., brush, toothpaste, watch, respectively), corresponding respectively with three error categories

(visual, semantic, unrelated). Words were read aloud by the examiner while MJC was reading ~~read~~ silently. Scoring of each item was binary (0 or 1), and thus the maximum score was 10 points.

Functional real object matching. MJC completed both parts of the Functional Real Object Matching Test we developed in our laboratory. The stimuli consisted of ten common objects (hammer, screwdriver, key, scissors, bottle opener, spoon, saw, cigarette lighter, knife and spanner) and of ~~the~~ ten corresponding recipients (nail, screw, padlock, sheet of paper, cap bottle, yoghurt pot, piece of wood, candle, slice of bread, and nut on bolt, respectively). Each recipient was presented at a time and MJC was asked to choose from an array of objects the correct one to match the target recipient (“Show me which object is the most appropriate to complete the task”). She was also asked not to touch objects and recipients. In the multiple-choice condition, the array consisted of the ten objects mentioned above. In the restricted-choice condition three objects were presented in an array consisting of the correct object and two foils chosen for sharing functional similarity or not (e.g., for the recipient “slice of bread”, the choice was between knife, pair of scissors and cigarette lighter). One point was given for each correct selection. Total score ranged from 0 to 10 for each condition.

3.2. Results

As shown in Table 2, MJC’s performance was clearly poor in both testing sessions. The Alternative Object Selection Test was the most severely impaired (not better than chance). In this task, the patient was generally uncertain, claiming that she did not know. “Unrelated” errors were more frequent (first session: 4; second session: 2) than “visual” errors (first session: 3; second session: 2) and “semantic” errors (first session: 3; second session: 1). We examined the distribution of errors by pooling errors made in both testing sessions. The effect of the type of errors did not reach significance (revised chi-square analysis, $\chi^2 = 0.15$, $df = 2$, $p = .93$). MJC’s performance was also severely impaired on the Recognition of Object Utilization Gestures Test. “Another object” errors were more frequent (first session: 5; second session: 3) than “orientation” errors (first

session: 3; second session: 1) and “holding” errors (first session: 3; second session: 1). The distribution of errors was examined by pooling errors made in both testing sessions. Revised chi-square analysis did not reveal any significant effect ($\chi^2 = 1.14$, $df = 2$, $p = .57$). MJC’s performance on the Functional Picture Matching Test was also impaired except for the associative condition in September 2005.

Of particular interest was the way in which she performed the Functional Real Object Matching Test. MJC scored below the cut-off on both conditions and in both testing sessions. However, although her responses were not expected, her verbalizations indicated that choice was not random. In the first session, when shown the padlock, the screwdriver was pointed to because “it can be inserted into it”. When shown the wooden board, she pointed to the key, arguing that “it can be useful for enlarging the hole”. There was indeed a small hole in the wooden board. Moreover, responses produced in the multiple-choice condition were relatively stable throughout sessions since the pair of scissors, the screwdriver and the key were selected twice for the slice of bread, the padlock and the wooden board, respectively. As expected, performance was better (but still not normal) in the restricted-choice condition.

Table 2 about here

3.3. Discussion

Conceptual knowledge assessment revealed a severe semantic impairment in both testing sessions. MJC generally scored below the range of the control group. Nevertheless, the manner in which she behaved when completing the tests pointed out that distinctive strategies were employed to respond. More precisely, performance on the Alternative Object Selection Test was not better than chance and MJC frequently repeated that she was uncertain. In contrast, erroneous responses she made in the Functional Real Object Matching Test were almost always verbally justified indicating that choice was not random. The screwdriver was chosen because its blade was fine

enough to be inserted into the lock. The key was chosen because it enabled hole enlargement. While not corresponding to usage, responses were seemingly produced according to reasoning about structural relationship between objects. Two alternative interpretations could be considered to account for the divergence of strategies employed by MJC.

First, it can be supposed that the Functional Real Object Matching Test is not a “pure” test of conceptual knowledge due to the presence of objects and because of recipients permit ~~permits~~ that conventional use of objects is retrieved thanks to the ability to infer function from structure (see Goldenberg and Hagmann, 1998). Nevertheless, this hypothesis is not sufficient to explain why MJC’s choices were not always oriented towards the usually associated object. Second, as MJC’s verbalizations rightly reminded us, target recipients could support mechanical relationships with unusually associated objects. Moreover given that instructions did not specify any explicit goal, MJC could be satisfied by any of these mechanical relationships. In this view, conceptual knowledge would not be critical to detect mechanical relationships but, rather, to establish which one of these relationships is the usual one (Gagnepain, 1990). This latter assumption was further investigated in the following sections.

4. Experiment 2: Praxis and usual use of objects

The assessment of praxis and usual use of objects was carried out in three sessions, namely, in September 2005, in October 2005 and in June 2006. Experiment 2 aimed to assess MJC’s ability to pantomime object use and to use objects in a usual way.

4.1. Methods

Pantomime of object use. MJC was required to execute ten actions in response to verbal commands (e.g., “Show me how to use a hammer to pound a nail”), to the sight of objects (“Show me how you would use this object”), and in imitation of models presented by the examiner (“Do exactly what I do”). Prior to testing, the examiner explicitly instructed MJC that, as she

pantomimed the object use, she should pretend having objects in hand. Gesture items were derived from the ten familiar objects and recipients used in the Functional Real Object Test (see section 3.1.). Each item was scored by the examiner on a 3-point scale: 0 = unable/gross errors; 1 = possible errors; 2 = correct (see Kimura and Archibald, 1974; Sunderland and Sluman, 2000). The error was rated as “possible” if the pantomime resembled the correct one, but was somewhat imprecise because of spatiotemporal deviations, or if the patient used a body part as the object. The error was rated as “unable/gross” if the pantomime was so wrong or incomplete as to be unrecognizable. Maximum score was 20 points for each condition.

Usual use of objects. The experiment was divided into two conditions. MJC was asked to only use her right hand in both conditions³. In the single object condition, MJC was given an object in isolation and asked to demonstrate its use (“Take this object in your hand and show me how would you use it”). In the object-and-recipient condition, demonstration of object use should be done with both the object and the recipient (“Show me how to use this object to finish this task”). The recipients were adapted as to enable a one-handed performance. For example, the nail to hammer upon was fixed in a piece of wood. Each condition consisted of ten trials. We used the same stimuli set of common objects and recipients that described in section 3.1. Performance was rated on a 3-point scale (0, 1, and 2). Two points were given for correct use. One point was given if the correct use was found after unsuccessful trials or if the performance was clumsy. No point was given if the intended action was not at all achieved (see De Renzi *et al.*, 1968; Goldenberg and Hagmann, 1998). Maximum score was 20 points. Four error categories were a priori identified (see De Renzi and Lucchelli, 1988).

Perplexity. No action is carried out, or objects – or recipients – are picked up then put down without be used.

Handling. The action is appropriate but carried out in an awkward way because of mishandling of the object (e.g., handling a knife as a pencil).

Spatial. The action performed with the appropriated object but poorly executed or carried out

either in ~~at~~ an inappropriate place (e.g., the screwdriver “drives” the wooden board and not the screw), or in a ~~an~~ trial-and-error way (e.g., the subject first attempts to turn the key to open the padlock while the key is not sufficiently driven in, but, after several attempts, he inserts it correctly, and opens the padlock).

Action. The performance is characterized by unrecognizable movements, or the object is used inappropriately (e.g., the hammer is rubbed against the nail).

Eighteen control subjects performed the task with the left hand and twenty-three controls with the right hand. Since no difference emerged in the use of either hand, the scores of the two subgroups were pooled together.

4.2. Results

Results from the Pantomime of Object Use test indicated that performance of each hand was impaired in both conditions and in all the testing sessions (see Table 3). MJC produced almost no response on verbal commands and to the sight of objects. She insisted that she did not know. This behavioural pattern cannot be explained as a result of lack of initiative because, when asked to imitate, gestures were performed immediately after models. Difficulties in imitating transitive gestures confirmed the observed pattern of meaningless gestures. In spite of spatiotemporal errors, gestures could be generally recognized. Besides, as can be seen in Table 3, the error pattern did not reveal any improvement throughout ~~across~~ sessions or differences in performance with either hand in all conditions.

Table 3 about here

As can be seen in Table 4, MJC showed a severe impairment in using objects in isolation that increased across testing sessions. Action errors were the most frequently produced. We examined the distribution of errors by pooling errors made in all three testing sessions (i.e., perplexity, 4;

handling, 2; spatial, 3; action, 13). The effect of the type of errors did not reach significance, so it confirmed the greater proportion of action errors (revised chi-square analysis, $\chi^2 = 11.46$, $df = 3$, $p = .01$). Of particular interest was the observation of a quasi-systematic strategy of using the desk to demonstrate the use of objects. For instance, in the first session (September 2005), she used the screwdriver as a gimlet, by applying it perpendicularly to the tabletop in both clockwise and anticlockwise rotations. She added that “one can make a hole with it”. In all three sessions, the key was used for scrapping the chamfered edge of the wooden desk. The tabletop had a hole usually used for inserting wires. The hole was closed by a plastic cork. In the second session (October 2005), she used the bottle-opener as lever for removing the plastic cork. These behaviours cannot be classified as toying behaviours (see Shallice *et al.*, 1989) because she almost always verbally justified her responses and, when asked to show again how is the object ~~is~~ used, she performed the same demonstration.

The presence of a recipient considerably improved her performance that was normal in the third session and near normal in the two first sessions (see Table 4). In contrast to the error pattern observed in the single object condition, she preferentially committed spatial errors.

Table 4 about here

4.3. Discussion

The assessment of pantomime of object use in response to verbal commands and to the sight of objects revealed difficulties to initiate the least movement. Two assumptions could be made. First, ~~the~~ difficulties are attributable to problems with ~~the~~ dynamic procedures involved in the executional stage that is essential for processing all gestures, meaningful or not, and with or without object in hand (Buxbaum, 2001). MJC was impaired in pantomime of object use and in meaningless gestures suggesting deficits at the executional stage. This conclusion was however not sufficient to explain the considerable improvement ~~in~~ of performance in imitation tasks.

A second hypothesis was that MJC had lost or impaired access to the visuokinaesthetic engrams related to object use (see Heilman *et al.*, 1982). Imitation of gestures might not be affected. As the examiner provided a model of the intended movement, there was indeed no need to evoke the shape of the movement from long term memory. More recent cognitive models of apraxia have posited that better preservation of the imitation modality precisely argues that the non-lexical route is less impaired than the lexical one (engram-based) route (Buxbaum, 2001; Cubelli *et al.*, 2000; Rothi *et al.*, 1991, 1997). Difficulties she encountered in using objects in isolation could also be attributable to this impairment, since gesture engrams have been postulated as the basis for semantic knowledge of object manipulation (Buxbaum, 2001; see also Buxbaum *et al.*, 2000). Nevertheless, this account does not predict that the presence of recipient does improve ~~improves~~ the performance. Moreover, MJC did not mishandle objects when recipients were given. For instance, she correctly inserted her fingers in the loops of scissors. The handle of the hammer was also grasped in such a way that she insured optimal percussion strength. The gesture engram hypothesis was thus not supported.

Several authors questioned about the role of semantic knowledge of object function in object use (Buxbaum *et al.*, 1997; Lauro-Grotto *et al.*, 1997; Moreaud *et al.*, 1998). However, evidence for the close relationship between this form of semantic knowledge and the ability to use objects was recently provided by Hodges and colleagues. They found in patients with semantic dementia, strong correlations between measures of conceptual knowledge and the use of isolated objects (Bozeat *et al.*, 2002; Hodges *et al.*, 2000). Of particular interest was the benefit provided by the presence of recipients in mildly impaired patients. On the basis of these findings, Hodges and his colleagues proposed that the ability to deduce the correct goal for an object is dependant on conceptual knowledge. Furthermore, the patients they examined retained good mechanical problem-solving skills that could have been employed to use objects in isolation. Thus, they supposed that, unless severely impaired, conceptual knowledge constrains object use. Likewise, they interpreted the benefit provided by recipients as the combination of two mildly impoverished semantic representations (for the object and its recipient). They also stressed that the patient's familiarity

with ~~the~~ objects was an important predictor of performance, suggesting that conceptual knowledge about familiar objects is likely to be relatively robust.

An attractive situation to test this hypothesis is the unusual use of common objects (e.g., driving a screw into a wooden board with a knife). Indeed, the robustness of conceptual knowledge about familiar objects implies that representations of objects' canonical functions are less sensitive to semantic impairment than representations supporting unusual use of objects. Then given that conceptual knowledge is employed to interact with objects, unless severely impaired, it can be expected that residual knowledge of canonical functions constrains object use (hereafter referred as the "residual knowledge hypothesis"). In a context of an unusually use, these impoverished semantic representations should, however, not be sufficient to support object use because of the divergence of goals associated with each representation.

We developed the Unusual Use of Objects Test to examine this hypothesis. As Hodges and colleagues' patients, MJC showed an impairment of conceptual knowledge about objects (see Experiment 1), although it was not severe enough to suppose the employment of mechanical problem-solving skills. She was impaired in using objects in isolation and was improved by the presence of recipients. According to the residual knowledge hypothesis, MJC was supposed to fail the unusual use of objects test. Note that this prediction was also supported by the poor performance of the Alternative Object Selection Test (see above).

5. Experiment 3: Unusual use of objects

The Unusual Use of Objects Test was given to MJC in September 2005, in October 2005 and in June 2006. Each item of this test required to use an object with an unusually associated recipient (e.g., pounding a nail with a screwdriver). In a first pilot study, objects and recipients were given to ten healthy subjects without explicit instructions ("Do what it has to do"). Two response strategies were then employed. Either the object was considered as the relevant criterion for acting and, as a result, the subject "pantomimed" its utilization by using the recipient, or vice versa. Efficiency was

then difficult to assess. Therefore, we performed a second pilot study with seven other healthy controls in which instructions about actions to be completed were given (e.g., “divide the sheet of paper in half”). Some of items were impossible actions (e.g., sawing a piece of wood with a spoon) and subjects were informed to determine whether the given object could achieve the action.

Presence of instructions about actions to be completed may be viewed as a limitation for testing the residual knowledge hypothesis since there would be no need to retrieve goals from long-term memory. This methodological limitation is nevertheless bypassed by the presence of impossible items which compel ~~compels~~ to retrieve goals from long-term memory, whether the unusual use has ever been experienced. Nevertheless, in accordance with the residual knowledge hypothesis, semantically impaired patients should encounter difficulties in accessing this kind of knowledge. We thus supposed that, even with explicit instructions, MJC should fail the Unusual Use of Objects Test.

5.1. Methods

MJC was asked to execute twenty-four actions (hereafter referred to as “items”), each involving an object and a recipient. The different items are summarized in Appendix. For the same reasons evoked in the Usual Use of Objects Test (see Footnote 2) MJC was asked to use only her right hand. Recipients were adapted as to enable a one-handed performance. MJC was informed that she would have to use familiar objects in an unusual way and that she would be required to show how the action can be achieved by acting with the given object. Nonetheless, if the action was considered as impossible, she was asked to point to a card on which “NO” was printed. As soon as a new recipient was proposed, instructions for the action to be completed (e.g., “divide the sheet of paper in half”) were said aloud. The examiner also presented two photographs depicting the given action (a whole sheet of paper – two half sheets). The corresponding action was also printed underneath the two photographs. The task was preceded by four practice items for which feedback on the correctness was given. One third of actions were “impossible” (e.g., sawing a piece of wood

with a spoon). The series of twenty-four items was presented a second time after a 5-min rest period in order to prevent any effect due to the orientation of objects. Each object was thus presented with the handle alternately oriented to left or right, giving a total of forty-eight items. A credit of 1 point was given for each correct performed action in possible items and for each impossible response obtained in impossible items. The maximum score was thus 48 points. Eighteen control subjects used the left hand and twenty-three used the right hand. No difference emerged in the use of either hand and scores of the two subgroups were pooled together.

5.2. Results

As shown in Table 5, performance was normal in September 2005, in October 2005 and in June 2006. She pointed to the card “NO” even while no movement was produced, as did control subjects, thereby suggesting that trail-and-error strategy was not employed.

Table 5 about here

5.3. Discussion

As Hodges and colleagues emphasized, conceptual knowledge might play a key role in object use by providing goals for objects (Bozeat *et al.*, 2002; Hodges *et al.*, 2000). In the Unusual Use of Objects Test, goals were explicitly expressed. Therefore, conceptual knowledge was not required to provide goals. Because of the presence of impossible items, conceptual knowledge should nevertheless be necessary for specifying whether actions have ever been experienced. However, semantic representations of unusual use of objects are not likely to be robust. Consequently, in accordance with the residual knowledge hypothesis, semantically impaired patients should fail the Unusual Use of Objects Test. MJC did not fail. Two assumptions could be made.

First, by knowing ~~the~~ goals but not whether ~~the~~ actions have ever been experienced, MJC could employ mechanical problem solving skills to resolve items. Hodges *et al.* (2000; see also Bozeat *et*

al., 2002) observed little evidence of trial-and-error explorations by semantic dementia patients. Similarly MJC did not exhibit trial-and-error strategy. Impossible responses were given without interacting with objects or recipients, suggesting that she could anticipate mechanical relationships. Second, goals could have been directly perceived from objects' physical features ~~of objects~~. This interpretation in terms of affordance (see Gibson, 1986) is nevertheless ruled out, otherwise she would not encounter difficulties in using isolated objects. In sum, residual conceptual knowledge, trial-and-error strategy, and affordance hypothesis could not explain why MJC was impaired in using objects in isolation but not in using objects with recipients.

6. General discussion

We reported the case of a closed-head injury patient with degraded conceptual knowledge about objects. Pantomime Performance in the Object Use Test was also impaired. It is important to note that she encountered difficulties in using objects in isolation, but not in using objects with recipients. MJC also performed normally when asked to use objects with unusually associated recipients.

With the help of this case report, the present study aimed to draw a demarcation line between utilization and usage, or more precisely, between the ability to determine utilization and the ability to determine usage. This distinction is not supported by current cognitive models of apraxia (Buxbaum, 2001; Cubelli *et al.*, 2000; Rothi *et al.*, 1991; Roy and Square, 1985). In these models, conceptual knowledge is viewed as one of possible ways to use objects and the presence of a recipient is not supposed to improve performance. The pattern of patients' performance reported in the literature (Bozeat *et al.* 2002; Dumont *et al.*, 1999; Hayakawa *et al.*, 2000) and that observed in the present study questions this view. Moreover, the residual knowledge hypothesis extrapolated from findings of Bozeat *et al.* (2002) was also not supported.

In general, studies investigating the object use postulate two distinctive routes for action, namely, a semantic route and a direct (non-semantic) route (see Pilgrim and Humphreys, 1991;

Rothi *et al.*, 1991; Rumiati and Humphreys, 1998). The ability to deduce the goal of an object can be accomplished by either route, thereby suggesting no distinction between goal and technical end. In contrast, following Gagnepain (1990; see also Le Gall, 1998; Le Gall and Sabouraud, 1995), we hypothesize that goals and technical ends are distinct and that knowledge about usage is useful for specifying the usual relationship between a technical end and a specific goal. Consequently and as Hodges *et al.* (2000; see also Bozeat *et al.*, 2002) stressed, we assume that conceptual knowledge is essential for using isolated objects when no instruction is given. Indeed having to use an object in isolation requires explicit remembering of the usage in order to determine which kind of technical end does the object provide. Action can be then undertaken as if a recipient was present. In contrast to the Hodges *et al.*'s perspective and to the two-route hypothesis, we assume that utilization is never guided by conceptual knowledge, but rather by reasoning about technical ends. Thus, we interpret MJC encountered difficulties in using isolated objects but not in using objects with recipients as a selective usage disorder.

This assumption is also supported by the strategy employed by MJC to demonstrate the use of isolated objects. Her demonstrations were oriented toward the desk as if she attempted to bring out mechanical relationships from the objects and the desk. Sirigu *et al.* (1991) observed a somewhat similar strategy in a patient (FB) with bitemporal lobe lesions caused by herpetic encephalitis. FB was unable to recognize many common objects but could nevertheless describe the manner by which they were manipulated. When asked to identify a nail clipper, for instance, he said: "It can attach several sheets of paper together. You turn the piece on the top and tip it back (makes the precise movement sequence). You press and it maintains them" (Sirigu *et al.*, 1991, p. 2566). Like our patient, FB could demonstrate a potential utilization by using contextual cues such as a stack of sheets of paper on a desk. Sirigu *et al.* (1991) argued that FB was able to achieve a precise analysis of the mechanical properties of objects because tactile and/or visual inputs were able to trigger non-semantic sensorimotor representations. The concept of sensorimotor representation agrees with that of gesture engrams (see Buxbaum, 2001). However, as mentioned above, the gesture engram

hypothesis does not predict that the presence of recipient can improve the performance. So, even if we are consistent with the idea that analysis of the mechanical properties of objects might be achieved without semantic knowledge, we do not assume that this analysis is based upon sensorimotor representations.

Before concluding it is important to note the relatively good performance observed on the Unusual Use of Objects Test contrasted with the impaired performance on the Alternative Object Selection Test. We think that these results indicated that MJC could perform technical reasoning, only when objects were physically present. Words alone made impossible such reasoning, due to her inability to represent familiar objects (and hence their physical properties) from their names. In other words, difficulties she encountered in the Alternative Object Selection Test might be another evidence of a selective usage disorder, making her unable to mentally represent absent familiar objects, when she was required to demonstrate the use of objects in isolation.

Finally, several authors have stressed that brain-damaged patients might benefit from environmental modification to compensate their deficits (Bäckman and Dixon, 1992; Dixon and Bäckman, 1995; Wilson, 2002, 2003). As mentioned above, difficulties that MJC encountered when using isolated objects but not objects with recipients were considered as evidence of a selective impairment of conceptual knowledge – i.e., usage. In contrast, technical skills – i.e., utilization – were supposed to be intact, enabling the patient to use objects with recipients. This account emphasizes that patients with a selective impairment of knowledge about objects (as MJC) would be particularly sensitive to workspaces in which devices devoted to specific goals (e.g., preparing the coffee, brushing teeth) would be spatially separated, thereby constraining preserved technical skills to infer relevant technical end and, thus, the appropriate goal.

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Table 1
Preliminary neuropsychological assessment

Test	Clinical features	Cut-off
MT-86 β Aphasia Battery		
Spontaneous speech	Fluent	
Auditory word comprehension (9)	8	8
Auditory sentence comprehension (38)	32*	33
Object manipulation on verbal command (8)	6	6
Written word comprehension (5)	5	4
Written sentence comprehension (8)	7	7
Verbal repetition (33)	27	25
Reading (33)	26	25
Token Test (36)	26.5*	29
DO80 Naming Test (80)	34*	69
Agnosis Visual Battery		
Visual form discrimination (10)	10	8
Identification of overlapping shapes (36)	34	30
Bells Test (35)	33	31
Rey-Osterieth Complex Figure (36)	5.5*	29
Imitation of Meaningless Gestures Test		
Hand posture – Right hand (20)	16*	17
Hand posture – Left hand (20)	13*	17
Finger posture – Right hand (20)	17	17
Finger posture – Left hand (20)	13*	17
Motor sequence (fist-edge-palm test)	Perservations	
Raven's Colored Progressive Matrices (36)	14	25 th percentile
Cognitive Assessment Battery		
Recall subtest (12)	0*	9
Forward digit span	4	
Backward digit span	3	
Semantic Knowledge Test (144)	131*	144
Frontal Assessment Battery (18)	5*	16

Values between brackets are maximum scores. Asterisks indicate pathological scores. The cut-off scores are those reported in the relevant literature except for the Imitation of Meaningless Gestures Test, for which normative data come from the forty-one healthy controls matched with MJC (see text for the method used to establish the cut-off).

Table 2
Conceptual knowledge assessment

	MJC		Controls		
	September 2005	June 2006	Cut-off	Range	Mean (SD)
Functional picture matching					
Associative (10)	8	6*	8	9-10	9.9 (0.2)
Categorical (10)	6*	7*	8	9-10	9.9 (0.3)
Recognition of object utilization gestures (20)	9*	15*	18	19-20	19.7 (0.5)
Alternative object selection (10)	2*	3*	7	8-10	9.8 (0.5)
Functional real object matching					
Multiple choice (10)	5*	5*	9	10	10
Restricted choice (10)	7*	8*	9	10	10

Values between brackets are maximum scores. Asterisks indicate pathological scores.

Table 3
Performance on the Pantomime of Object Use Test

		MJC			Controls		
		September 2005	October 2005	June 2006	Cut-off	Range	Mean (SD)
Verbal commands (20)	Left hand	0*	0*	4*	16	17-20	18.3 (0.8)
	Right hand	0*	2*	2*	14	15-20	17.6 (1.9)
Sight of objects (20)	Left hand	5*	1*	2*	15	16-20	18.4 (1.1)
	Right hand	3*	0*	0*	16	17-20	18.6 (1.1)
Imitation (20)	Left hand	10*	13*	6*	14	15-20	18.4 (1.5)
	Right hand	10*	13*	10*	15	16-20	18.7 (1.1)

Values between brackets are maximum scores. Asterisks indicate pathological scores.

Table 4
Performance on the Usual Use of Objects Test

	MJC			Controls		
	September 2005	October 2005	June 2006	Cut-off	Range	Mean (SD)
Single object (20)	11*	8*	6*	18	19-20	19.8 (0.5)
Error category						
Perplexity	0	2	2	—	—	—
Handling	2	0	0	—	—	—
Spatial	2	0	1	—	—	—
Action	4	4	5	—	—	—
Object and recipient (20)	17*	17*	19	18	19-20	19.9 (0.2)
Error category						
Perplexity	0	0	0	—	—	—
Handling	0	0	0	—	—	—
Spatial	3	1	1	—	—	—
Action	0	1	0	—	—	—

Values between brackets are maximum scores. Asterisks indicate pathological scores.

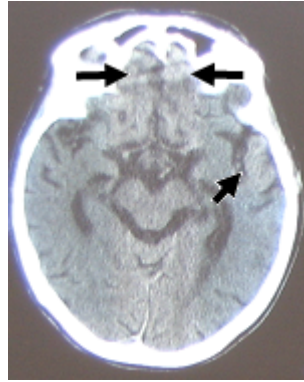
Table 5
Performance on the Unusual Use of Objects Test

	MJC			Controls		
	September 2005	October 2005	June 2006	Cut-off	Range	Mean (SD)
Correct responses (48)	33	35	39	32	34-47	40.8 (3.1)

Values between brackets are maximum score.

Figure legends

Fig.1. CT scan image of the subject MJC showing haemorrhage contusion of the left anterior temporal and bilateral frontal regions. Left and right are inverted.



Appendix

Items of the Unusual Use of Objects Test

Possible items		Impossible items
Bottle cap/screwdriver	Yoghurt/brush	Yoghurt/saw
Sheet of paper/knife	Yoghurt/fork	Hazelnut/pen
Milk brick/knife	Nail/knife	Hazelnut/fork
Milk brick/pen	Nail/corkscrew	Metal wire/corkscrew
Milk brick/screwdriver	Nail/screwdriver	Metal wire/hammer
Nail/pliers	Nail/saw	Piece of wood/spoon
Screw/knife	Nail/scissors	Piece of wood/scissors
Screw/scissors	Sheet of paper/fork	Sheet of paper/razor

Footnote 1

We follow the suggestion (Bozeat *et al.*, 2002; Hodges *et al.*, 2000) to use the terms “object” for the implement performing an action (e.g., a hammer) and “recipient” for the implement receiving an action (e.g., a nail).

Footnote 2

Note that items of this test refer to both small (e.g., screwdriver) and large (e.g., car) man-made objects (one item in the associative condition and five items in the categorical condition refer to large man-made objects). Some studies have reported that brain lesions can selectively impair knowledge of small or large man-made objects (Warrington and McCarthy, 1987; Warrington and Shallice, 1984). One account of these impairments is that this category specificity reflects the differential weighting of knowledge about object manipulation (Buxbaum and Saffran, 2002). However, the use of some small man-made objects does not require any “manipulation” (e.g., flowerpot, mirror), while some parts of large man-made objects generally require to be “manipulated” when using (e.g., car, washing machine). Note also that Buxbaum and Saffran (2002), who supported the hypothesis of differential weighting of object manipulation knowledge to account for impairments of knowledge about small or large man-made objects, assessed object manipulation knowledge in using a picture matching test in which large man-made objects were represented (e.g., washing machine, piano). Consequently, given that the theoretical dissociation between small/large or between manipulable/non-manipulable objects remains unclear, we considered the Functional Picture Matching Test for assessing general knowledge about man-made object functions, without taking into consideration the real size of objects.

Footnote 3

The group of controls matched with MJC performed the Usual Use of Objects Test with only one of their hands. Given that we did not have data from controls completing the test with one hand and then the other, MJC was also assessed with only one hand ~~of her hands~~. The right hand was chosen because of better performance in the Imitation of Meaningless Gestures Test.