Apraxia, mechanical problem solving and semantic knowledge
Contributions to object usage in corticobasal degeneration

Abstract To investigate the nature of the apraxia in corticobasal degeneration (CBD) five patients with CBD and five matched controls were compared on tests of: i) meaningless and symbolic gesture production, ii) a battery of semantic tasks based on 20 everyday items (involving naming and picture-picture matching according to semantic attributes, matching gestures-to-objects, object usage from name and with the real object) and iii) a novel tool test of mechanical problem solving.

All five patients showed severe impairment in the production of meaningless and symbolic gestures from command, and by imitation, and were also impaired when using real objects. Deficits were not, however, restricted to action production: four were unable to match gestures to objects and all five showed impairment in the selection and usage of novel tools in the mechanical problem solving task. Surprising was the finding of an additional semantic knowledge breakdown in three cases, two of whom were markedly anomic. The apraxia in CBD is, therefore, multifactorial. There is profound breakdown in the organisation and coordination of motor programming. In addition, patients show central deficits in action knowledge and mechanical problem solving, which has been linked to parietal lobe pathology. General semantic memory may also be affected in CBD in some cases and this may then contribute to impaired object usage. This combination of more than one deficit relevant for object use may explain why CBD patients are far more disabled by their dyspraxia in everyday life than any other patient group.

Keywords corticobasal degeneration · apraxia · semantic memory · tool use · miming

Introduction

In 1968 Rebeiz and colleagues [1] described the clinical and pathological characteristics of a previously unknown degenerative disease which they called corticodentatonigral degeneration with neural achromasia. While the name corticobasal ganglionic degeneration might capture the pathological findings more closely [2] it seems that the shorter term corticobasal degeneration (CBD), first used by Gibb and colleagues, [3] has now established itself as the name for this condition. CBD is characterised by an asymmetric limb akinetorigid syndrome that is unresponsive to levodopa, in combination with apraxia, myoclonus, alien limb phenomenon, focal dystonia [4, 5] and occasionally cortical sensory loss and bulbar features. Typically, the disorder begins insidiously in the sixth decade of life or later. Functional imaging (PET) studies show asymmetric reduction of cortical oxygen metabolism in the parietal, posterior...
temporal and occipital lobes, in combination with a distinctive 6 Fluorodopa uptake pattern in the basal ganglia [6]. Pathological features include parietal and frontal atrophy with neuronal loss and gliosis. A range of abnormal cytoskeletal inclusion bodies are found in both neurons and glia, including tau-positive (ubiquitin and synuclein negative) inclusions as well as astrocytic plaques, coiled bodies and argyrophilic threads in glia [7–9].

Apraxia, “the neurological disorder of learned purposive movement skill that is not explained by deficits of elemental motor or sensory systems” [10], is one of the key features of CBD and was found in 84% of patients in one study [5]. Most importantly, CBD is the only disease where problems with handling objects are a frequent cause for presentation. While apraxia in stroke patients is arguably often more a laboratory finding than a clinically relevant or handicapping symptom [11] (but for counter argument see Cubelli and Della Sala [12], and Foundas et al. [13]), patients with CBD are highly impaired in performing everyday motor activities.

Regarding the nature of the apraxia, most authors have claimed that CBD patients suffer from ideomotor apraxia [2,4,5,14–16], but others have argued that the patients’ problems with real objects indicate a degree of ideational apraxia [14]. Some have found clumsiness, especially of fine distal movements, irrespective of the kind of movement and of context, and have used the term limb-kinetic (or melokinetic) apraxia [17–19] originally coined by Liepmann [20]. These different conclusions are, at least partly, due to the confusing and inconsistent terminology which has dogged the field. While some investigations have used the term ideomotor apraxia to denote impairment in miming actions and not in object usage, others have used the same term to refer to impairment in single but not multiple object usage. Similarly, ideational apraxia has been applied variously to mean difficulty with object usage or with sequencing actions (see [10]).

In the present study, we decided to stand back from the confusion inherent in current terminology and instead to address a series of practical and theoretically motivated questions aimed at addressing the nature and cause of the apraxia in CBD:

1. Can apraxia in CBD be explained by peripheral motor programming and action selection deficits?
2. To what extent are patients impaired in the use of real tools and objects, as opposed to their ability to mime the use of such objects?
3. Do deficits in real tool use indicate a loss of the semantic knowledge underlying such usage? In other words, do patients with CBD have a loss of knowledge about how, or in what context, tools are used?
4. Is mechanical problem solving ability, hence the ability to infer the use of an object from its perceivable physical characteristics, impaired in CBD?

**Subjects**

Five right-handed patients with CBD (3 men and 2 women) participated in the study. All presented to a Neurology Clinic with complaints of clumsiness leading to progressive difficulty using one or both hands and by the time of assessment were virtually unable to write, shave, dress and perform other activities of daily living. Four of the patients had symptoms of alien, or anarchic, hand and two had noted spontaneous myoclonic jerks (see Table 1).

Examination revealed hypomimia and bradykinesia with increased limb tone in all cases. Three had touch or posture induced myoclonus. All were severely apraxic: two were unable to use their dominant hand for any tasks. Reflexes were retained and plantar responses flexor. Cerebellar incoordination was not present. All five patients fulfilled the recently proposed criteria for CBD: a slowly progressive asymmetric akinetic-rigid syndrome with one or more of the following signs: apraxia, myoclonus, cortical sensory loss or alien limb syndrome, associated with walking difficulty or gait instability [21]. Investigations for unusual causes of dementia and extrapyramidal syndromes were negative including full haematological screening, cerebrospinal fluid examination, and electroencephalography. MRI was obtained in all five cases. Four underwent a HMPAO-SPECT scan and one a FDG-PET. The results of neuroimaging studies are shown in Table 1.

**Controls**

The test of gesture production, all subcomponents of the 20 object task and the test of mechanical problem solving were given to five age and education matched controls from the MRC Cognition and Brain Sciences Unit subject panel.

**Methods**

**General Neuropsychological Assessment**

The following battery of neuropsychological tests was administered: the Mini-Mental State Examination as a general measure of cognitive impairment [22], the digit span subtest of the Wechsler Memory Scale-Revised (WMS-R) to assess auditory-verbal short term memory; verbal fluency for the letters F, A, S to test executive function; copy and immediate recall of the Rey Complex Figure to test visuospatial skills and episodic memory. Various subtests from the Visual Object and Space Perception battery were also used to assess visuospatial function in more detail [23]. Semantic memory was assessed using the Pyramid and Palm Trees Test [24] of associative semantic knowledge. In this assessment, subjects are asked to choose one of two items that is most closely associated with the target (e.g., for the target pyramid, the choice is between palm tree and pine tree). The CBD patients’ scores were compared with those of 25 age – and education – matched controls from the MRC Cognition and Brain Sciences subject panel.