Apraxia in neurorehabilitation: Classification, assessment and treatment

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Abstract. Apraxia is a higher-order motor disorder impairing the ability to correctly perform skilled, purposive movements as the result of neurological disorders most commonly stroke, dementia and movement disorders. It is increasingly recognised that apraxia negatively influences activities of daily living (ADL). Early diagnosis and treatment should be part of the neurorehabilitation programme. The aim of the present article is to describe the most important subtypes of apraxia such as ideational and ideomotor apraxia as well as their impact on ADL and outcome. Furthermore, the relationship to associated disorders such as aphasia is discussed. Finally, strategies concerning assessment, management and treatment of the disorder are presented.

Keywords: Apraxia, classification, assessment, treatment

1. Introduction

After surviving a stroke, most patients and their relatives are confronted with a complex mixture of sensorimotor, cognitive, and behavioural problems [1]. When specifically praxic functions are disturbed this is called apraxia. Apraxia is defined as “a disorder of skilled movement not caused by weakness, akinesia, differentiation, abnormal tone or posture, movement disorders such as tremor or chorea, intellectual deterioration, poor comprehension, or uncooperativeness” [2]. Generally the disorder is bilateral which means that skilled movements of both arms and hands, the legs and feet, and also axial movements can be disturbed [3–5]. Around 50% of patients who suffered a left hemisphere stroke appear to have apraxia [6], 25% may have modest to severe apraxia as shown in a recent study [7]. It is also found after lesions of the right hemisphere and deeper subcortical lesions, although less frequent and less severe [7–9]. Although it is commonly seen in patients with a stroke it can also be present in dementia and various movement disorders such as corticobasal degeneration [10,11], progressive supranuclear palsy [12], Alzheimer’s disease [13], Parkinson’s disease [14] or Huntington’s disease [15].

Studies have shown that apraxia negatively influences ADL functioning [16–19], gait [20–22], transfers and wheelchair mobility [23], and that it can be a persistent disorder in stroke patients [24]. The absence of apraxia is a significant predictor of return to work after stroke [25]. Considering its negative impact on the functional ability, treating and management of apraxia should be part of the neurorehabilitation programme. Stroke patients with apraxia are referred to occupational or physical therapists who teach the patients different strategies to cope with their disabilities [26,27].

There is scarce literature concerning the effectiveness of the treatment and management of apraxia [28]. So far, only a few randomised controlled trials have been performed to investigate the effect of rehabilitative treatment protocols [29–31]. Specific guidelines for therapists on how to treat the disorder are lacking.

The purpose of this paper is:
1. to provide clinicians a classification of the main subtypes of apraxia, prognosis and recovery, and its relationship to aphasia
2. to show how apraxia affects the functional ability of a patient
3. to present assessment and treatment strategies for the disorder.

2. Traditional classification of apraxia

An allocation of apraxia subtypes is presented, which is largely based on the traditional classification from Hugo Liepmann, formulated a century ago [32]. Most apraxia subtypes are multi-modal, that is, the disorder is present irrespective of the modality of perceptual input (visual, verbal or tactile). Traditionally, one distinguishes between ideational apraxia (IA), ideomotor apraxia (IMA) and limb kinetic apraxia (LKA). IA and IMA will be described in more detail because they are most commonly described in the literature and sometimes seen as the two classical forms of apraxia [33]. LKA is defined by a loss of fine, precise and independent finger movements (for instance, when flipping a coin or picking up a paper clip) not explained by elementary sensory-motor deficits. However, whether LKA represents a true apraxic disorder has been questioned [34] and therefore, this type of motor disorder will not be discussed further.

2.1. Ideational apraxia

Patients with ideational apraxia (IA) are seriously disabled when they carry out a sequence of actions requiring the use of various objects in the correct way and order necessary to achieve an intended goal (e.g. preparing a cup of coffee with milk and sugar). They can obtain knowledge of how to perform a sequence task, but fail to properly order the elements of a task. Often they also forget to carry out an action necessary for completing the sequence (e.g. trying to pour water from the bottle into the glass without having previously taken off the cap). Ochipa and colleagues have suggested restricting the term “ideational apraxia” to the failure to sequence correctly a series of acts leading to an action goal as defined by Poeck [35]. They introduced the term “conceptual apraxia” to denote the loss of different types of tool-action knowledge [36]. However, as the term conceptual apraxia is not widely accepted, we use the term IA to denote a severe apraxic disorder significantly affecting object use, which is either inappropriate or in the wrong sequence. Accordingly, patients with IA don’t know what to do if they are asked to demonstrate tool use. In daily activities, such as brushing teeth, they may use scissors instead of a toothbrush. Furthermore they typically show content errors when pantomiming tool use (e.g. screwdriver for hammer) or may be unable to select the appropriate tool presented with other objects, e.g. tooth paste and a tooth brush out of three related foil objects (comb, shampoo, and hair brush). Patients also experience difficulties in selecting alternative tools to complete a task when the tool for typical use is not available.

2.2. Ideomotor apraxia

Ideomotor apraxia (IMA) is the inability to correctly perform gesture pantomimes and imitations, whereas actual use of tools is less affected [37]. Patients with IMA do know what to do, but don’t know how. The idea or plan of the action is not impaired, but the implementation of the movement plan into proper action execution is disrupted [38], which is indicated by common spatial and temporal errors.

Typical spatial errors are false positioning of the hand in an appropriate posture (e.g. closed fist for drinking from a cup), wrong orientation of a movement toward an imagined object (e.g. demonstrating the use of a toothbrush at the level of the chest) [38], and failure to coordinate joint movement (e.g. demonstrating a screwdriver by rotating at the shoulder instead of the elbow) [39]. The patients also produce “body-part-as-object- (BPO-)” errors by using a body part as if it were the imaginary tool [38,40] e.g. using the index finger as a tool to demonstrate brushing teeth. This kind of behaviour is normal in children but it is not common in adults [40]. Normal subjects correctly modify the BPO error when reinstructed to imagine holding a tool in their hand and not to use their fingers [38]. Perseverations also occur as the repetition of a whole movement but, much more frequently, as the intrusion of motor elements that were part of a movement correctly or incorrectly performed even in previous tasks [40]. Besides spatial errors, patients may also make temporal errors which can be called sequential [41] (e.g. demonstrating key use by rotating the wrist, then extending the arm) or called timing error where patients fail to coordinate speed with the spatial aspects of the gesture [39].

The somewhat arbitrary dichotomy between ideomotor and ideational apraxia has been questioned [42] since both subtypes rarely appear isolated in individual patients. Furthermore, there has been some contro-
rather clumsy in nature, and were unable to make turns who were unable to initiate walking, were compensatory strategy. relearn to dress because they are unable to learn a new basic ADL tasks. Apraxia can affect patients’ ability to to similar conclusions regarding the impact of IMA on severity and dependency in physical functioning. Gold-

also found a significant relationship between apraxia apraxia and healthy controls. Hanna-Pladdy et al. [18] more difficulties than left hemisphere patients without controls. It was found that apractic patients exhibited batteries in a tape recorder, in patients with apraxia and changing the actions than the control group. There was a significant positive correlation between the degree of apraxia and the number of action errors. 

Foundation et al. [17] videotaped the mealtime organ-

isation of a small group (10) of left-hemisphere brain damaged patients and healthy subjects and compared their behaviour. The ten patients were also tested for limb apraxia. Eight of them were found to be apractic. The results indicated that the LBD group was less organised, used fewer tools, and produced fewer tool actions than the control group. There was a significant positive correlation between the degree of apraxia and the number of action errors.

Later studies confirmed these findings. Goldenberg et al. [50] assessed complex ADL, such as changing the batteries in a tape recorder, in patients with apraxia and controls. It was found that apractic patients exhibited more difficulties than left hemisphere patients without apraxia and healthy controls. Hanna-Pladdy et al. [18] also found a significant relationship between apraxia severity and dependency in physical functioning. Goldenberg and Hagmann [51] and Walker et al. [19] came to similar conclusions regarding the impact of IMA on basic ADL tasks. Apraxia can affect patients’ ability to relearn to dress because they are unable to learn a new compensatory strategy. 

Some case-reports [21,22] described patients following a stroke who were unable to initiate walking, were rather clumsy in nature, and were unable to make turns and to imitate foot/leg movements performed by the examiner. The authors came to the conclusion that these patients suffered from apractic gait. Another case report [23] described a patient with major difficulties performing transfers from the wheelchair into bed, unable to use the wheelchair properly. These difficulties were ascribed to an existing apraxia because the patient was unable to formulate the appropriate motor plan to perform these actions.

4. Prognosis and recovery of apraxia

It has been shown that the disorder is persistent and enduring and that it may not recover spontaneously [16, 24,52,53]. In a study by Norwegian occupational therapists the degree of self-care in 120 patients who had suffered stroke was assessed at different stages of recovery. All apraxia variables appeared to be significant predictors of subsequent dependency. They conclude that the effect of apraxia on ADL in the domestic situation has to be given more attention [16].

Recently Dutch researchers investigated a large group of stroke patients (n = 108) with apraxia [24]. The aim was to study the course of apraxia and ADL functioning in stroke patients. They found out that about 88% of the patients were still apractic after 20 weeks which negatively influenced ADL functioning. They concluded that apraxia is a persistent disorder and may not recover spontaneously.

Some authors have suggested that while improvement in some aspects of limb praxis occurs over time, other aspects of the disorder are persistent [38]. They looked at the pattern of recovery in limb apraxia over a 6-month period of time. Using a qualitative error system, they found differential patterns of recovery for intransitive gestures (i.e. gestures not requiring a tool or object, such as “waving goodbye”) and transitive gestures (i.e. gestures requiring tool use). For intransitive gestures there was a spontaneous decrease in the number of content errors, whereas for transitive gestures there was a spontaneous decrease in the number of unidentifiable production errors. Spatial and temporal errors were found to be persistent. The natural course of recovery in apraxia suggests that if performance improves, it is in the areas of meaningfulness and recognisability of their gestures [38]. If the site of the lesion was taken into account it was found that patients with anterior lesions have a better chance of recovery than posterior lesions. Age, gender, type of aphasia, level of education, initial severity of apraxia, the presence
of a second lesion in the opposite hemisphere and the size of the lesion didn’t seem to influence the recovery process [54].

In summary, it appears that some patients do recover spontaneously, others don’t. The exact mechanisms of this recovery from apraxia are still not well understood. Functional neuro-imaging studies may provide further insight [55–57].

5. Apraxia and aphasia

Apraxia is often seen in association with aphasia (i.e. loss of the ability to speak or understand speech) due to the encroachment of the lesion upon contiguous structures, differentially specialised for language and praxis [58].

In a study of 177 acute and chronic stroke patients a correlation of 0.40 was found between apraxia and aphasia [59]. Although the deficits frequently coexist, it is now acknowledged that their relationship is not causal. Clear evidence of a double dissociation between apraxia and aphasia was presented by Papagno and co-workers [60]. Of 699 patients, they found that 10 were apractic but not aphasic and 149 were aphasic but not apractic. This suggests that praxis and language make use of different, but partly overlapping networks.

The evidence of this double dissociation was further supported by a few single case studies. Selnes and colleagues [61] studied a right-handed man with a left-sided stroke showing a marked limb apraxia, but no aphasia. Watson and Heilman [62] studied a woman who had suffered a spontaneous corpus callosum disconnection, which resulted in apraxia and apractic agraphia without significant language impairment.

Besides the fact that apraxia and aphasia frequently coexist, apraxia is also frequently accompanied by several other deficits. It has been shown that stroke patients with apraxia have more additional cognitive impairments than stroke patients without apraxia. The apractic patients seem to have more problems in comprehending sentences, in cognitive orientation, and short term memory functioning [63].

6. Assessment and treatment strategies

6.1. Assessment of apraxia

Several quantitative and qualitative tests of apraxia have been reported in literature [33]. Despite that, there is still little consensus on the proper way to test for apraxia. Most of the tests have been developed for research purposes and are not useful in praxis setting. Above all many existing apraxia tests do not meet standard psychometric properties. That’s why we recently developed a test to measure upper limb apraxia (TULIA), which assesses gesture production. In contrast to other existing apraxia tests the reliability and validity was thoroughly investigated [7]. The TULIA test consists of 48 items incorporating six subtests for both imitation and pantomime of non-symbolic (Put index finger on top of nose), intransitive (communicative gestures e.g. “waving goodbye”) and transitive (gestures involving to pretend object use e.g. “Show me how to use a hammer”) gestures. Responses are scored quantitatively on an ordinal scale (0–5) and qualitatively, including error analysis based on widely used classifications [40,64]. The TULIA is not conceived to be used for bedside evaluation of apraxia. Therefore we developed a screening test for apraxia, called the apraxia screen of TULIA (AST) which has shown high diagnostic accuracy [65].

Testing should be done bilaterally in non-paretic patients as apraxia affects both limbs. In hemiparetic patients, apraxia is usually tested on the ipsilateral non-paretic limb only, as on the contralateral side apractic deficits are masked by weakness and loss of sensation [37].

Discrimination and recognition tasks are also often added in testing for complete apraxia evaluation. Discrimination of gestures involves asking the patient to discriminate between well-performed and poorly performed gestures, while recognition is assessed by asking the patient to indicate which object corresponds to a pantomimed gesture [64].

The problem with assessing apraxia only in testing situations is that there may be no strong correlation between formal test results and actual performance in ADL. That’s why observation in daily routine is a very important measurement to detect the influence of the apractic disturbances. Some authors have developed standardized tools to measure ADL [66,67]. In this way it can be examined to what degree the impairments in praxis function lead to problems in everyday functioning.

Self-report questionnaires and interviews should also be reflected in diagnostic settings to understand in which way the apractic behaviour subjectively influences the daily life of patients and their relatives [68].

Consequently, comprehensive assessment of apraxia should include a formal testing, a standardized measurement of ADL, observation in daily routine and targeted interviews with patients and their relatives.
7. Management and treatment

The term management refers to the practice of modifying the apractic patient’s interactions with the environment to accommodate their behavioural deficit. Apractic patients are typically anosognostic for their praxic deficits [69] or attribute their disabilities to their right hemiparesis or inexperience using their left arm (if right handed) [64]. Furthermore, apractic deficits are often overlooked in neurorehabilitation where the patient’s needs are anticipated or where opportunities for independent tool use are limited. Therefore help is needed in identifying tool use deficits and determining how restructuring of the home environment may make the transition from neurorehabilitation centre to home less traumatic for both patient and relatives. If tool use problems cannot be ruled out, rehabilitation staff and family members must be warned to limit the patient’s access to those tools (e.g. knife which is left on the table in the dining room, or scissors close to the sink) which, if misused, may be dangerous. Some management strategies would include replacing tasks that may require tools with those that can be performed without tools wherever possible (e.g. to avoid using a knife when preparing a sandwich) limiting the selection of tools or objects to be worked on, avoiding series of tasks, having the patient perform tasks with which they are most familiar (e.g. handicraft work or cooking), and utilising verbal (e.g. “now you can start with and continue to do”) or tactile (e.g. to touch the hand of the patient and then point afterwards to the to be used tool) cues to facilitate the task, when possible.

Besides management, direct treatment of apraxia should be part of the rehabilitation programme. Although, until now no standardized treatment method has been established [70]. Roth [71] conceptualises treatment approaches as being either restitutive or substitutive in nature. Treatments predicated on restitution of function are designed to maximise the recovery ultimately governed by the nervous system. Restitutive treatments are designed to address the underlying deficit and encourage maximum return of function within those limits set by the system. In contrast, substitutive treatments aim to achieve the behavioural goal in a new way that is, improving functioning despite the presence of impairments. Compensatory techniques are designed to help the patients effectively use residual skills by teaching them ways to minimize the extent to which problems impinge on daily activities [72]. It is not mentioned in literature which treatment concept should be preferred. Probably this is due to the scarcity of well designed studies concerning treatment of apraxia. Until now only a few randomised controlled trials were set up to investigate the effect of a specific treatment program for apractic patients [29–31].

Donkervoort and colleagues [31] used a substitutive approach in their RCT in which the patients were taught to compensate internally or, if necessary, externally for apraxia. Examples were self-verbalisation to support the performance and writing down or showing pictures of the proper sequence of activities. The treatment aimed at gradually teaching the patient more efficient strategies. The assumption underlying this strategy programme was that, although recovery is possible in some cases, the apractic impairment is frequently irreversible. Therefore, treatment should focus on teaching patient ways to improve their ADL functioning by learning strategies to compensate for the apractic impairment. The study showed that patients, after 6 weeks of intensive strategy training, clearly improved more in their all daily activities compared to the patients who received only conventional occupational therapy. One study [73] even showed that with the use of this method generalization of training effects occurred to other tasks and other contexts. This substitutive approach seems to be particularly of interest for patients with ICA because different tasks, such as washing, dressing or eating, are specifically trained in the proper sequence.

In contrast, Smania and co-workers [29] opted for a more restitutive treatment method. A behavioural training program consisting of gesture-production exercises was used to reduce the apractic errors made by apractic patients. The gesture training consisted of three phases in which the patient was (1) shown use of common tools, (2) shown a static picture of a portion of a gesture and asked to pantomime the gesture, (3) shown a picture of a common tool and asked to produce the associated gesture. It was found that, due to this specific apraxia training method, patients significantly improved on apraxia tests which were used as outcome measurements. A later study [30] confirmed these results and additionally showed significant improvements in ADL. In contrast to the strategy training, it can be assumed that patients with IMA could benefit more from this gestural training. However, further studies are needed to show if this assumption is justified.

Some practical guidelines have been offered as well. Landry and Spaulding [27] summarized that instructions for patients with apraxia should be clear, concise and include feedback in form of physical guidance, visualization (e.g. with the use of pictures), modelling (e.g. demonstration by the therapist) and step-by-step
verbal instructions. Therapy should be tailored to the needs and desires of the patient and their family. Furthermore, training of functional activities should be well structured, include errorless training [50,51], and preferred within the usual context of the patient. In this way the transfer of the learned tasks can be optimised into the home situation. Although these guidelines are useful in clinical practice, they are not at all evidence-based.

Based on the existing evidence, we recommend that, for patients with IA, therapy should focus on functional activities and teaching patients compensatory strategies for their apractic impairment. As transfer of training effects for these patients into the home situation is sometimes difficult to achieve, specific activities, such as washing, eating or dressing, in specific contexts, such as bathroom or dining room, close to their normal routine are preferable in the therapeutic setting. If patients suffer from IMA gestural behavioural training could be sufficient to obtain optimal functional outcome. Although, future studies are needed to clarify which treatment intervention is most effective for the different forms of apraxia.

8. Conclusion

For clinicians it is important to recognise that apraxia is a common disorder among patients with neurological disorders and that its presence negatively influences functional outcome. Specific treatment approaches for apraxia can be effective compared to the existing conventional therapies such as gestural training or strategy training, although more randomised controlled trials and follow-up studies are needed to confirm these results. Treatment should be focused on functional activities which are structured and practised using errorless learning. In this way one can expect an optimal transfer of the learned tasks into the home situation.

This paper has reviewed the major types of apraxia with a focus on the clinical features, its prognosis and relationship to aphasia. Its impact on the functional ability of the patient has been discussed and the importance of comprehensive assessment and specific treatment strategies are highlighted. Future research is still needed to investigate the generalization of treatment effects, and to understand the recovery and prognosis of apraxia over a longer period of time.

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