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The alien hand syndrome: classification of forms reported and discussion of a new condition

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Abstract The term "alien hand" refers to a variety of clinical conditions whose common characteristic is the uncontrolled behavior or the feeling of strangeness of one extremity, most commonly the left hand. A common classification distinguishes between the posterior or sensory form of the alien hand, and the anterior or motor form of this condition. However, there are inconsistencies, such as the phenomenon of diagonistic dyspraxia, which is largely a motor syndrome despite being more frequently associated with posterior callosal lesions. We discuss critically the existing nomenclature and we also describe a case recently reported by us which does not fit any previously reported condition, termed agonistic dyspraxia. We propose that the cases of alien hand described in the literature can be classified into at least five broad categories: (i) diagonistic dyspraxia and related syndromes, (ii) alien hand, (iii) way-ward hand and related syndromes, (iv) supernumerary hands and (v) agonistic dyspraxia.

Key words Alien hand • Agonistic dyspraxia • Corpus callosum • Diagonistic dyspraxia • Frontal lobe • Parietal lobe • Split brain

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Introduction

A large variety of complex, abnormal, involuntary motor behaviors have been described following callosal lesions which may or may not be accompained by hemispheric damage, especially in the frontal medial region. Although the different terminologies used to describe these movements attempt to address their clinical specificity, there is a noticeable nosological confusion in the literature which results in assigning similar names, often inappropriate, to diverse phenomena and vice versa. One example of such confusion is the group of syndromes labeled as "alien hand" [1], "anarchic hand" [2, 3], "way-ward hand" [4, 5], "intermanual conflict" [6] and "diagonistic dyspraxia" [7, 8]. These conditions are most commonly observed after traumatic brain lesions, but have also been recently described in neurodegenerative diseases such as Creutzfeldt-Jacob disease [9] and corticobasal degeneration [10, 11]. Some authors have classified these syndromes into a "posterior" or "sensory" form and an "anterior" or "motor" form [12]. To us, this categorization may be insufficient to account for the variety of clinical forms observed for this syndrome. Instead, we categorize these syndromes into at least four broad categories (which may include subcategories), and propose a fifth category for an observation recently made by us [13], which has been termed agonistic dyspraxia.

From a nosological point of view, the motor and sensory hand disturbances associated with callosal and extracallosal

Table 1 Types of alien hand syndrome and their brain localization

Syndrome	Clinical manifestation	Lesion localization
Diagonistic dyspraxia or intermanual conflict [6–8]	Motor	Posterior CC [19, 20], anterior midbody CC? [17, 20, 22]
Alien hand [1]	Sensory	Posterior CC [1, 25], parietal [26, 27]
Anarchic hand or way-ward hand [2, 4, 5]	Motor	Frontal, anterior CC [5, 17, 20, 25, 31]
Supernumerary hands [14, 15]	Sensory	Frontal, anterior CC [14, 15]
Agonistic dyspraxia [13]	Motor	Anterior midbody CC, posterior midbody CC [13]

CC, corpus callosum

lesions seem to us to be classifiable in at least the following four classes (Table 1):

(i) Diagonistic dyspraxia [7, 8] and intermanual conflict [6], phenomenon in which the left hand (in right-handed subjects) performs actions contrary or opposite to, or interferes with, the actions executed by the right hand;
(ii) Alien hand sign [1], which usually affects the left hand and is characterized by the subjective feeling that the hand does not belong to the patient;
(iii) Syndrome of the anarchic hand [2] or way-ward hand [4, 5], in which the affected hand, being contralateral to the lesion, performs propositive or goal-directed movements that the patient does not perceive as initiated or controlled by his own will; and
(iv) Supernumerary hands, in which the patient reports the feeling of having an extra extremity [14, 15]. These different forms may coexist in one patient [16, 17].

Another form of abnormal hand movement is the "levitating hand" sometimes observed in patients with corticobasal degeneration, in which the hand contralateral to the lesion levitates aimlessly [10, 11]. This condition will not be discussed further.

Diagonistic dyspraxia, intermanual conflict and conflict of intentions

With this term, Akelaitis et al. [7, 8] described, in callotosomized patients, involuntary movements of the left hand which acted in an opposite way to the actions executed by the right hand. For example, a patient puts clothes on with the right hand, but pulls them off with the left hand. Bogen [6] described intermanual conflict as a more general dissociative phenomenon "in which one hand is acting at cross-purposes to the other" but does not necessarily perform the opposite action. Rather, the hand interferes with the movements executed by the other hand. This phenomenon is observed at least to some degree in most complete commisurotomy patients in the early post-operative period. It rarely if ever persists in the long-term.

In their more recent description of three patients with callosal lesions accompained by variable degrees of extracallosal damage, Tanaka et al. [18, 19] emphasized the syndromatic specificity of diagonistic dyspraxia and its distinction from other motor abnormalities. They defined this syndrome as a "peculiar dissociative behavior of the left hand in the absence of pathological grasping phenomena in the hand: the left hand often acted at cross-purposes to the right" [19]. The patients with diagonistic dyspraxia described by Tanaka et al. [19] also exhibited several other abnormal behaviors in the left hand during right-hand tasks or during bimanual tasks, such as non-antagonistic, irrelevant movements to the right, and the occasional inability to move the left hand at will during a bimanual task. Diagonistic dyspraxia has been proposed to be associated with lesions in the posterior end of the body of the corpus callosum, especially in its ventral part, and need not involve extracallosal damage [19–21]. Anterior and midbody callosal damage has also been suggested in some reports [17, 20, 22], but in these cases image resolution may not have been optimal.

Parkin [23] has proposed that intermanual conflict occurs preferentially in unimanual tasks in which there is more than one option (e.g. opening or closing a bottle, dressing or undressing), and in complex tasks that are not overlearned (e.g. cooking, choosing the clothes to wear). He suggested that, normally, the hemisphere ipsilateral to the intended hand is inhibited by the contralateral hemisphere via the corpus callosum. In patients with callosal damage, this inhibition is blocked, and the ipsilateral hemisphere becomes engaged in the task.

Nishikawa et al. [24] recently described three callosal-lesioned patients, two of whom had lesions in the posterior half of the callosal body and with no significant cortical involvement. All 3 patients were unable to perform whole body actions because another intention emerged in competition with the original one. The authors named this condition conflict of intentions, and considered it to be a special case of intermanual conflict or diagonistic dyspraxia.

Alien hand

The alien hand sign (*main étrangère*) was originally proposed by Brion and Jedynak [1] to describe a generally bilateral, subjective deficit in recognizing the hand as one's own when it was kept out of visual contact. The patients (three with tumors in the posterior callosum and one with a posterior paracallosal angioma) did not recognize the left hand when it was held by the right hand, but also did not recognize the

right hand when held by the left. In none of these four patients, were abnormal movements described. Recently, Marchetti and Della Sala [25] considered that the alien hand should be thought of as a partial hemiasomatognosia in which the patient has a subjective feeling of the hand not belonging to the self. There may or may not be sensory deficits associated with this feeling. These authors have also proposed that this condition is caused by posterior callosal lesions which may include parietal areas. However, the sensation of alienness of the left limb has been also associated with contralateral parietal damage with no callosal involvement [26, 27].

Unfortunately, the use of the term "alien hand" has led to significant confusion. For example, Bogen [6] initially suggested that the alien hand is a lesser form of intermanual conflict. In his description of callosal syndromes, he defined the alien hand as a "circumstance in which one of the patient's hands, usually the left hand in the right-handed patient, behaves in a way which the patient finds 'foreign', 'alien' or at least 'uncooperative'". More recently, Bogen recanted and proposed the use of the term "anarchic hand" instead. Other authors described the alien hand emphasizing the presence of movements performed against the patient's will, instead of the original subjective feeling of the hand not belonging to the self. Goldberg et al. [4] gave still another meaning to the alien hand, underlining the autonomous way-ward movements of the left hand. Since then, a variety of subjective sensations and motor phenomena have been included as belonging to the alien hand syndrome. Doody and Jankovic [28] included "a spectrum of complexity from action induced, patterned and rhythmical movements to non-goal directed grasping and groping behavior, goal-directed activities like the compulsive manipulation of tools or even self-destructive acts". More recently, others have proposed the term sensory alien hand syndrome to describe sensory deficits associated with hemispatial attention and involuntary movements of the left hand [12, 29, 30]. For example, Ay et al. [12] reported a patient with involuntary movements of her left hand, sensory deficits and a triple sensory, optic and cerebellar ataxia of the left arm; this patient had a lesion in the posterior callosum, inferior temporal lobes and subcortical regions.

Anarchic, way-ward hand and frontal alien hand

Della Sala et al. [2, 3] proposed to restrict the term "alien hand" to the partial hemiasomatognosia reported by Brion and Jedynak [1], and suggested the term "anarchic hand" to describe the occurrence of "complex movements of an upper limb that are unintended although clearly goal-directed and well executed" [3]. These authors described a patient who "never doubted that the wayward hand was a part of her own body. Instead, she felt her left hand had a will of its own" [3].

A similar deficit, labeled "way-ward hand", was described by Goldberg [5] in eight patients with deep frontal ischemic lesions. The hand contralateral to the lesion grasped objects or performed semipurposeful acts which were not consciously initiated by the patients. This phenomenon has been observed in cases of diagonistic dyspraxia, but unlike the latter, these movements usually do not oppose to the movements of the other hand. Goldberg et al. [4] described a patient with a left medial frontal lobe lesion whose right hand came up to keep her glasses on after she had removed them with the left hand. However, as they suggested, this condition may be a form of intermanual conflict due to anterior callosal damage. Feinberg et al. [20] coined the term frontal alien hand to describe the compulsive manipulation of tools and reflexive grasping of the dominant hand after frontal cortex lesions (see also [17]). But such movements cannot be considered purposeful as they are not usually associated with feeling of "disownership". Pageot et al. [31] described a patient whose abnormal movements of the left hand were similar to the "way-ward hand" but not presenting grasp reflex as did Goldberg's patients. Note that in all these cases, the patients did not lose the feeling that the unwilled hands were their own. Thus the term "alien hand" is inappropriate.

Supernumerary hands

The subjective sensation of having three or more hands, reported by Halligan et al. [14] and Hari et al. [15], usually results from lesions in the right hemisphere, sometimes involving callosal damage. This condition sometimes extends to the lower limb, as Hari et al. [15] reported the case of a patient with lesions in the right frontal lobe and in the anterior callosum who had the feeling of having three arms and three legs. Although these extra extremities may not be felt as performing involuntary actions, they are sometimes perceived as directing the real limbs to perform such movements [13].

Agonistic dyspraxia

We recently reported a right-handed patient with hemorrhage in the corpus callosum without extracallosal compromise, as seen on magnetic resonance imaging (MRI) (Fig. 1) [13]. In addition to signs of callosal interruption, the patient exhibited a variety of abnormal motor behaviors [13]. Some of these were transient and involved only the right hand, most likely accounted for a mild and short-lasting frontal involvement. In addition, the patient presented a persistent abnormal behavior, not described before. When instructed to follow a motor command with either the right or the left forelimb, the patient used the forelimb on the opposite side while the "correct" hand remained immobilized. This did not occur when the patient imitated unimanual movements or executed them spontaneously. Furthermore, the patient felt that the contralateral movement was involuntary and had serious difficulties in controlling it (the examiners sometimes had to

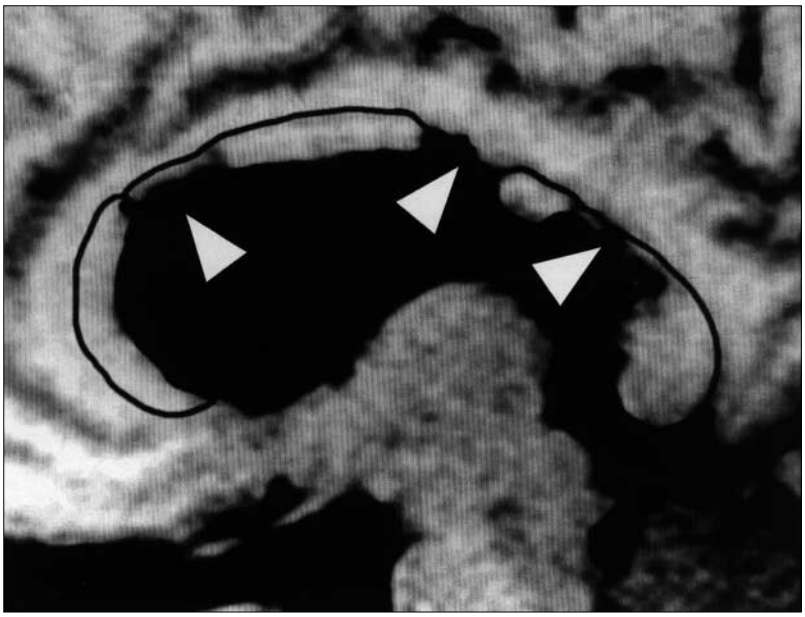

Fig. 1 Midsagittal MR image indicating the lesioned regions (*arrowheads*) along the corpus callosum of a patient with agonistic dyspraxia [13]. There were no extracallosal lesions in this patient

strongly seize this hand to prevent it from moving). We proposed to call this condition agonistic dyspraxia.

Transiently, our patient [13] presented crural paresis, transcortical motor aphasia, grasp reflex and compulsive manipulation of tools, all indicative of left frontal medial dysfunction, probably associated with vasospasm and compression caused by the hematoma [19, 32]. The transient nature of these signs, together with the absence of an extracallosal lesion as seen on MRI, although not eliminating the possibility of laminar necrosis in the frontal cortex, renders persistent frontal damage unlikely. Longer lasting motor disturbances included ideomotor apraxia of the left hand, a mild intermanual conflict, the sensation of a third hand during the execution of some bimanual tasks, and the condition that we described as bilateral agonistic dyspraxia. In this context, Goldberg et al. [4] and McNabb et al. [33] asserted that frontal lesions are sufficient to explain the alien hand syndrome, so that callosal damage is not required. Della Sala et al. [2] have argued that chronic forms of the alien hand are associated with frontal lobe damage, while purely callosal lesions render only transitory forms of this syndrome. However, in this patient we documented a 7-month long lasting case of abnormal control of hand movement with a purely callosal lesion and with no evidence of chronic frontal involvement.

Initially, the patient reported the sensation of having a supernumerary small hand, which was located over the dorsal surface of her left hand. Her third hand ("the bad one" according to her) was independent of her conscious will, and caused the "real" left hand to perform movements that were in many cases antagonistic to those performed by the right hand, as occurs in intermanual conflict. Furthermore, contrary to other cases of a phantom third limb, in our patient the supernumerary hand was associated with a purely callosal lesion. As suggested by Halligan et al. [14], it is possible that the sensation of supernumerary hands is more common than has been considered before, because this patient, like others with this symptom, was reluctant to speak about this sensation and only talked about it when she was directly questioned.

The unusual behavior described here, in which the patient executed the instructed act with the hand opposite to the one that was specified by the examiner (whichever it was, left or right) probably corresponds to a sign of callosal disconection not described previously. In fact, this was still observed several months after the callosal hemorhage, when the signs attributable to frontal damage had long disappeared, and it was concomitant with well-known signs of callosal disconnection. In this patient, the lesion was restricted to the corpus callosum, but since it was widespread along its length we cannot specify which of the damaged callosal regions were associated with her unusual symptoms.

In contrast to diagonistic dyspraxia, the condition described here consists of the agonistic movements of the contralateral hand to perform those movements for which the specified hand is apraxic. The inability of this patient to respond with the left hand may perhaps fit the classic callosal disconnection syndrome. However, this syndrome predicts that instructions to the right hand (controlled by the left hemisphere and therefore not requiring callosal transfer) should be responded to adequately, and those responses should be nearly as fast as the automatic responses performed by the same hand [34]. In this patient neither of these conditions occurred: the left hand, instead of the right, usually responded to instructions to the right hand, and in the instances where the patient was able to respond with the right hand, it did so after a long delay and in an apraxic-like manner [13]. Somehow, the callosal lesion was inhibiting the purposeful movement of one hand but also contributing to the release of the movement in the contralateral hand, whether it was right or left (although the inhibition was stronger when the voluntary hand was the left, which requires a callosal relay).

Voluntary control of unilateral hand movements

There is evidence that, in normal subjects, the intention to select one hand to perform a complex action implies bilateral hemisphere activation, especially when the selection of movements has been made voluntarily [35–37]. Furthermore, at the level of the body of the corpus callosum, the cingulate cortex contains a gigantopyramidal field which apparently corresponds to the source of cingulate corticospinal projections observed in the monkey [38]. This cingulate region is activated by manual and bimanual movements [39–42], and lesions in this area have been associated with the alien hand syndrome [4]. Callosal fibers connecting this region with the contralateral hemisphere may have been damaged in the anteriormost lesion of our patient.

In our patient, there were two abnormal behaviors that were observed in both hands, and are difficult to explain in terms of the classic disconnection syndrome: (i) the hand specified by the examiner (hereafter the voluntary hand) appeared either unable to execute the instruction, or performed it with great difficulty, and (ii) the contralateral hand (hereafter the automatic hand) quickly executed the instruction given to the patient. Regarding the second point, the selection of the voluntary hand may be somehow mediated through the corpus callosum, which possibly mediates the balance of activity between both hemispheres. Failure to exert this hemispheric dominance for the preferred hand due to a partial callosal lesion might result in abnormal activation of the hemisphere ipsilateral to the voluntary hand, which would produce movement of the automatic hand. It is possible that the anterior callosal lesion in this patient somehow rendered the non-instructed hemisphere unable to inhibit the activation of the movement of the hand.

Although the preceding arguments may explain the quick execution of movements with the automatic hand, it leaves open the explanation of the first point raised previously, i.e. the difficulty in performing the movement with the voluntary hand, which is evident in the much longer delays of response for this hand when compared to the automatic hand, and in the performance of ideomotor praxis tests which was consistently better in the automatic than in the voluntary hand [13]. It is as if the patient was unable to move the hand once she directed attention to it. This phenomenon may be tentatively explained by the following model: normally, there is a transitory inhibition (or lack of activation) of the voluntary hand (and the contralateral hemisphere) when instructed to perform the action. This could be attributed to focus on propioceptive perception, due to the fact that the subject is giving special attention to this hand. The inhibition of the voluntary hand (hemisphere) may in turn be normally overriden, followed by activation of the motor cortex. This process may be partly mediated by the corpus callosum. Interhemispheric facilitation of the hand representation of the motor cortex has been reported in humans [43], which may partly account for the proposed excitatory mechanism. In this patient, the callosal lesion may have produced a deficit in the activating mechanism that permits movement of the hand, resulting in great slowness and difficulty in performing the movement. While the voluntary hand remains inhibited, the contralateral hand (which is not being inhibited, since attention is not directed to it) can be recruited to quickly execute the action. In other patients with anterior callosal damage, there may be other, non-callosal activating mechanisms which override the transient motor inhibition of the left hand. In this patient these non-callosal mechanisms are perhaps not well developed due to individual differences in brain organization. Another possibility is that both the normal inhibition of the voluntary hand and the subsequent activation mechanism depend on the corpus callosum but use different fiber systems. In this patient, the callosal lesion might have damaged predominantly the excitatory fibers while sparing the inhibitory ones, producing a maintained inhibition of the voluntary hand.

Conclusions

The term “alien hand” indicates a wide spectrum of motor and sensory deficits, which may be caused by parietal, frontal, or callosal lesions. We have tentatively classified these symptoms into four categories that may specify different nosological entities, although the brain regions and cerebral mechanisms involved in this process have not been totally elucidated. In addition, we propose a new, fifth category, which we term agonistic dyspraxia. Although our proposal is based on the observation of one case, we consider that the symptoms do not fit any previous description and thus deserve to be considered a distinct clinical entity.

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