Inverted or tilted perception disorder

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INVERTED OR TILTED PERCEPTION DISORDER

Summary. *Aim. In the context of the increasing number of reported cases of patients presenting tilt or reversal of vision anomaly (here reviewed), we call the attention to the work of Justo Gonzalo (1910-1986), scarcely known in the contemporary literature. His work deals with that anomaly, and with tactile and auditory inversion, in relation to what he called central and paracentral syndromes, interpreted from the functional model he developed.* Development. *Gonzalo makes reference to 25 patients with chronic tilted vision, some of them with almost inverted perception in visual, tactile and auditory systems, under minimum stimulus. The central syndrome is caused by unilateral lesion in the parieto-occipital cortex, equidistant from the visual, tactile and auditory projection areas, and is characterized by bilateral multisensory involvement, and by dynamic effects following physiological laws of nervous excitability. Thus, as the illumination of an object was diminishing, it was perceived progressively tilted, reduced, and losing form and colors, following a physiological order; however the image was corrected by increasing the illumination, or by facilitation through other sensory stimulus. The central syndrome is compared with the reviewed cases.* Conclusions. *This syndrome involves a deficit of nervous excitability which would induce an integration deficit, tilted vision emerging as a more common affection than believed. The central syndrome reveals aspects of the cerebral dynamics, suggesting a functional continuity and unity of the cortex. This is reflected in the model that was proposed, based on functional gradations through the cortex and scaling laws of dynamic systems.* [REV NEUROL 2007; 44: 157-65]
Key words. *Brain dynamics. Facilitation. Neurophysiology. Parieto-occipital lesion. Perception. Reversal of vision. Tactile inversion. Tilt illusion.*

INTRODUCTION

Inverted vision is considered a rare anomaly consisting of an inversion in the visual perception of objects, i.e., the image is perceived to be rotated 180º, in general in the frontal (coronal) plane. If the rotation is less than 180º the result is tilted vision, also called environmental tilt illusion. In almost all cases reported in the bibliography, this disorder is described as a transitory phenomenon with a variable duration, from some seconds to several hours, and without evident changes in size and shape of the image.

The most complete bibliographic review up to 1987 was made by Solms et al [1]. These authors make reference to 21 cases reported from 1805 to 1982 and describe the case found by themselves, which is the first case, referred in the literature, of inverted vision after a frontal lobe lesion. A remarkable fact is that the patient was able to abort the inversion by briefly closing the eyes. This case presented a clear difference with respect the previous ones in which a suspected location for the lesion was specified: the parieto-occipital region [2-7], or the vestibulo-cerebellar system [6-11].

In the following we review other cases that complement the review made in [1]. In what follows, it must be understood that the tilt or inversion is in the frontal plane if no specification is made. There is a case of inverted vision caused by encephalitis and cranial traumatism [12], diverse cases of tilted vision (or inverted vision in most of them) related to ischaemia or cere-

brovascular disturbances in vertebrobasilar region [13] (five cases), [14-19], cerebellar region [20-22], pontine zone [23] (two cases with sagittal tilt of 90º), [24], and right parieto-occipital cortex [25]; there is a case with tilt of vision associated with lateral medullary compression [26], a case with 150º tilt of vision in acute multiple sclerosis [27], a case of reversal of vision during an epileptic attack involving the second sensory cortex [28], three cases with brainstem lesion which experienced 90º tilt of vision following vestibular stimulation [29], a case of inverted vision in patient with multiple sclerosis in which a brainstem lesion was demonstrated by imaging [30], two cases with respective tilt less and greater than 90º associated with peripheral vestibular lesions [31,32], and a case of reversal of vision for a few hours after sudden interruption of the right vestibulocochlear nerve [33].

Other six cases with inverted or tilted vision were reported by River et al [34]. Five of them had signs of occipital or parieto-occipital lesions and the other one presented pure brainstem syndrome. None of them had visual defects except one of them who had transient hemianopsia. Three of these patients had tilted vision, one clockwise and twice counterclockwise, and also rotation of less than 90º in the sagittal plane in one of the cases. An important observation is the transient recovery in one of the patients when he moved his hand in front of him or saw the flame of a match. In other cases [21,31] the alteration also disappeared when the patient held on to a fix object.

Arias et al [35] report on six cases of patients with inverted or tilted vision related to varied etiology. Four of them with left-right inversion in the horizontal plane showed MR hyper-signal in left subcortical parietal or fronto-parietal regions. Other patient with clockwise tilt of vision had signs in MR of basilar thrombosis, and the other one with inverted vision in the sagittal plane and with antecedent of basilar migraine had normal MR.

Malis et al [36] describe 23 cases with inverted or tilted vision, of which, 17 were associated with peripheral vestibular disorders, one of them with tilt in the sagittal plane; another case with inverted vision was associated with ischaemic lesions

in the brainstem, left thalamus and right occipital lobe, demonstrated by MR; one more case was due to a possible transitory ischaemia; and for the other four cases, the cause of inverted vision remained unknown.

Other recent cases with varied etiology are: a case of tilted vision of 90º related to VIII nerve neuritis [21], two cases with tilt of vision related to nuclear vestibular lesions and cerebellar hemorrhage [37], a case of inverted vision in patient with an old pontine stroke and whose EEG, made during episodes of reversal of vision, did not present anomalies in surface [38], a case of 45º clockwise tilted vision related to a left posterior thalamus lesion [39], a case of inverted vision in relation with Susac syndrome, where multifocal involvement or a migrainous mechanism is suggested [40], a case of inverted vision at the beginning of epileptic attacks, associated with a dysplasia detected from MR in the left parieto-occipital cortex [41], and finally, a case of clockwise tilted vision of 22.6º with simultaneous visual allesthesia (see below), in relation to bleeding in the left parietal and parieto-temporal regions [42]. In this last case, it is interesting to note that the perceived image was weak, without color, and compressed in horizontal size by 20%.

Some authors propose that the region concerned with reversal of vision process is the parieto-occipital zone [41], even in some cases with brainstem syndromes which would have concomitant parieto-occipital lesions [34]. It is also proposed a disfunction of the multisensory parieto-insular vestibular cortex, or its afferences, or of its association cortical areas [21,35], or a disorder of visiospatial integration [25,29,42]. In this context the works of some authors are of especial interest [43-45].

It must be noted that the above reversal of vision phenomena must be distinguished in principle from the so-called visual allochiria, or visual allesthesia, though a connection is not excluded. In visual allochiria or allesthesia, objects situated on one side of the visual field are perceived in the contralateral visual field, i.e., there is a type of left-right inversion, in general from the healthy side to the affected one, and usually originated by a right cerebral lesion (but not always). Some recent cases of allochiria had lesion in the right occipital lobe [46], right temporo-occipital-parietal region [47], right fronto-parietal region [48], and left parietal and parieto-temporal regions [42], for example. This last case presented simultaneously tilted vision, as was referred above.

There is a comment made by Critchley concerning inverted vision [49], where Wilder, Hoff, Gonzalo, Penta and Klopp are cited. Their works, except those of Hoff and Gonzalo, are also cited in the review of Solms et al [1] (where reference to the comment of Critchley is made). However, the non-referred works are also relevant, but accessing them may be difficult. Hoff [50] reported on a patient with a brain injury in the parieto-occipital zone which presented tilted vision of about 30º during epileptic attacks. An interesting fact is that a similar tilted vision could be also provoked by cerebral cooling through the cranial injury.

In what follows, we just deal with the work of Gonzalo [51-53], where many patients with tilted or almost inverted vision were investigated with detail from neurophysiological and neuropsychological points of view. This author studied about one hundred selected patients with brain injuries from the Spanish Civil War (1936-39). Twenty five of them presented chronic manifestation of tilted or almost inverted vision under conditions of minimum stimulation (e.g., illumination): 13 cases between 2-12º, six between 12-30º, and six between 30-170º, in the frontal plane, and a few ones also with small tilt in the sagittal plane. Twelve of them with brain injury in the parieto-occipital zone and special features led to the characterization of what the author called 'central' syndrome, and to the proposal of a dynamic interpretation of certain problems of cerebral localizations. This allowed the author to explain the cases of first hand and others reported in the literature, offering also an alternative interpretation of the much-discussed Schn case of Goldstein et al [54]. Since the central syndrome presented also tactile and auditive inverted perception in acute cases, the direction problem was approached in a general way.

Details about data, methods and interpretation of the results are exposed extensively in the two-volume book [51] and summarized in [52,53]. The author developed a functional model of some aspects of brain dynamics, supported by physiological laws of nervous excitability, exposed in part in [51] and further developed in [52,53,55-57]. The immediate repercussion of this research [49,58,59] diverted later towards the development of cerebral processing models [60-65]. Historical notes have recently appeared [66,67].

In the next section, we briefly expose some phenomena that characterize the central syndrome, and their interpretation from the functional model that was proposed. Next, a discussion is made by establishing a comparison with the other cases with tilted and inverted vision reported in the literature. Some general aspects are remarked in the conclusion section.

THE CENTRAL SYNDROME: DYNAMIC PHENOMENA

Gonzalo [51-53] called central syndrome of the cortex the sensory phenomena associated to a unilateral lesion in the parieto-occipital cortex, equidistant from the visual, tactile and auditory projection areas ('central' region). Six cases with pure central syndrome are shown in Fig. 1, as an example [53]. The more acute one (M) presented almost inverted vision. Another one (T), with injury in the same zone as M but smaller in magnitude and with less intensity in the anomalies, was compared to M in the explorations. In case M, the region of the cortex destroyed by the projectile trajectory (with entry and exit orifices in the left parieto-occipital convexity) corresponded to the middle of area 19 (Brodmann terminology), the anterior part of area 18 and the most posterior part of area 39. In case T, the location of the cerebral lesion corresponded only to the center of the projectile trajectory of case M, with only cortical contusion by osseous sinking, as demonstrated from neurosurgery data.

The central syndrome is characterized by a multisensory and symmetric bilateral involvement, disgregation of the sensory qualities, and capability to sensory facilitation and to temporal summation by iteration, which are dynamic phenomena related with modifications of the central nervous excitability and that are dependent on the quantity of neural mass lost in the 'central' lesion.

Bilateral multisensory involvement

In central syndrome, there is a multisensory involvement with maximum symmetry, i.e., visual, tactile and auditory systems are equally affected, in all its functions, and with symmetric bilaterality in spite of being a unilateral lesion. In the visual system for example, in addition to other disorders, there is a bilateral and symmetrical concentric reduction of the visual field.
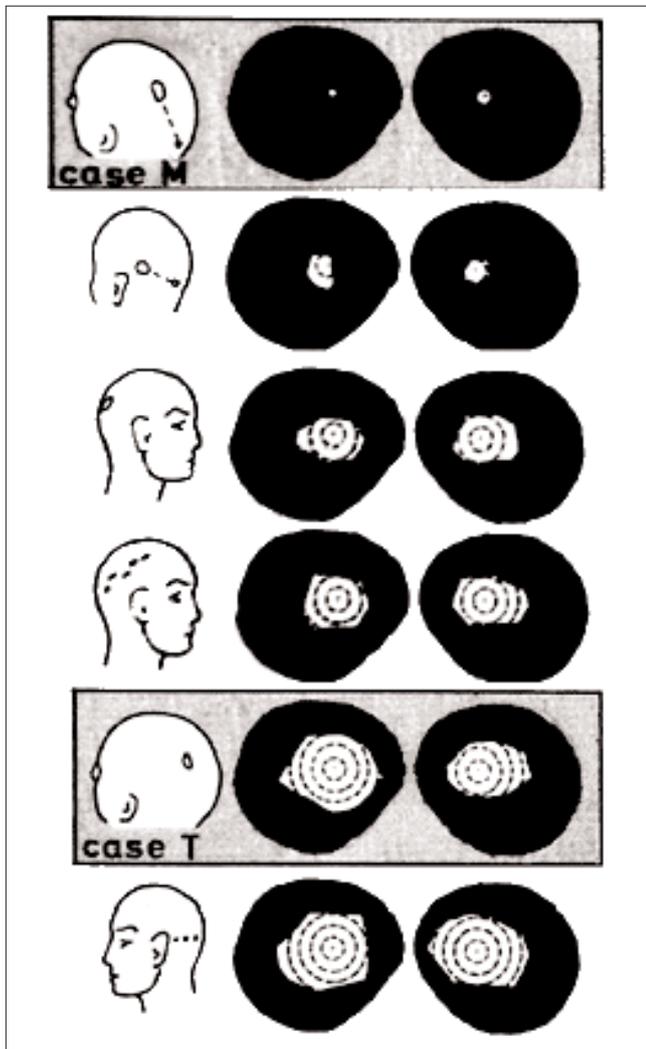
Figure 1. Visual fields of six cases (M and T included) with central syndrome in different degree. The position of the brain injuries is schematically shown.
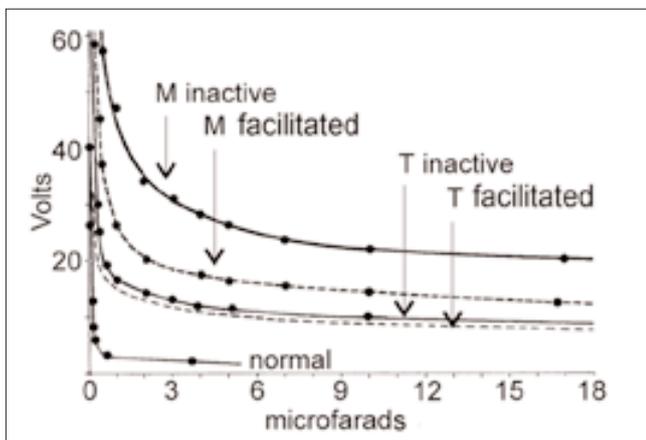
Figure 2. Excitability threshold curves for electrical stimulation of the retina with condenser discharge (cathode on eyelid), for right eye of patients M and T with central syndrome; in inactive state, facilitated state by strong muscular contraction (see the text), and in a normal case. For a given electrical intensity (given voltage V), each point represents the time (expressed indirectly in microfarads of the condenser) necessary to obtain minimum phosphene (minimum luminous sensation) (adapted from figure 3 of [53]).

This concentric reduction consists of an increasing functional deficit from the center to the periphery of the visual field. It was found that the intensity of the anomalies was greater as the magnitude of the 'central' lesion was greater. The magnitude was determined by the trajectory of the projectile or from surgery data in some cases.

The central syndrome, involving a loss of rather unspecific (or multispecific) neural mass, is characterized by a functional 'depression' reflected in a hypoexcitability of the nervous centers, as was shown in simple excitability experiences (Fig. 2).

The syndromes corresponding to lesions in the respective projection areas were called here marginal or peripheral syndromes, the defect –functional 'suppression'– being restricted to the contralateral half of the corresponding sensory system, and lacking dynamics effects. The syndrome associated with a lesion between a projection area and the so denoted 'central' area, was called 'paracentral' syndrome, being possible to verify that when the lesion was nearer the 'central' region, the multisensory involvement with symmetric bilaterality was more evident.

Functional disgregation: inversion process

This dynamic phenomenon is the dissociation or separation of sensory qualities which are united in normal perception. In particular, it reveals the 'direction function'.

First we analyze this phenomenon in the visual system. For example, in case M in inactive state (free of sensory facilitation, as explained below), the perception of a vertical upright white arrow suffered from the following disgregation phenomena as the cerebral excitation was diminished (diminishing the illumination of the arrow). At high enough illumination, the perception of the arrow was upright, well defined and with a slight green tinge. As lighting was reduced, the arrow was perceived to be more and more rotated in the frontal plane (Fig. 3a), at the same time that became smaller and losing its qualities of form and colors in a well-defined physiological order [51-53]. The first function lost was the meaning of the object, then, visual acuity, blue color, yellow color, red color, luminosity, so that if the tilt of the vision was greater than 90º and nearing inversion, the object was perceived as a small shadow. The tilt was measured by rotating the arrow in the opposite direction until it was seen upright. If the test object was situated to one side of the visual field, the object was seen to rotate with centripetal deviation, coming to rest, inverted and constricted, in contralateral position quite close to the center of the visual field (Fig. 3b). The more peripheral the vision, the more tilted the arrow was perceived to be. In central vision, the rotation was clockwise for the right eye and counterclockwise for the left eye. In peripheral vision, the rotation was clockwise (counterclockwise) in the right (left) side of the visual field.

These phenomena appeared in both left and right unilateral lesions. The process was reversible and was seen to follow approximately Fechner law, as shown in figure 4 for case M in inactive and facilitated states (see below) [51-53]. The perceived turn was dependent on the size and distance of the objects, i.e., on the subtended angle of vision, and also on the illumination and exposure time. Thus, a nearby object appeared to be greatly inclined if it was only seen for an instant. As no inclination was perceived in clearly distinguished (well illuminated) objects, many patients were unaware of their anomalies, which were only relevant when provoked in inactive state (see below) and under low intensity of the stimulus.

In case M, the maximum inclination perceived was about 170° with the left eye and 145° with the right one. In case T, the maximum inclination was only about 25° with the right eye and 16° with the left one, following the same behavior as case M. The disorder was chronic in both cases. It was found in case T that two days after an epileptic attack the maximum inclination was 120° with the right eye and 70° with the left one. A slight tendency to rotation in the sagittal plane was also detected in case T and other cases.

The reversal of vision was discovered in patient M when a moving object was seen by the patient with inverted direction of movement, and perceived as a mere blurred spot moving along a much smaller trajectory. As the velocity of the object increases, the elapsed time it is seen in a given place diminishes. Then, the short exposure time makes the perceived trajectory to be tilted, almost inverted in case M.

Figure 5 shows the correlation between the degree of tilt of vision and the reduction of the visual field, for 25 cases (including M and T) all them presenting chronic tilted or almost reversed vision. All cases belong to central or paracentral syndromes, with right or left parieto-occipital lesion caused by projectile in the Spanish Civil War [53].

Concerning the most complex function (gnosia) in cases M and T, in addition to a diffuse conception of objects, it was also detected the so-called 'orthogonal' disorder, in which objects are seen the same independently of their orientation. For example, texts can be read upright or upside-down (rotated 180°) without noting any difference. Another detected disorder in the most acute case M was the substitution of the halocentric spatial orientation by the egocentric one.

Other cases were also reported [51,53] presenting a sudden and transitory tilt or reversal of vision, mainly during epileptic auras. In this type of sudden turn, the visual scene was not so deteriorate as in the cases above analyzed. Some of the cases with chronic disorder in the direction function, as explained, also experienced this type of sudden and transitory tilted or inverted vision.

In addition to the visual direcction function, other visual functions such as acuity, colors and forms, were studied with detail from a physiological point of view in cases M and T [51] (p. 96-388). Let us mention, for example, the chromatic irradiation or 'flat colors' (the color is perceived as separated from the object) which were interpreted as a dissociation between the chromatic function and the spatial localization function, due to their different excitability thresholds.

The tactile system was also studied extensively, in particular tactile inversion [51-53]. For example, for a mechanical pressure stimulus on one hand, five phases in the dissociated perception were distinguished successively in case M as the energy of the stimulus was being increased (Fig. 6a): I, primitive tactile sensation without localization; II, deviation to the middle with irradiation (spatial diffusion, similar to chromatic irradiation); III, inversion phase but closer to the middle line of the body than the stimulus; IV, homolateral phase; V, normal localization, which required intense stimulus, or moderate stimulus and facilitation by muscular contraction (see below). The lower sensory level phases (I, II, III) were separated only by very small increments in the stimulus intensity while the higher ones (IV, V), close to the normal localization, were separated by large increments, being the most perturbed phases by the cerebral excitability deficit.

When a cutaneous mobile stimulus was perceived in the inversion phase (Fig. 6b), the perception was contralateral and
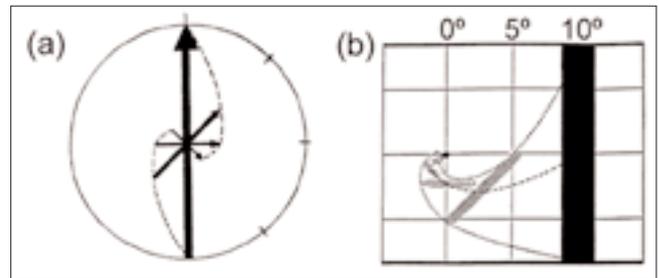
Figure 3. (a) Scheme of the perceived directions of a vertical test arrow in the center of the visual field of right eye, in central syndrome (adapted from figure 1a of [57], with permission of Springer Science and Business Media). (b) Scheme of the perceived images with centripetal deviation of a test obect in the periphery of the right side of the visual field, in central syndrome (adapted from fugure 3a of [55], with permission of The MIT Press).
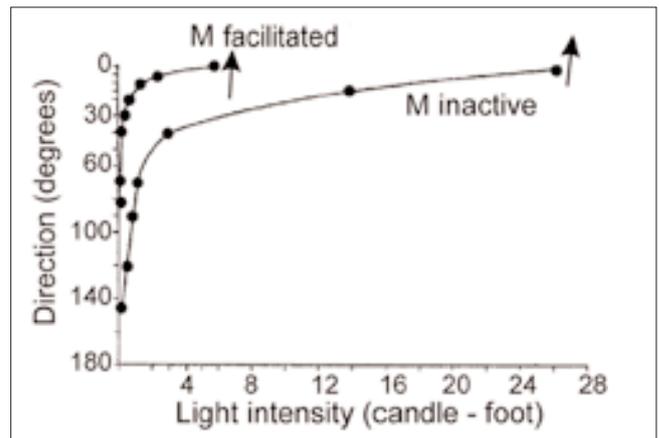

Figure 4. Perceived direction by patient M, right eye, of a vertical white 10 cm size test arrow, versus light intensity illuminating the arrow on a black background, at 40 cm patient-arrow distance; for inactive state and facilitated state by strong muscular contraction (adapted from figure 3c of [55], with permission of The MIT Press).

close to the middle line of the body, with a very shortened trajectory (approximately 1/10 in case M) and almost inverted direction of movement within three autonomous zones of inversion: head, upper extremities and lower extremities. The tactile qualities with greatest demand of nervous excitation were the first lost as the intensity of the stimulus was diminished, so that the first one lost was temperature, then pain, and then pressure.

Tactile inversion was studied for cutaneous and articular stimulation including complex processes as walking. In moderate walking, the process showed striking characteristics: the first step was ignored, the second step was felt inverted, the third one as transversal, the fourth oblique, etc. This is a progressive recruitment of the direction of perceived steps due to accumulation of excitation in the nervous centers by iterative action of steps (see below temporal summation). In slow walking there was no summation and the direction remained inverted for each step, the steps being felt very short.

These processes and others concerning tactile system were measured quantitatively [51] (vol. II) and it was found that the general laws for the tactile direction were the same as for the visual direction function. In consequence, spatial inversion was addressed in a general way and as an essential fact in the organization of sensory functions with a spatial character.

With respect to the auditive system, cases M and T present-
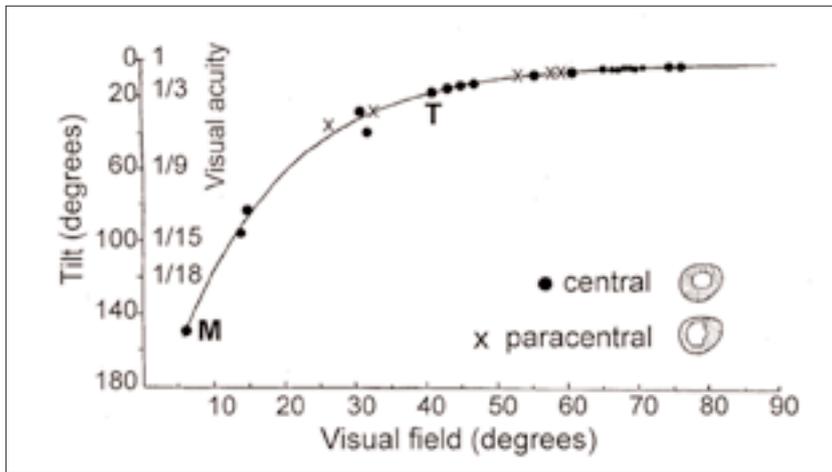
Figure 5. Correlation between the degree of tilt of vision (visual acuity indicated) and the width of the visual field, for chronic cases with central or paracentral syndromes, including M and T cases (adapted from figure 4 of [55], with permission of The MIT Press).
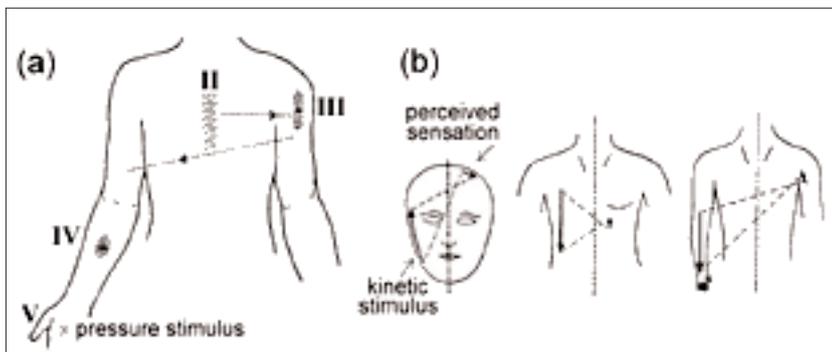
Figure 6. a) Phases of tactile localization of a stimulus in case M inactive (see the text). III: inversion phase; b) Inversion and centripetal deviation of cutaneous kinetic stimuli in case M inactive (adaptations from figure 2 of [57], with permission of Springer Science and Business Media, and from figure 4 of [66], with permission of Grupo Ars XXI de Comunicación S.L.).

ed also a deficit of excitation and a dissociation phenomenon in analogous way as in vision and touch, consisting of a dissociation between simple sonorousness and real tone of a particular sound. Contralateral localization, due to spatial inversion, of a sound stimulus occurred only in case M when the stimulus was weak and the patient was in inactive state. The inverted perception always lacked tonal quality [53].

Sensory facilitation and temporal summation

The sensory facilitation here considered is a dynamic phenomenon characterized by the improvement in the perception of a stimulus by adding simultaneously one or more different stimuli.

In the cases studied, it was remarkable that a strong muscular contraction was very efficient at improving the perception, reducing the functional disgregation significantly. This type of muscular 'reinforcement' straightened the tilted vision almost instantly, and simultaneously cleared the vision and dilated the visual field (about five times in case M). Figure 7 shows the perceived inclination of a vertical upright test arrow versus muscular contraction in case M [51]. Other types of reinforcement are, binocular summation, in which one eye reinforces the other, as well as tactile and acoustic stimuli, although their effects are far less dramatic than that obtained with strong muscular contraction. However, regardless of the intensity of this reinforcement,

it is unable to correct completely the defect. It was found that visual and auditory stimulations scarcely improved the tactile perception. By contrast, muscular contraction as well as another different tactile stimulation were very efficient to improve the tactile perception.

It was also found that the capability to sensory facilitation was greater as the deficit of cerebral excitation due to the lesion was greater, i.e., as the quantity of 'central' neural mass lost was greater (in M was more significant than in T), being null in a normal case. It is noticeable that the mere fact of being in a siting position, standing up or walking, instead of recumbent, modified the perception. The so called inactive state, free of reinforcements by sensory facilitation, was then difficult to achieve, specially in acute central syndrome cases.

Sensory facilitation can be considered to be as a 'spatial' summation where different groups of neurons act at the same time on different receptors. It modifies the cerebral system essentially, becoming more rapid and excitable, i.e., it supplies in part the neural mass lost in the 'central' lesion, thus reducing the functional disgregation. In this respect, note the different behavior of case M in inactive state and in facilitated state, as shown in Figs. 2 and 4.

Unlike sensory facilitation, 'temporal' summation is merely a particular means of stimulation. The slowness of the cerebral system in central syndrome makes the cerebral excitation due to a short stimulus to decay slowly. If a second stimulus arrives before this excitation has completely fallen down, excitations are summed up, so that it is possible to achieve an excitation threshold to produce a sensory perception, so reducing the mentioned pathological dissociation. The capability to temporal summation is also greater as the 'central' lesion is greater, as was shown in the experiences.

Interpretation and model

From many cases of first hand and others reported in the literature, the diverse syndromes were ordered according to the position of the lesion (central, paracentral and marginal) and its magnitude. The complete gradation found between central syndrome, in which the neural mass lost has rather unspecific physiological activity, and a marginal syndrome originated by a lesion in the projection area, where there is a destruction of the nervous path, led to the definition of two types of continuous functions through the cortex (called 'cerebral gradients' [53]) as shown schematically in figure 8. One type comprises the specific sensory function densities, of contralateral character, with maximum value in the respective projection areas and decreasing gradually towards more 'central' areas and beyond so that the final decline of the specific visual density function, for example, must reach tactile area as well as other areas. For the visual function to be normal, the action of the region with greatest density is not enough, and the whole density gradation through

the cortex must be involved. This type of function takes into account and combines the factors of position and magnitude of the lesion, since the more 'central' is the lesion, the more extensive must be the lesion to originate the same intensity in a specific anomaly. The other type of function, of unspecific character, is maximum in the 'central' region (where the decline of the above mentioned specific functions overlap) and vanishes towards the projection areas. It represents the multisensory effect in the anomalies and the bilaterality or interhemispheric effect by the action of the corpus callosum. These functions are mere abstractions of the observed facts, that account for a functional continuity and physiological heterogeneity of the cortex, and that allow an ordering and an interpretation of the different syndromes.

Spatial inversion was considered a general and essential fact in the problem of sensory organization. This problem was approached by generalizing the concept of sensory 'field' to all sensory systems having a spatial nature and by proposing a spiral development of the sensory fields [51-53]. A sensory signal in a projection area is only an inverted and constricted outline that must be elaborated (magnified, reinverted, ...), i.e., integrated over the whole region of the cortex where the corresponding specific sensory density function is extended, including the 'central' region. Magnification would be due to the increase in recruited cerebral mass, and reinversion due to some effect of cerebral plasticity, following an spiral growth similar to that of figure 3. In the visual system, reinversion and bilateralization would occur in the 18 and 19 secondary areas (Brodmann terminology) where the sensory representation is already reinverted. A remarkable result is, for example, the significant participation of the 'extravisual' cortex in the 'maintenance' of the visual field.

When there is a lesion in the rather unspecific 'central' region, the main consequence is a deficit of nervous excitability which would lead to a deficit of integration through the cortex, determined by the lesion magnitude (neural mass lost). This deficit gives place, according to the experiences achieved, to the dissociation or decomposition of normal perception into its components or qualities, in such a way that the most complex qualities, with greatest nervous excitability (and integration) demand, become lost or 'delayed' in greater degree than the most simple ones (with lower excitability demand). Sensations usually considered as elementary are then seen to be decomposed into several functions, one of them being the direction function. Very small differences in the excitation of different qualities occur already in the normal individual (in colors for example), and they grow considerably in central syndrome.

The cerebral system after a 'central' lesion, and once the new dynamic equilibrium is reached, was considered to be a scale reduction of the normal cerebral system since the originated functional depression maintains, nevertheless, the same cerebral organization as in normal case. This can be appreciated from the concentric reduction of the visual field and its sensibility profile. Both maintain approximately the same shape as in normal case but on a reduced size. Also, the excitability and luminosity threshold curves as well as the visual acuity function experience only a down shifting of its values, but keeping the same form as in normal case [51-53]. Then, the concept of dynamic similitude, according to which different parts of a dynamic system change differently under a change in size of the system, was applied. In particular, in biological growth, the sizes of two parts (say x and y) of a biological system, are related by a potential law approximately, $y = a\,x^n$, n being different for different
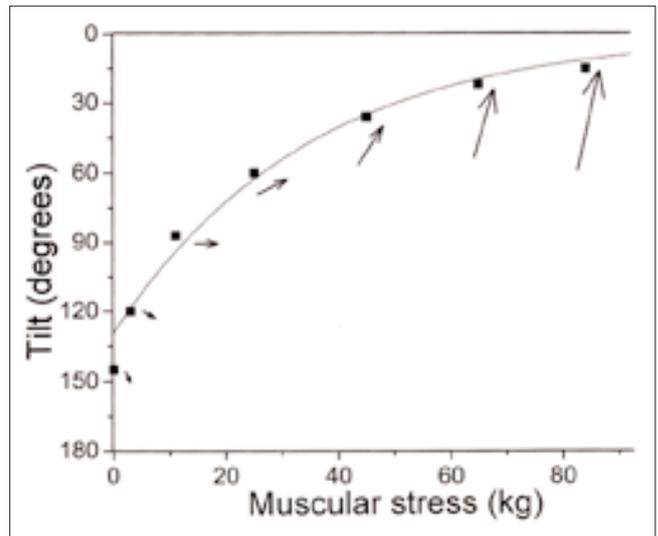

Figure 7. Perceived direction by patient M, right eye, of the same vertical test arrow as in figure 4, versus muscular stress (kilograms held in his hands).
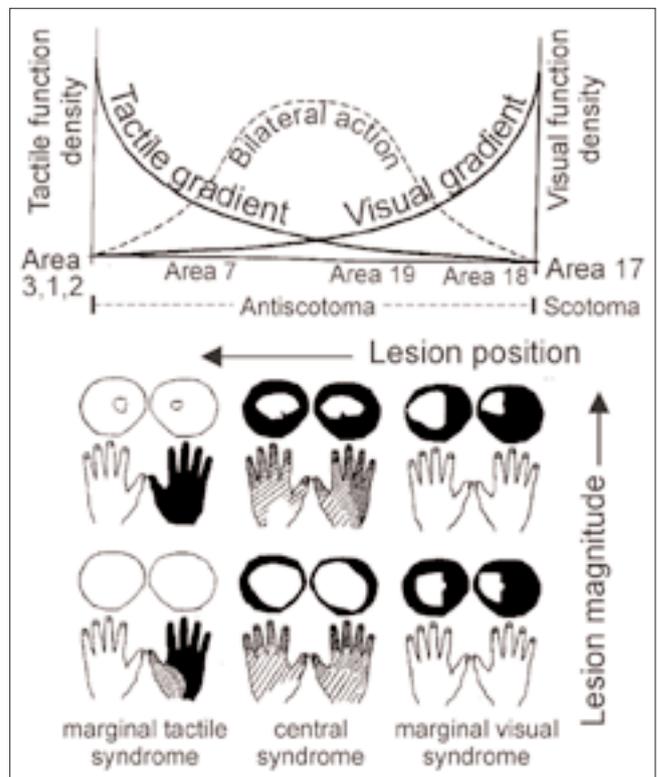

Figure 8. Lower part: visual fields and tactile sensitivity of cases ordered according to the position and magnitude of the lesion. The degree of the defect is greater in darker regions. Upper part: scheme of specific functional gradations (visual and tactile), and the unspecific functional gradation which represents the multisensory and bilateral effect (adapted from figure 5 of [55], with permission of The MIT Press).

parts (y_1, y_2...) of the system which then change differently, i.e., allometricaly. These scaling laws were applied by Gonzalo to the sensory growth (this one linked to the neural mass and nervous excitation), and an allometric variation of the sensory qualities was proposed. For the ensemble of cases explored with central syndrome of different magnitude, it was found that the

visual acuity (say y_1) and the visual perceived direction (say y_2), for example, followed approximately potential allometric laws with respect to the width of the visual field (say x), each one with a different exponent [56]. These laws would give the different variation of each sensory quality or function in the sensory growth as well as in the sensory decrease, thus quantitatively describing the dissociation between the sensory qualities.

In central syndrome, the sensory level may grow by intensifying the stimulus, by iterative temporal summation of stimuli and by sensory facilitation. The best example is the extreme case M, who could approach the physiological and sensory level of case T by the use of strong muscular contraction, following a law of the type of biological growth [57]. For very high intensity of the stimulus, the perception can be almost normal. The anomalies are then very relevant only for low intensity of the stimulus, the patient being free of sensory facilitation and temporal summation.

DISCUSSION

In the reported cases in the bibliography, the experience of tilted or inverted vision is usually described as a transitory and paroxysmal phenomenon without loss of shape and size of the perceived object or the visual scene, except in a recent case of tilted vision combined with visual allesthesia in which the perceived image laked color and was reduced about 20% in the horizontal direction [42]. In the cases studied of central or paracentral syndrome [51-53], the affection was chronic, and the perceived tilt or inversion could be provoked under conditions of threshold stimulation and inactivity. In these cases there was a degradation of the perception together with the inclination: diminution of size, and loss of shape and color, as explained. In this sense, the recent case reported in [42] shows some similar features. It would be of interest to know if similar behavior to that described in the central syndrome could be observed in some of the cases reported in the literature, under similar exploration to that performed in this syndrome. Gonzalo also described cases of transitory tilted or inverted vision, mainly during epileptic auras, which were more similar to those described in the literature. However, in some of them, a chronic disorder as that explained was also detected.

In almost all cases reported in the literature and those described with central or paracentral syndromes, the rotation of the visual image was in the frontal plane. In one of the cases of River et al [34] the sense of the rotation of the visual scene was specified to be counterclockwise for the left visual field, as in the cases described in the preceding section. Four cases [6,7,23,34] presented rotation in the sagittal plane, and some of them presented in addition rotation in the frontal plane, as in case T. In other few cases [3,35], the image was rotated in the horizontal plane, leading to left-right visual inversion.

As explained, sensory facilitation and temporal summation are important mechanisms of improvement of perception that were quantitatively evaluated in central syndrome. In particular, facilitation by strong muscular contraction was very efficient. There are also some cases reported in the literature in which certain stimuli as eye closure, changes in body position, moving one hand, seeing a flame, or holding on to a fix object, corrected and reinverted the vision [1,6,7,9,21,31,34].

As for the orthogonal disorder described in central syndrome, in which objects upright and upside-down seem the same without noting any difference, a phenomenon related to it seems to occur in the case reported by Solms et al [1].

According to Gonzalo [51], the disorder in the visual direction function is not an autonomous syndrome, but it is connected with the rest of visual functions, and could be present in cases with cerebral lesions in different locations, provided there exists some involvement of visual functions. According to the 'cerebral gradients', the densities of the specific functions are extended in gradation through the cortex, so that there would not be a particular localization for such a disorder. In this respect, this author stressed his observations of different degrees of tilted vision in cases with lesions on the left or right parieto-occipital region, on the occipital pole, and also far from the occipital area (e.g., a very anterior parieto-temporal region), showing that the anomaly occur not only in central syndrome but also in the high diversity of the so-called paracentral syndromes. In fact, the cases of tilted or inverted vision reported in the literature are associated to a variety of cerebral lesions.

Concerning the tactile and auditive inversion in central syndrome (with similar laws to those of visual inversion), analogous phenomena have not been described, to the best of our knowledge. This type of tactile inversion must be distinguished in principle from tactile allochiria (tactile allesthesia), frequently described. In this phenomenon, analogously to visual allochiria or allesthesia, tactile localization is contralateral to the tactile stimulus, in general symmetric, and from the healthy side to the affected side ([68,69] e.g.).

CONCLUSION

Contrary to the usual believe that tilted or inverted vision is a very rare disorder, Gonzalo concluded [51] that it could be a rather common affection since, from what is said above, the direction function is easily perturbed in different type of lesions, giving place, at least, to small inclinations of the visual image. These tilts can be only evidenced under convenient exploration since a good illumination of the objects and sensory facilitation make the chronic disorder of tilted or inverted vision to go unnoticed for the patient very often.

The analysis of the phenomena displayed in central syndrome under minimum stimulation reveals dynamic aspects of the sensory organization. The proposed functional model highlights a functional unity and continuity in the cerebral cortex, in two ways. One of them is reflected in the 'cerebral gradients'. These would account for a functional continuity through the heterogeneity of the cortex, allowing an ordering in continuous gradation and a consistent interpretation of the great variety of cases, according to the lesion position and its magnitude. For a sensory function to be normal, the visual one for example, the cerebral integration process should be performed over the whole visual density gradation ('gradient') extended through the cortex and not only over the region with higher density ('visual region'), this suggesting a functional unity.

The other way refers to the dynamic phenomena in the central syndrome. A continuity from simple sensory functions to more complex ones, according to their nervous excitability requirements or thresholds, was observed. As said, a lesion in the 'central' region produces a deficit in nervous excitation which would induce an integration deficit, the sensory level of the patient depending noticeably on the magnitude of the lesion and on sensory facilitation. The use of scaling laws of dynamic systems would

account for the law of the continuous variation of a sensory function or quality with the excitation, and for the different (allometric) variation of different sensory functions or qualities (one of them being the direction function). It formally explains the functional disgregation or decomposition of normal perception into its qualities by the loss of the most complex ones as the excitation

diminishes. A functional unity of the cortex is also manifested through the capability to improve the perception by sensory facilitation, this capability increasing with the excitability deficit.

Finally note that this approach could be connected with those based on a distributed character of the cerebral processing and its adaptive and long-distance integrative aspects [70].

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EL TRASTORNO DE LA PERCEPCIÓN INVERTIDA O INCLINADA

Resumen. Objetivo. *En el contexto del número creciente de casos descritos de pacientes con anomalía de visión inclinada o invertida (aquí revisados), llamamos la atención sobre el trabajo de Justo Gonzalo (1910-1986), escasamente conocido en la bibliografía actual. Su trabajo trata de dicha anomalía y de la inversión táctil y auditiva, en relación con lo que dicho autor denominó síndromes central y paracentral, interpretados con el modelo funcional que propuso.* Desarrollo. *Gonzalo hace referencia a 25 pacientes con visión inclinada crónica, alguno con percepción casi invertida en los sistemas visual, táctil y auditivo, bajo estímulo mínimo. El síndrome central es consecuencia de una lesión unilateral en el córtex parietooccipital, equidistante de las áreas de proyección visual, táctil y auditiva, y se caracteriza por una afección polisensorial bilateral con efectos dinámicos que siguen leyes fisiológicas de la excitabilidad nerviosa. Así, cuando la iluminación de un objeto disminuía, éste se percibía progresivamente inclinado, reducido y perdiendo forma y colores según un orden fisiológico, pero la imagen se corregía aumentando la iluminación o por facilitación con otro estímulo sensorial. El síndrome central se compara con los casos revisados.* Conclusiones. *Dicho síndrome involucra un déficit de excitabilidad nerviosa que induciría un déficit de integración, resultando la visión inclinada una afección más común de lo que se cree. El síndrome central revela aspectos de la dinámica cerebral que sugieren una continuidad y unidad funcional del córtex, reflejadas en el modelo que se propuso, basado en gradaciones funcionales a través del córtex y leyes de escala de sistemas dinámicos. [REV NEUROL 2007; 44: 157-65]* **Palabras clave.** *Dinámica cerebral. Facilitación. Ilusión de inclinación. Inversión táctil. Lesión parietooccipital. Neurofisiología. Percepción. Visión invertida.*