The Placing Reaction in Adult Neurology

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SUMMARY: *The first description of the placing reaction (PR) in 12 human adult cases is given. The optimum position for eliciting the placing reaction (PR) is the dangling leg posture, i.e. the same as for the forward groping of the foot. There are three forms of PR quite similar to those noticed in animal physiology, i.e. the visual-PR, the dorsum-PR and the sole-PR. The term contact placing is preferred for the last two forms. The PR is encountered only in patients displaying a forward and medial groping of the foot as well as a groping of the hand on the same side. The PR is usually ipsilateral to the main cerebral lesion but there was no single case with a well limited unilateral lesion. An involvement of retrorolandic areas seems to be necessary for the occurrence of PR. It is concluded that both groping phenomena and the PR are highly coordinated reflexes subserving self-preservation and belonging to antigravity mechanisms, i.e. the standing posture.*

RÉSUMÉ: *L'auteur décrit la réaction d'appui chez 12 patients adultes. La position optimale pour obtenir la réaction est celle où le patient est assis, les jambes pendantes, i.e. la même position que pour obtenir le réflexe de tâtonnement du pied. On décrit trois formes de réaction d'appui tout à fait similaires à celles observées dans la physiologie animale, c'est-à-dire la réaction d'appui visuelle, la réaction d'appui par excitation de la face dorsale du pied et enfin celle par excitation de la face plantaire du pied. Les deux dernières formes peuvent être englobées dans la même réaction, i.e. la réaction d'appui par stimulation tactile de contact. La réaction d'appui est d'habitude ipsilatérale à la lésion, mais chez tous ces patients il y avait des signes de souffrance hémisphérique bilatérale. L'atteinte des aires rétrorolandiques est nécessaire pour l'apparition de la réaction d'appui. On en conclut que les phénomènes de tâtonnement et de poursuite des pieds ainsi que la réaction d'appui sont des réflexes intégrés au niveau le plus supérieur et qui, en dernière instance, appartiennent aux mécanismes de lutte contre la gravité.*

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The placing reaction (PR) has been used in pediatric neurological clinics (Zappella, 1963; Barnet et al., 1966; Zelazo et al., 1972) for years but it has not been described in adults. We initially elicited the PR incidentally, while studying the groping phenomena of the foot (Fradis and Botez, 1958, 1958a).

Terminology, method and material

The *grasp reflex of the hand* (Seyffarth and Denny-Brown, 1948) has two components, i.e. a flexor response to cutaneous stimulation of the palm and a proprioceptive stretch reflex of the long finger flexors. This reflex has then a catching and a holding phase (Rushworth and Denny-Brown, 1959).

The *groping of the hand* is the pursuit of an object which has touched the hand or crossed the field of vision (Schuster and Pineas, 1926; Adie and Critchley, 1927). The main peculiarity of groping of the hand is the patient's tendency to move the hand and the whole arm so as to place the hand in the most favourable position for grasping the object that touched it.

The classical descriptions of the *tonic foot response to stimulation of the sole* (Goldstein, 1938) and of the grasp reflex of the foot (Schuster and Pineas, 1926; Brain and Curran, 1932) are confusing because both can be elicited by a moving or a stationary stimulus. In our reflex testing (Botez and Bogen, 1976) we made a distinction between the tonic foot response and the grasp reflex of the foot on the basis of the catching and holding phases as described for the grasp reflex of the hand by Rushworth and Denny-Brown (1959).

The *tonic foot response to stimulation of the sole (TFR)* was present

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only when a slow tonic plantar flexion and an adduction movement of the toes were elicited by a firm stationary stimulus across the plantar surface of the foot just beneath the metatarsophalangeal joints. The stimulus was usually the handle of the reflex hammer. Increasing the local pressure leads to increased tonic flexion of the toes. This is the TFR proper. If the TFR was elicited, this was then used to elicit the holding phase of the grasp reflex of the foot and the supporting reaction (Botez and Bogen, 1976).

We considered the *grasp reflex of the foot (GRF)* to be present if both the catching and holding phases were elicited by moving the shaft of the reflex hammer distally on the sole by a stroking movement from the heel forwards. In positive cases there is a slow plantar flexion and adduction movement of the toes, hollowing of the sole with some wrinkling of the skin, followed by the catching phase of the GRF. When the catching phase occurred, it was utilized to test the holding phase of the GRF, i.e. the grasp of the foot proper.

The *positive supporting reaction (SR)* was elicited as follow: when the holding phase of the GRF was present, one maintains a firm local pressure with the handle of the reflex hammer at 2-3 cm underneath the metatarso-phalangeal joint; subsequently the SR is evidenced by: (i) the extensor posture of the lower limb due to a massive contraction of all agonists and antagonists but chiefly of the extensors; the lower limb then becomes a rigid pillar, and (ii) the accompanying contraction of the quadriceps muscle. Consequently, the examiner can raise the extended lower limb in the air (Botez et al., 1975). Classically, the positive SR of Magnus (1924) develops in a supine patient following a passive dorsal flexion of the foot (Foerster, 1936). Besides decerebrate animals (Magnus, 1924) the SR has been elicited also from newborn infants (Monnier, 1946), chronic oblongata and midbrain animals (Schoen, 1926) and from patients after incomplete severance of the spinal cord (Schwab, 1927). Our method of elicitation of the positive SR is different in two ways: (i) we used two positions of elicitation of the SR, i.e. (a) the patient lying in bed and (b) sitting comfortably on a high enough chair (or bed) to have the feet hanging in the air and (ii) we used the elicitation of GRF as the first phase of the SR in the two positions. The positive SR as elicited by us is thus different from the classical positive SR of Magnus (1924) since the labyrinthine influences are different in the supine subject, but, it seems to be a closely related phenomenon.

The *normal plantar flexion reflex of the toes* was elicited either by a moving tactile stimulus on the sole (from the heel forwards) or by a sudden stationary stimulus to the plantar surface of the foot just beneath the metatarsophalangeal joint. The stimulations are followed by a flexor response of the toes followed by a quick return of the toes to normal position. The features which distinguish the TFR from the normal plantar reflex of the toes is the slow, tonic flexion in the former as contrasted with a quick return of the toes to the normal position in the latter. This normal reflex is of particular importance in clinical practice. False positive results may be obtained in normal subjects or in some mental patients who during the elicitation of the TFR, GRF and positive SR show a normal plantar flexion reflex followed by a tendency to push and to grasp the handle of the reflex hammer. Those subjects however did not develop the characteristically slow tonic flexion of the foot nor the progressive increase of muscle tone in the lower limb. They withdraw their toes quickly to the normal position if they are told to remain relaxed and not to push the handle of the reflex hammer. While the TFR, the GRF and the positive SR could be elicited in both supine and sitting positions, the groping phenomena of the foot and the placing reaction (see below) could be produced only in the sitting position and if the patient was sitting on a high enough chair to have the feet hanging in the air. If the patient was sitting as usual, i.e. the feet being supported on the floor, neither groping phenomena of the foot nor placing reaction could be evoked.

Forward groping of the foot was elicited as follows: the patient sat in the dangling leg posture; repeated tactile stimulations on the tips of the first three toes with the handle of the reflex hammer produced alternating flexion and extension movements of the toes with a tendency to grasp; flexion of the toes (grasping) coincided with the touch. If the reflex hammer was gradually withdrawn, the leg slowly moved in the direction of the hammer as if drawn by a magnet (Fradis and Botez, 1958; Botez, 1974).

Medial groping of the foot was elicited by repeated tactile stimulations of the anterior third of the medial part of the foot; the response was a progressive medial rotation of the leg with adduction and a turning-to movement towards the handle of the stimulating reflex hammer.

Lateral groping of the foot could be elicited in a similar way. Repeated tactile stimulations on the lateral part of the sole, with the patient in the dangling leg posture, would induce a progressive lateral (or external) rotation and adduction of the leg and turning-to movements towards the stimulus (Fradis and Botez, 1958a).

In our first investigation (case 1) we used a piece of cardboard about 20 cm long, 10 cm wide and 2-3 cm thick. The plantar surface of the toes and the dorsal part of the foot were then stimulated with the edge of the cardboard in two separate trials.

Tactile stimulation on the plantar surface of the toes will elicit the *sole-contact* PR; stimulation of the dorsal aspect of the toes or of the foot was used for elicitation of the *dorsum-contact PR*. Repeated tactile stimulations with the smooth surface of the cardboard are followed by a cephalad movement of the toes and of the foot, a turning-to movement of enfolding and contourning the edge of the cardboard with the ensuing PR on the horizontal stimulating solid surface of the cardboard.

The pure *visual-PR* has to be understood as a tendency to put the sole on the cardboard when it is pre-

sented in front of the patient's toes without any tactile stimulation on the tips or on the back of the toes.

Both forms of contactual placing were checked in two circumstances, i.e. (i) under visual normal condition and (ii) vision excluded i.e. the patient was blindfolded. The pure contactual placing has to be considered, however, only in blindfolded patients. Hein and Held (1967) showed that the visual PR may be dissociated into an elicited and a guided component in the cat. They showed that kittens reared without sight of their limbs, extended their forelimbs when carried down toward the edge of a horizontal surface. However, unlike normally reared kittens, they were not capable of guiding their paws accurately to the solid parts of an interrupted surface. We introduced in our patients a similar procedure in testing both components of visual PR. Instead of a continuous horizontal surface as stimulating object (the cardboard) we used a special woodboard with spaced cut-outs (Fig. 1).

Twelve patients displaying the PR will be presented in this study. All patients were hospitalized and underwent full neurological examination, routine EEG, brain scan, cerebral angiography, pneumoencephalogram (PEG) and isotope cisternography with ^{111}Indium or computed axial tomography if necessary. Three cases underwent neurosurgical procedures because of brain tumors.

Clinical case reports

Case 1. L.A., female, aged 76. Diagnosis: polycythemia vera. Bilateral parietal and fronto-parietal atrophy more marked on the right.

The patient was admitted to hospital with a three-week history of progressive mental deterioration and a left-sided motor weakness. She was under treatment for polycythemia vera for two years.

Routine clinical examination and laboratory findings: Dementia, incontinence of urine and feces were noticed. She had a left-sided hemiplegia with Babinski, Rossolimo and Hoffmann's signs. Tendon reflexes were brisk (3/4) on the left and normal on the right (2/4). She reacted less to noxious stimulations on the left than on the right side of the body. Hematological findings were compatible with polycythemia vera.

The EEG was frankly abnormal, showing a bilateral slow paroxysmal dysrhythmia from both frontal regions. The PEG showed a mild dilatation of the posterior parts of both lateral ventricles. There was bilateral fronto-parietal atrophy. An atrophic well-delimited area in the paramedian parietal region on the right (Fig. 2) was observed (2.5 cm in diameter).

Special testing procedures: When she was supine a groping movement of the hand, a TFR, a GRF with a positive SR were elicited on the right. When she was in the dangling leg posture, a medial and a lateral groping were easily elicited on the right. Both the forward and the medial groping were followed by a GRF with the subsequent positive SR. The examiner was then able to move the extended limb in different directions because of the GRF and of the ensuing SR. The sole-PR was easily elicited: mild stimulations upon the plantar aspect of the toes were followed by alternate tonic flexions of the toes and the ensuing PR on the horizontal stimulating solid surface of the woodboard. Tactile stimulations on the back of the big toe with the reflex hammer resulted in forward groping and tonic grasp movements, both followed by the sole-PR (Fig. 3). Repeated stimulations upon the dorsum of the right foot were followed by the avoiding reaction, i.e. a turning-to movement which consisted in enfolding and contourning the edge of the woodboard followed by flexion of the toes upon the stimulating surface and the ensuing dorsum-PR (Fig. 4). Once the surface was reached, no other movements of "adjustment" were observed. When the cutoff surface was used, the patient did not try to reach the edge of the solid surface of the woodboard and her lower limb remained extended in the cutout space for a few seconds. GRF and SR on the right. Changes in positions of the head with respect to the body induced no modifications in any of these reflexes. Tactile stimulations on the dorsum of the left (paralyzed) foot induced a cross-placing of the right leg and, of course, no reaction on the left.

Case 2. A.R., female, aged 66. Diagnosis: three cerebral metastases, i.e. a fronto-parietal, a parieto-occipital and a cerebellar, all on the left.

This patient was admitted to hospital because of a six-month progressive mental deterioration. She underwent an operation for

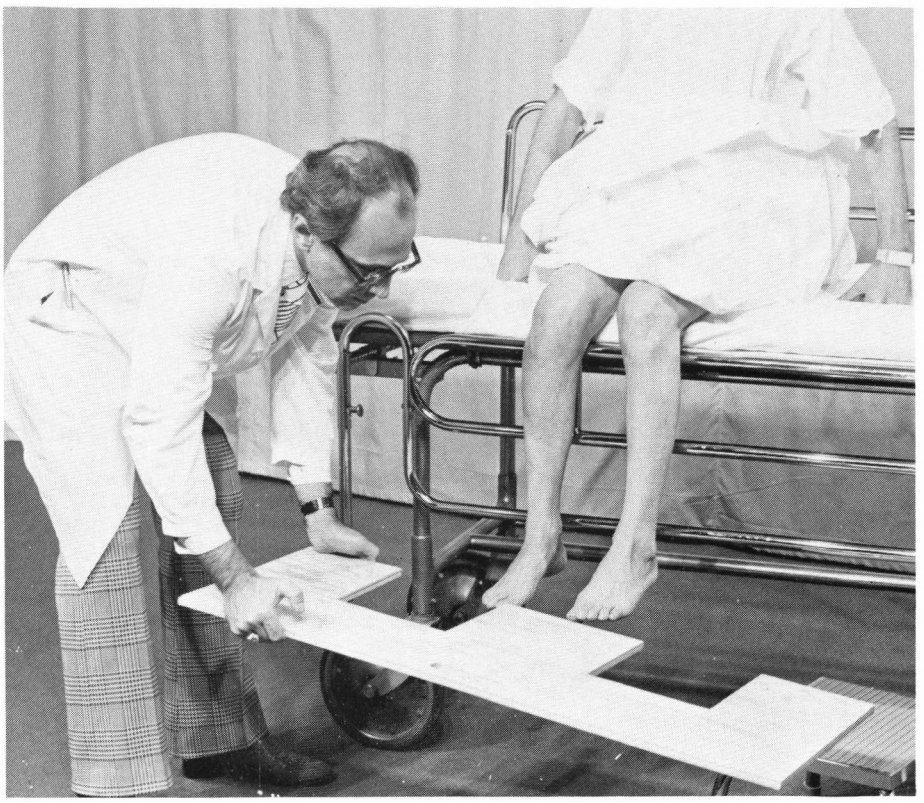

Figure 1—The special woodboard with spaced cutouts used for the elicitation of PR.

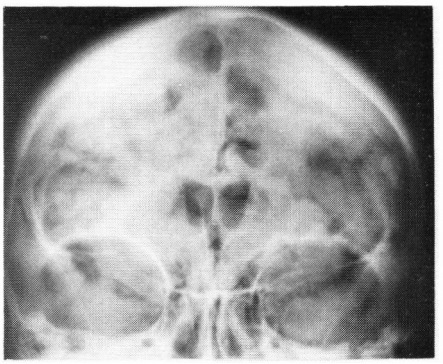

Figure 2—Case 1. PEG, anterior view. Bilateral fronto-parietal atrophy.

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an adenocarcinoma of the breast five years previously.

Routine clinical examination and laboratory findings: She had dementia and a severe receptive aphasia with jargonaphasia and right homonymous hemianopsia. She had bilateral papilledema. There was a definite motor weakness of the left upper limb. Tendon reflexes were a little brisker on the left than on the right side of the body where they were normal. She displayed Hoffmann and Babinski's signs on the right. Plantar response was flexor on the left. She also had a sucking reflex. She was able to walk but she had a marked apraxia of gait.

The EEG showed a definite focus of slow delta waves from the left central area. The brain scan was compatible with two lesions, probably tumors: one in the left fronto-parietal and the other in the left posterior parietal area.

Special testing procedures: When the patient was lying in bed, the grasp reflex was not elicited in the right hand probably because of motor weakness; there were a grasp reflex and a groping of the left hand. The groping was easily elicited by tactile intermittent stimuli touching the palmar surface of the left hand, the dorsum of the hand and occasionally the lower part of the forearm. Usually she did not look at the groping hand, and when her eyes were blindfolded there was no decrease in response to touching the hand. The tendency to grip was sometimes spontaneous, i.e. she grasped the sheets and the blanket. Very light stimulations on the dorsum of the hand were followed by an avoiding reaction (Denny-Brown, 1958). After GRF had been elicited the forced extensor posture of the left lower limb ensued and the examiner was able to lift the lower limb at an angle of 70-80° (SR) to the horizontal. The GRF and the SR were induced only occasionally on the right. When she was in the sitting position, i.e. in the dangling leg posture, the TFR, the GRF on the right foot were easily elicited. The positive SR was also elicitable on the right foot. There were no PR. On the left side, the TFR, the GRF, the positive SR as well the groping of the hand and the forward groping of the foot were elicited bilaterally but definitely more easily elicited than on the right. Besides those phenomena, she had also a medial and a lateral groping of the left foot. The dorsum-PR was evident: repeated tactile stimulations upon the dorsal aspect of the left foot were followed by a cephalad displacement of the toes and foot, a tendency to contourning the stimulating surface followed by a plantar flexion of the toes and foot upon the edge of the woodboard. At the same time the patient put the toes firmly on the solid surface. No other "readjustment" movements of the toes or of the foot were observed thereafter. The maintenance of local pressure upon the woodboard of the "placed" foot resulted in a forced extension posture of the lower limb (SR). Tactile stimulations on the medial aspect of the dorsum of the right foot induced a cross-placing of the left leg. Even tactile stimulations upon the dorsal surface of the big toe resulted in abduction of the toes followed by a retreat movement (4-5 cm backwards), a medial displacement with a raising of the foot above the stimulating surface and consequently the PR. The sole-PR was easily elicited on the left; after tactile light stimulations of the plantar surface of the toes, the forward groping and movements of flexion of the toes (grasp and "turning-to" movements of the foot) were elicited (phase I). The maintenance of 1-2 seconds of the stimulating surface upon the plantar surface of the toes resulted in PR followed by an SR.

As we mentioned above, either under visual control or blindfolded, the PR was never followed by adjusting or guided movements, i.e. the patient put her foot on the edge of the horizontal surface and did not move any further. If during the first phase of the dorsum-PR (i.e. during the avoiding or the withdrawal of the foot) the solid surface was replaced by a cutout space, the patient maintained the foot in a rather extensor posture without trying to reach the solid surface. She was never guiding the foot, but only placing it.

Her neurological condition worsened rapidly. She gradually became stuporous and died 10 days after admission. The autopsy showed a liver and lung metastases. In the brain there were (a) a left fronto-parietal; (b) a left deep parieto-occipital and (c) a left cerebellar metastases. All were surrounded by softening areas of the cerebral tissue (Fig. 5).

Case 3. B.P., male, aged 71. Diagnosis: adenocarcinoma of the right lung; right cerebellar and right frontobasal metastases.

This patient was admitted because of a three-week history of headaches, vertigo, dizziness, mild ataxia and lack of ability to make skilled movements with his right hand.

Routine clinical examination and laboratory findings: Routine laboratory tests, X-ray of the lungs and transthoracic biopsy showed a massive adenocarcinoma of the right upper lung. The neurological examination on admission disclosed: (i) a right cerebellar syndrome, i.e. marked dysmetria of the right hand with a tendency to fall backwards and on the right; (ii) an occasional Babinski sign on the right; (iii) deep tendon reflexes were equal; (iv)

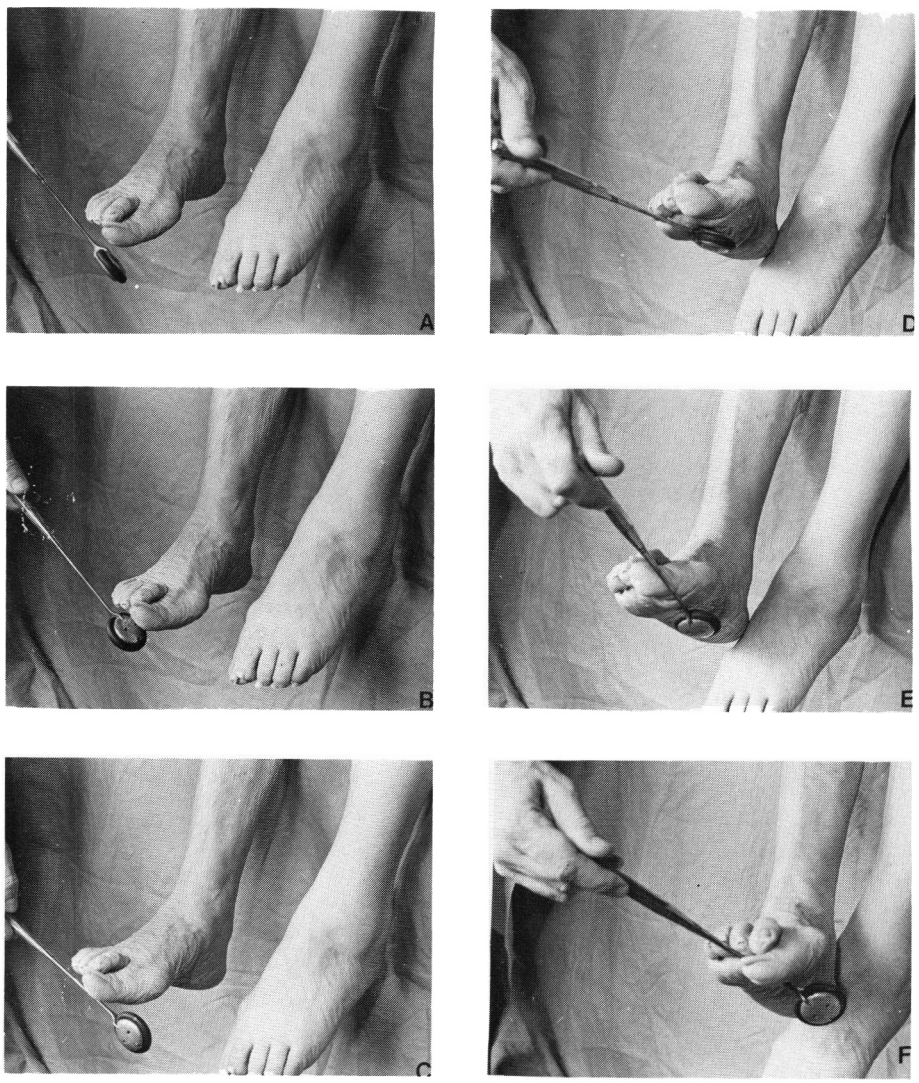

Figure 3—Case 1. Successive stages of forward groping phenomenon with the ensuing sold -PR.

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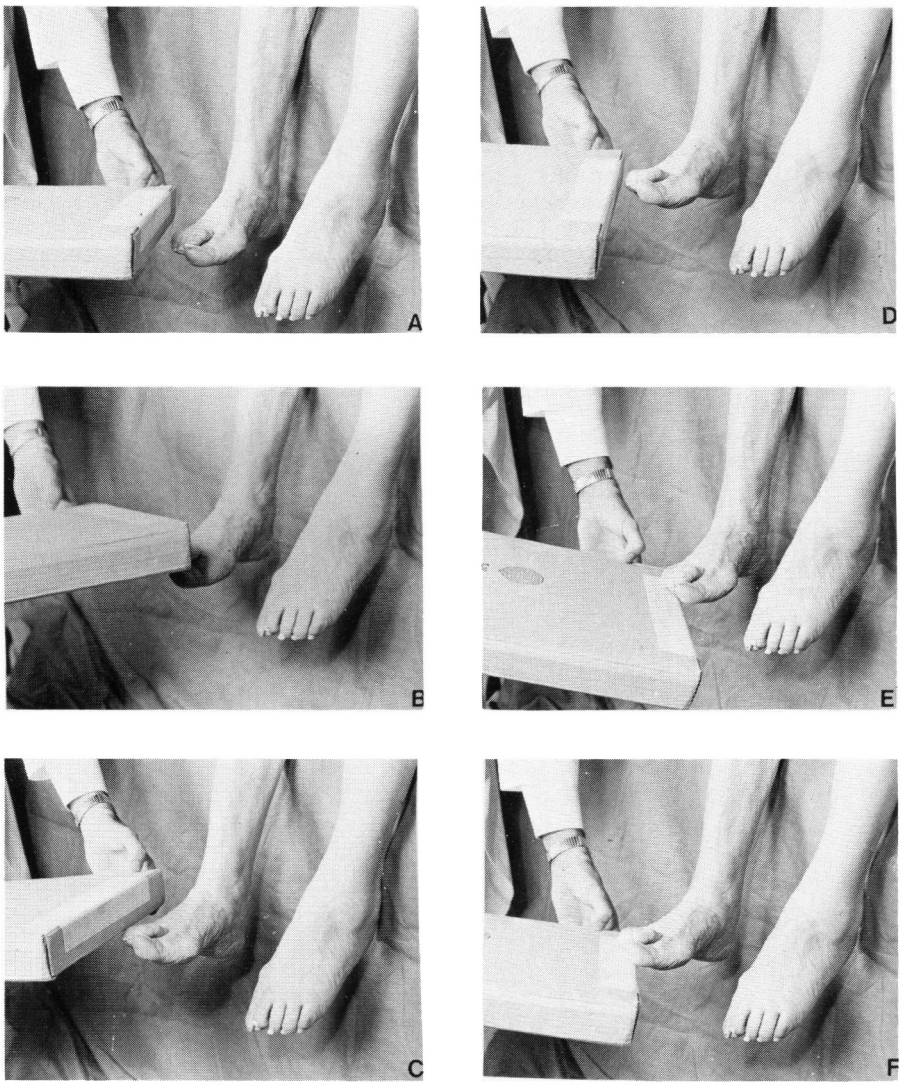

Figure 4—Case 1. Successive stages of elicitation of the dorsum-PR.

ataxic gait and (v) TFR and GRF on both sides more marked on the left. No grasp reflex of the hand, no groping of the hands or feet or PR could be elicited. He had daily severe frontal headache attacks lasting 20-30 minutes, partially relieved by aspirin. There was no mental deficit. The EEG showed a right fronto-central delta wave focus while the brain scan was normal.

During the first two weeks of hospitalization, the patient's neurological and mental conditions worsened. A second evaluation showed a more marked right-sided dysmetria. He was unable to rise from bed or to walk unassisted although there was no weakness.

Special testing procedures: When he was lying in bed there were a bilateral TFR and GRF, more marked on the right. When the patient was in the dangling leg posture, forward and medial groping with a tendency to medial rotation of the foot was present on both sides, more marked on the right. A lateral groping followed by the tendency to grasp the object was easily elicited on the right but not on the left side. There was no difference with the patient blindfolded or seeing both of his legs during the elicitation of the groping phenomena. The TFR, the GRF and the SR were bilaterally present. The sole-PR and the dorsum-PR were easily obtained on the right following the procedures described above. On the left side both reactions were milder and occurred only occasionally, while on the right side they were promptly elicited. If, during the elicitation of the dorsum-PR i.e. when he was ready to put the sole on the edge of the woodboard, we replaced the continuous surface with a spaced cutout surface, the patient did not try to guide his foot in searching the solid surface of the woodboard. There was no difference with or without vision, the lower limb was not guided to the edge of the woodboard and remained extended in the air. No cross-placing reaction could be elicited in this patient.

The right-sided dysmetria of the hand was more pronounced. The ophthalmological examination showed bilateral choked discs. The patient was well oriented in time, was conscious of his disability but lacked initiative. There were times when he answered questions alternatingly with slowness and verbal negativism. Memory of recent events was seriously impaired. He was doubly incontinent.

The patient was given dexamethasone 4 mg intramuscularly every 6 hours for 6 days. His condition improved rapidly. After 3 days the right dysmetria improved: the dorsum-PR, the sole-PR, the medial and lateral groping of the feet and the groping of the left hand disappeared while the forward groping of the feet, the grasping of the right hand as well as both TFR and GRF subsided. After six days of treatment we found only the bilateral TFR and GRF both in the supine and the dangling posture. The right cerebellar syndrome persisted but his mental condition became normal. He was no longer incontinent. A repeat brain scan showed a definite right frontal tumor and probably another tumor in the right posterior fossa located paramedially. During the following weeks, his condition

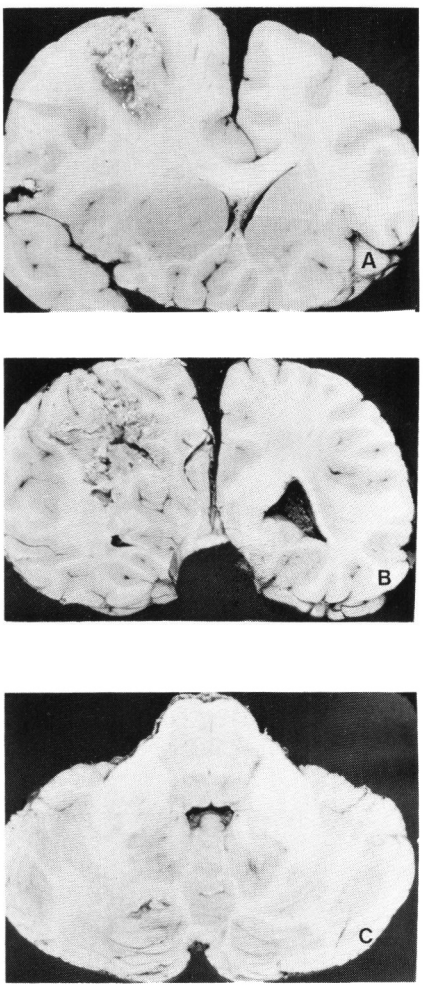

Figure 5—Case 2. Subcortical fronto-parietal (A) deep parieto-occipital (B) and a cerebellar metastasis (C) all on the left are shown.

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TABLE I

Case	Sex	Age	Initials	Diagnosis	Mental State	Grasp of the hand		Groping of the foot	
						R	L	R	L
4	F	68	M.-R.G.	Left parieto-callosal tumor (glioblastoma)	Dementia Incontinence of urine and faeces	0	+	0	+
5	F	61	Y.B.	Bilateral fronto-parietal atrophy	Dementia	+	+	+	+
6	M	69	C.A.	Hydrocephalus and severe bilateral fronto-parietal atrophy	Severe mental deterioration	+	±	+	+
7	M	66	M.L.	Bilateral carotid stenosis (R > L). Diffuse cerebral atrophy more marked on the right rolandic and retro-rolandic areas	Dementia	+	+	+	±
8	F	55	L.E.	Diffuse brain-stem damage following a three-week comatose state of traumatic origin (cerebral concussion). Diffuse cerebral atrophy on PEG	Dementia + Urinary incontinence	+	+	+	+
9	M	61	P.A.	Long-lasting (three months) severe meningo-encephalitis (Haemophilus influenzae)	Dementia	+	+	+	±
10	F	66	B.P.	Right fronto-parietal glio-blastoma involving the corpus callosum and the contra-lateral frontal lobe	Lack of drive Drowsiness Mental confusion	±	±	0	0
11	F	65	L.B.	Partial obstructive hydro-cephalus. Paget's disease. Bilateral fronto-parietal atrophy	Dementia Incontinence of urine and feces	+	+	+	±
12	F	36	J.R.	Right fronto-parietal glio-blastoma involving the corpus callosum	Lack of drive Negativism Drowsiness Apathy	+	0	+	0

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GRF*		PR**		SR***		Babinski sign		Motor weakness (hemiplegia or hemiparesis)		Sensory symptoms		Other clinical signs	Case
R	L	R	L	R	L	R	L	R	L	R	L		
0	+	0	+	0	+	+	0	+	0	Unilateral spatial neglect	?	Gait ataxia Bilateral choked disks	4
+	+	±	+	+	+	0	0	±	0	0	0	Gait ataxia, ideational apraxia, mild receptive aphasia, echolalia. Sucking reflex	5
+	+	+	±	+	±	0	+	0	±	0	0	Gait ataxia, ideational apraxia, agraphia	6
+	+	+	0	0	±	0	±	+	±	?	?	Bilateral carotid bruit R > L	7
+	+	±	+	+	+	±	0	±	0	?	?	Right hemi-cerebellar syndrome, paresis of the left abducens and oculo-motor nerves. Dysarthria, receptive dysphasia. Sucking refl., oral groping	8
+	+	+	±	+	0	0	0	0	0	?	?	Meningeal syndrome. Sucking reflexes. Oral groping. Fever. Cachexia	9
+	+	±	0	+	0	0	+	0	±	0	0	Brisk deep reflexes on both sides.	10
+	+	±	±	+	±	0	0	0	0			Bilateral brisk deep reflexes. Parinaud's syndrome (Palsy of the upper gaze movements	11
+	0	+	0	+	0	0	+	0	+	?	?	Left central facial paresis. Bilateral papilledema	12

*GRF Grasp reflex of the foot and tonic foot response to stimulation of the sole.
**PR Placing reaction.
***SR Supporting reaction.

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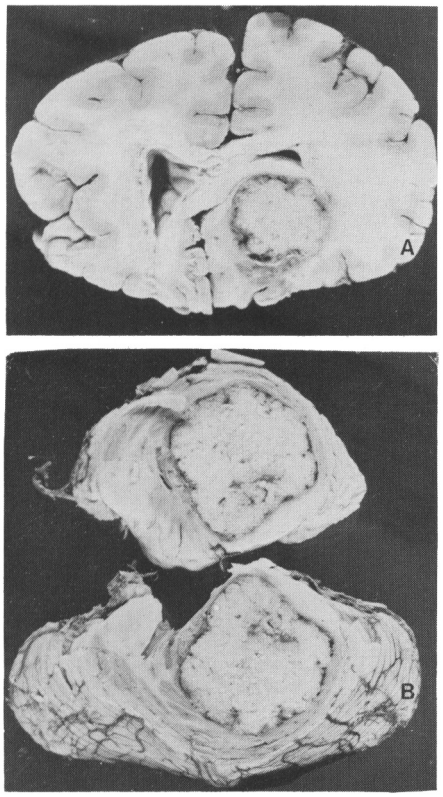

Figure 6—A right fronto-basal (A) and a right cerebellar (B) metastases are shown.

progressively worsened; he became more and more confused. During this period the groping of the hand and feet and the PR reappeared. Finally he became stuporous and died after eight weeks of hospitalization.

The autopsy findings were: an adenocarcinoma of the right lung and two metastases of the brain, i.e. the right frontobasal metastasis was 3.8 cm in diameter while the cerebellar was 3.5 cm compressing and infiltrating the right brachium pontis and dentate nucleus and the vermis.

The pertinent findings in the other patients are summarized in Table I. From the 9 patients presented in this table, three cases (nos. 4, 7 and 12) had a frank hemiplegia; four cases (nos. 5, 6, 8 and 10) had only a hemiparesis, while the remaining two (nos. 9 and 11) had no discernible motor weakness.

DISCUSSION

(a) Semiological and clinical features. The PR had not been described in adults because the dangling leg posture has never been used. As in experimental physiology (Bogen, 1974) we have to consider three forms of PR, i.e. the visual-PR, the dorsum-PR and the sole-PR. The pure visual-PR occurred only occasionally in two of our patients (cases 5 and 8). Both patients had severe bilateral cortico-subcortical brain damage. The PR is, then, chiefly contactual; it can be reinforced and maintained by vision but only in a very few severely brain-damaged patients could it be triggered by vision.

There are no significant differences between the dorsum-PR and the sole-PR; in all patients both reactions were present together. If the back of the toes is alternatively stimulated with the woodboard, there is a tendency to pursue the stimulating surface which is gradually withdrawn and followed by the PR. When the dorsum of the foot is stimulated, all sequences observed in animal physiology (Bogen, 1974) would appear: dorsal flexion of the toes with alternate flexion and extension movements of the toes followed by a cephalad displacement, a retreat reaction of the foot followed by the final PR. The patients puts his foot firmly on the horizontal surface of the woodboard. The direction of the retreat, i.e. avoiding reaction, depends on the localization of the tactile stimulations upon the foot. If the stimulation is on the midline of the dorsum of the foot, the avoiding movement is initially downward and medial, contourning the stimulating object. If the stimulation is carried out upon the medial aspect of the foot, there will be a lateral avoiding reaction followed by a medial-directed movement, displacement and subsequent PR. The cross-PR was induced in four patients (cases 1, 2, 5, and 8). In all these patients the diffuse brain damage was perhaps the most severe. Changes of posture of the head and body did not influence the strength and reliability of the PR. The PR in human adult neurology is the most severe form of the grasp and groping phenomena. Not all patients with groping of the hand and forward groping of the foot will display a PR, but all patients with PR had the forward and medial groping of the foot. From the clinical point of view, we can conclude that the degrees of severity are as follows:

(i) the visual-PR; (ii) the lateral groping; (iii) the cross-PR; (iv) the dorsum- and sole-PR; (v) the medial groping; (vi) the forward groping and SR and finally (vii) the GRF and TFR. The GRF can sometimes be followed by a subsequent SR. Those patients who displayed (i) had all the other signs. Lateral groping (ii) is not necessary for the occurrence of the dorsum- and sole-PR but the medial and the forward groping are. The patients who had the cross-PR also had lateral groping of the foot. Inversely, not all patients with medial and forward groping had a PR. The fact that the GRF and the TFR are the last signs to disappear during recovery led us to introduce these signs in current practice, especially in those patients with a history of subjective memory disorders, headaches, etc. We found the GRF a single objective neurological finding in patients with occult hydrocephalus or cerebral atrophy (Botez et al., 1974, 1975). The groping phenomena usually disappear when the Babinski sign appears. They can be met together occasionally during the course of the disease until the motor weakness sets it. The PR was always accompanied by a forced groping of the hand.

(b) *Localizing value of the PR.* The explanation is simple. The PR has no localizing value because the lesions are usually bilateral or callosal. The lesions were: (i) bilateral fronto-parietal atrophy with or without hydrocephalus; (cases 1, 5, 11); (ii) multiple cerebral metastases on the same side but with brain edema: (cases 2 and 3); (iii) parieto-callosal tumor: (case 4); (iv) severe meningoencephalitis: (case 9); (v) unilateral fronto-parietal tumors invading the corpus callosum and infiltrating and compressing the contralateral hemisphere: (cases 10 and 12); (vi) diffuse cerebral atrophy: (cases 6, 7 and 8). The PR was always homolateral to the main lesion but there was always evidence of diffuse or bilateral brain damage.

The classical concept (Adie and Critchley, 1927) states that unilateral forced grasping of the hand, in a patient with a cerebral tumor, is unequivocal evidence of a contralateral frontal localization (Botez, 1974). We cannot say the same for the PR because a retrorolandic involvement

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seems to be necessary for the development of this reaction (cases 1, 4, 5, 10, 11, 12). Our findings seem to confirm some previous results of Hecaen et al. (1956) who found a severe homolateral groping of the hand following retrorolandic lesions. In other cases, midline callosal or diffuse lesions are necessary for the release of the PR. One exception is case no. 3 with a fronto-basal and a cerebellar metastasis, which will be discussed below.

(c) *Comparative neurology*. (i) the interdependence of cerebrum and cerebellum in the general area of adjustments of posture has interested many investigators (see the general review of Bogen, 1974). Soriano and Fulton (1946) showed in the rhesus macaque, unlike dog and cat, complete ablation of the anterior lobe of cerebellum failed to cause marked augmentation of the positive supporting reactions with spasticity. If, however, ablation of the anterior lobe was combined with extirpation of areas 4 and 6 of the cerebral cortex, a conspicious and enduring spasticity ensued in the extremities opposite the lesion. Our cases nos. 2 and 3 could be correlated with the above physiological findings. Both patients had a contralateral hemiparesis but a homolateral placing reaction.

(ii) In our human cases, either under visual control or blindfolded, the tactual or visual PR was never followed by adjusting or guided movements, i.e. the patient puts his foot on the edge of the horizontal surface of the object and does not move any further. *They are not guiding the foot, they are only placing it.* This is in confirmation of the experimental findings (Hein and Held, 1967) showing that the guided reach requires an integration of sensorimotor systems which is not necessary for development of the elicited extensor response.

(iii) In recent years the general belief (Bard, 1931; Woolsey and Bard, 1936) that the cortex is essential to placing reactions has been invalidated by the following facts: (a) although both anterior and posterior neocortex are involved in visual placing in rats, neither seems necessary for such behaviour to occur (Braun, 1966); (b) placing can be elicited in decorticated cats given amphetamine (Meyer et al., 1963); (c) placing can be elicited also in newborn infants in spite of the poor development of the cortex (Zelazo et al., 1972); (d) in hemispherectomized cats the placing returned after a second operation, i.e. by contralateral frontal ablation (Bogen and Campbell, 1962). Bogen (1974) concluded that the best explanation at present is that the sensori-motor cortex has a facilitating influence on a contralateral reaction organized within the brain stem and the spinal cord. Removal of this contralateral facilitation is poorly compensated because of an excess of tonic inhibition from ipsilateral sensorimotor cortex.

This explanation could be valuable in our cases with bilateral sensorimotor lesions in which the PR was ipsilateral to the main lesion. It is only a working hypothesis because it is certainly true that "there may be a large number of facilitatory and inhibitory influences whose balance can be upset or redressed in any number of ways" (Bogen, 1974).

(iv) What is then the final biological significance of the groping phenomena of the foot and hand as well of the ensuing reactions? A lesion of any part of the cingulate cortex, areas 6 or 8 of the supplementary motor area of Woolsey, resulted in an exaggeration of grasping and groping phenomena associated with disappearance of the contrary withdrawal or "tactile avoiding" reactions (Denny-Brown, 1960). Ablation of the parietal cortex or of the pre- and postcentral gyrus resulted in release of such avoiding reactions. Denny-Brown (1960) pointed out that the withdrawal movement is balanced against the instinctive exploratory reactions, so that damage to either results in enhancement of the other. In our cases, the withdrawal movement (or the avoiding reaction) and the instinctive exploratory reactions are different parts of the same final phenomenon, i.e. the placing of the foot. The patient avoids the edge of the woodboard not because he does not want to touch it but because he is preparing the standing posture. The initial avoiding reaction in our patients is an "exploring" movement (i.e. the *reverse* phenomenon after Denny-Brown) because it is the first phase of a final PR. The groping of the foot even when accompanied by PR has the same biological value. Regarding the groping of the hand, our data confirm previous findings (Seyffarth and Denny-Brown, 1948), i.e. we never observed the hand pursuing a movement object unless it has touched it just before.

It should also be remembered that flexion is a misleading term for plantar curling of toes, which forms part of the pattern of physiological extension of the limb which includes coactivation of rectus femoris. (Manfredi et al., 1975).

If we take into consideration the evidence we have briefly summarized we can conclude that the GRF, the groping phenomena of the foot and the PR are different stages of highly coordinated standing reflexes with the final aim of providing support for the body. Their evolution in clinical conditions in adults plus their evolutionduring ontogenesis as well as animal physiology strongly suggest this biological function. Regarding the similar phenomena of the hand, the fact that the groping of the hand can be elicited in a patient in a supine position (which is not the case for the foot) is due to the specialization of the hand in primitive man during the night of prehistory. The primary function of the hand was also to provide a support of the body during dangerous situations when for example Australopithecus was climbing trees to protect himself from animals. The function of standing and of supporting are "masked" in man because of the long evolutionary phylogenetic process, during which the purposeful movement took the place of the pure instinctive "grasp". However, after severe brain lesions the groping phenomena of the hand has the same value as a PR because the clinical peculiarities are the same. If, for example, the dorsal aspect of the fingers is stimulated the subsequent avoiding and exploring movements

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are followed by turning-to movements (Goldstein, 1938) and an instinctive grasp (or placing) of the stimulating object.

We can consider all these phenomena as belonging to antigravity mechanisms. The variόus semiological forms in human adult life represent different degrees of release of the same biological function after lesions at various levels of the central nervous system.

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