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The nuchocephalic reflex[1]

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SYNOPSIS The nuchocephalic reflex, previously undescribed, was investigated in a controlled study of 146 subjects ranging in age from 11 hours to 94 years. In 110 subjects over 16 years of age, the presence of the reflex was correlated directly with evidence of diffuse cerebral dysfunction as measured by a shortened form of the Wechsler Adult Intelligence Scale. Thirty-six children were studied from the newborn period to the age of 16 years. The reflex was found to be uninhibited in infants and to become inhibited by the age of 4 years. Among the adult subjects, the nuchocephalic reflex was found to be a sensitive indicator of the status of higher cortical function. The presence or absence of the reflex appears to have somewhat different predictive value at different points in the adult age spectrum.

Dementia, the loss of higher intellectual and emotional capacity, is a common manifestation of a multitude of disorders (degenerative, metabolic, infectious, neoplastic, and mechanical). It has been estimated that approximately 15% of patients with dementia have treatable disorders (Marsden and Harrison, 1972). Therefore, any patient presenting with dementia warrants a thorough examination in search of a remediable cause. At the present time, the diagnosis of diffuse cerebral dysfunction is made on the basis of a number of factors including a bedside examination of the mental state, the presence of certain abnormal neurological signs, and complex neuropsychological testing.

Various physical signs associated with dementia have come to be accepted in the neurological literature as aids in the assessment of loss of higher cortical function. The most prominent of these are the grasp, glabellar blink, palmomental, Babinski, and feeding reflexes (Wells, 1971). These are often termed regressive reflexes as they are present in childhood, disappear with increasing age and cortical maturity, and return only with loss of higher cortical function later in life. This phenomenon has been considered to be a release from cortical inhibition (Paulson and Gottlieb, 1968).

We have investigated a previously undescribed sign, the nuchocephalic reflex, to determine its effectiveness as an indicator of the presence of diffuse cerebral dysfunction and its characteristics during development and maturation of the central nervous system. We feel that this reflex is analogous to the familiar oculocephalic reflex, sometimes termed the doll's-eye phenomenon.

METHODS

SUBJECTS We investigated 146 subjects ranging in age from 11 hours to 94 years. Those patients with known or suspected disease of the central nervous system had evidence of diffuse involvement only. Patients who had evidence from the neurological and/or neuropsychological examinations of unilateral or bilateral focal cortical lesions were not included in the study.

Thirty-six of the subjects were infants and young children (age 11 hours to 15 years) seen in the newborn nursery or the Well-Baby Clinic of the Dartmouth-Hitchcock Medical Center, and none had evidence of any disease or physical abnormality. Only the neurological examination was performed on these subjects.

Of the 49 subjects between 16 and 60 years of age,

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27 were selected at random and included hospital staff, inpatients, and medical students of the Dartmouth-Hitchcock Medical Center. The remaining 22 subjects were individuals to whom had been administered the Halstead-Reitan Battery of tests for complete neuropsychological evaluation of suspected higher cortical dysfunction. Thus, this group is not a representative sample of the general population between 16 and 60 years of age.

Sixty-one subjects over the age of 60 years were studied. Their mean age was 72.2 years. They were selected from various sources in order to assure large numbers from both the normal and demented extremes of the spectrum of cerebral function and cannot be considered as a representative sample of the general population older than 60 years. Twenty-two of these 61 subjects were from a local nursing home and had a mean age of 80.5 years. A physician in a local community hospital selected 14 subjects from his practice who were over 60 years old and appeared to have intact cerebral function. Their mean age was 64.6 years. Seven subjects responded affirmatively to a letter requesting volunteers which was sent to 266 senior citizens, 60 years of age or older, in the town of Lebanon, New Hampshire. If they took part they had to arrange their own transport to and from the Dartmouth-Hitchcock Medical Center. Their mean age was 70.1 years. Seven of the subjects over 60 years of age were selected as normal by the house staff from the patient population of the Dartmouth-Hitchcock Medical Center. Their mean age was 71.3 years. The remaining 11 subjects over 60 years old were referred for complete psychometric evaluation of suspected cortical dysfunction and had been administered the Halstead-Reitan Battery. The mean age of this group was 67.3 years.

FIG. 1 *Demonstration of the disinhibited and inhibited nuchocephalic reflex. In both subjects, the shoulders are being turned to the left from the face-on view. The upper right subject demonstrates the inhibited reflex with the head turned in the direction of the shoulder movement. The lower left subject demonstrates the disinhibited reflex with the head holding its original position.*

TESTING PROCEDURE The nuchocephalic reflex is elicited by rapidly turning the shoulders of a standing subject to the right or left while his eyes are closed to avoid visual fixation. The reflex is considered fully elaborated and uninhibited if the subject's head holds its original position, an act necessitating bilateral contraction of cervical musculature. The reflex is inhibited if the subject actively turns his head in the direction of the shoulder movement usually following a time lag of approximately one-half second (Fig. 1).

The testing of the nuchocephalic reflex was part of a complete neurological examination including evaluation of the cranial nerves, motor and sensory systems, and deep tendon reflexes. In addition, various other purported physical signs of dementia (including glabellar blink, grasp, Babinski, palmomental, oculocephalic and feeding reflexes, motor impersistence, paratonia, and abnormalities of face–hand discrimination) were investigated simultaneously as part of a larger study which will be reported later.

Each subject's cognitive function was appraised by administering an abbreviated intelligence test and comparing the IQ estimated from the results (age-corrected) with the IQ that one would expect from the subject's educational history. Specifically, subjects were given two verbal subtests (Information and Similarities) and two performance subtests (Picture Completion and Block Design) from the Wechsler Adult Intelligence Scale (WAIS). Only these four subtest scores were used in evaluating those 33 individuals who had received the complete WAIS included in the Halstead-Reitan Battery.

To ensure adequate control within the experimental design, the nuchocephalic reflex was evaluated by one of two investigators and the subsequent neurological examination and psychometric testing were performed by the other, who had no knowledge of the nuchocephalic testing. Those subjects receiving the Halstead-Reitan Battery were tested by a trained technician who was not associated with the study.

The principal investigators independently interpreted each finding in the neurological examination of eight patients and agreed consistently in their evaluation. Two independent observers, a neurologist and a neurology fellow, performed identical neurological examinations on two subjects after the principal investigators' testing. There was complete agreement in the results.

ASSESSMENT OF COGNITIVE FUNCTION Verbal, Performance, and Full Scale IQs were estimated by prorating. The expected IQ for each subject was estimated according to his or her educational level (PhD, MD, or JD=128; MS or MA=123; BS or BA=118; two years of college=110; high school=105; 8th grade or less=95) and the extent to which each subject fell below this level was used as a basis for assignment to four categories of cognitive functioning. A rationale for this approach may be found in Fogel (1964). A subject was placed in group I (no impairment) if his measured IQ was as high as or no more than 5 IQ points below his expected IQ; in group II (mild impairment) if his IQ were 5–15 points lower than expected; in group III (moderate impairment) if his IQ were 15–25 points lower than expected; in group IV (marked impairment) if his IQ were more than 25 points lower than expected.

RESULTS

The results of nuchocephalic testing in children under 16 years of age are shown in Fig. 2. The uninhibited reflex was present in all children under the age of 2 years and then decreased in frequency with increasing age.

The data for nuchocephalic testing between

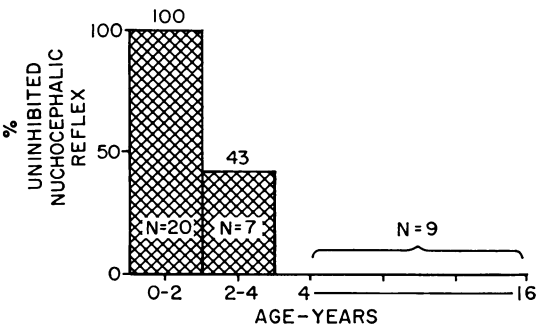

FIG. 2 *The uninhibited nuchocephalic reflex as a function of age in children. The percentage of subjects with the uninhibited nuchocephalic reflex decreases with increasing age.*

TABLE 1

RESULTS OF NUCHOCEPHALIC REFLEX TESTING IN SUBJECTS 16–60 YEARS OF AGE

Nuchocephalic reflex	*Cognitive category*				*Total*
	Normal	*Mild impairment*	*Moderate impairment*	*Marked impairment*	
Disinhibited	0	3	4	3	10
Inhibited	27	6	6	0	39

TABLE 2

RESULTS OF NUCHOCEPHALIC REFLEX TESTING IN SUBJECTS 60 YEARS OF AGE AND OLDER

Age (yr)	*Number*	*Nuchocephalic reflex*	*Cognitive category*				*Total*
			Normal	*Mild impairment*	*Moderate impairment*	*Marked impairment*	
60–72	31	Disinhibited	4	4	1	3	12
		Inhibited	15	2	2	0	19
73 and over	30	Disinhibited	4	7	6	5	22
		Inhibited	8	0	0	0	8
60 and over	61	Disinhibited	8	11	7	8	34
		Inhibited	23	2	2	0	27

TABLE 3

SUMMARY OF FALSE POSITIVE DISINHIBITED REFLEXES AND FALSE NEGATIVE INHIBITED REFLEXES BY AGE GROUP

Age (yr)	False positive Disinhibited reflexes		False negative inhibited reflexes	
	(No)	(%)	(No)	(%)
16–60	0/10	0	12/39	31
60–72	4/12	33	4/19	21
73 and over	4/22	18	0/8	0
60 and over	8/34	24	4/27	15
16 and over	8/44	19	16/66	24

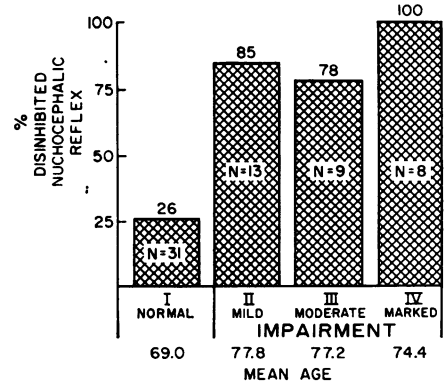

FIG. 3 *The disinhibited nuchocephalic reflex as a function of cognitive category in subjects 60 years of age and older. The percentage of subjects with disinhibited nuchocephalic reflexes increases with the degree of cognitive impairment.*

the ages of 16 and 60 years are shown in Table 1. None of the ten subjects with disinhibited nuchocephalic reflexes was judged normal on psychometric testing. Of the 39 subjects who had an inhibited nuchocephalic reflex, 27 (69%) were judged normal on psychometric testing.

Figure 3 shows the incidence of a disinhibited reflex as a function of cognitive category in subjects over 60 years of age. The frequency of the disinhibited reflex ranges from 26% in category I (normal) to 100% in category IV (marked impairment) and thus increases with the degree of cerebral dysfunction. The degree of dysfunction in this age group is not a function of increasing age as the mean age for each category actually remains the same with increasing impairment. The mean age for all 30 subjects who were impaired on psychometric testing was 76.7 years, while the mean age for the 31 subjects evidencing no impairment was 69.0 years.

The relationship of the nuchocephalic reflex to age is shown in Table 2. The subjects aged over 60 years are subdivided at the approximate median age of their group into 'younger' and 'older' subgroups. The frequency of dementia increases with age. Twelve of 31 (39%) of the 'younger' subjects were impaired, while 18 of 30 (60%) of the 'older' subjects were impaired. The frequency of the disinhibited reflex increases with age. Twelve of 31 (39%) of 'younger' subjects had a disinhibited reflex, while 22 of 30 (73%) of 'older' subjects had a disinhibited reflex. Of the 12 'younger' subjects with the disinhibited reflex, eight (67%) were judged to have some loss of cognitive function. Of the 22 'older' subjects with the disinhibited reflex, 18 (82%) were shown to have some loss of cognitive function. Overall, 76% (26 of 34) of subjects over the age of 60 years who had disinhibited nuchocephalic reflexes (mean age 77.0 years) were shown to have measurable loss of higher cortical function. Subjects over the age of four years with the disinhibited reflex are expected to have some loss of cortical function. Therefore, the false positive rate is 24%. Of all subjects over the age of 60 years who had inhibited nuchocephalic reflexes, 85% (23 of 27) (mean age 70.1 years) were shown to have normal higher cortical function. This leads to a false negative rate of 15%. None of these false negatives fell in group IV (marked impairment), and all were between 60 and 72 years of age.

Table 3 summarizes for each age group the false positive and false negative rates of the disinhibited and inhibited reflexes respectively. Between 16 and 60 years of age, the disinhibited reflex was present only when there was some degree of diffuse cortical dysfunction. With increasing age the incidence of the disinhibited reflex in subjects with no evidence of loss of higher cortical function increases to 33% between the ages of 60 and 72 years, and then decreases in subjects older than 73 years to 18%. Over the age of 73 years, the inhibited reflex was present only when there was no evidence of loss of cortical function. Furthermore, the incidence

of an inhibited reflex in dementia decreases with increasing age.

DISCUSSION

We have attempted to delineate the nuchocephalic reflex as a useful clinical indicator of diffuse cerebral dysfunction. In this context we have sought to define the nuchocephalic reflex as a regressive reflex. Its presence in infants and children up to the age of 4 years and its inhibition throughout the rest of life until the intervention of diffuse cerebral dysfunction seem to support its classification as such.

Proprioceptive input from the trunk and neck and possibly a vestibular input are presumed to play a role in eliciting the nuchocephalic reflex. The inhibition of the reflex with the head turning in the direction of the shoulder movement is assumed to have a cortical origin similar to that of the mechanism which inhibits the oculocephalic reflex (Plum and Posner, 1972).

The results suggest that despite the complementary nature of the disinhibited and inhibited reflex, each response has different implications at different ages. The presence of a disinhibited response between 16 and 60 years of age always signified loss of higher cortical function in our subject population. On the other hand, the presence of an inhibited response in this age group did not imply intact higher cortical function as consistently. Some individuals may have the inhibited reflex but evidence cortical impairment on abbreviated psychometric evaluation. As age increases beyond 60 years, the presence of a disinhibited reflex seems to become less significant in indicating impairment, while an inhibited response becomes a more significant indicator of intact cortical function.

The disability that has been focused on is one of diffuse, bilateral neuronal dysfunction. Of course, the degree of dysfunction is not necessarily equal and symmetrical throughout the cortex of each individual. The localization of the origin of the cortical mechanism which inhibits the nuchocephalic reflex is not known and may be involved to a greater or lesser degree from subject to subject. In some normal individuals, this mechanism may never develop at all. However, none of our 10 subjects with disinhibited reflexes between 16 and 60 years of age had normal cortical function. The observation of the changes with age in the false positive rate of the disinhibited reflex (Table 3) suggests that the neuronal connections involved with the cortical mechanism may become compromised before impairment can be detected by abbreviated neuropsychological evaluation. While this technique is only a moderately precise way of assessing cognitive impairment, whatever measurement error it contains would tend to vitiate rather than inflate the magnitude of the relationship between the nuchocephalic reflex and cognitive impairment. It is possible to conduct a much more thorough psychometric assessment of cortical function and in our future research we will be using the full Halstead-Reitan Neuropsychological Battery.

In summary, the disinhibited nuchocephalic reflex correctly predicted the loss of higher cortical function in all subjects between 16 and 60 years of age, and in approximately 75% of subjects older than 60 years. The inhibited nuchocephalic reflex correctly predicted intact higher cortical function in approximately 70% of subjects between 16 and 60 years of age, and in approximately 85% of subjects older than 60 years. Whether inhibited or disinhibited, the nuchocephalic reflex predicted correctly the state of higher cortical function in 75–80% of all subjects older than 16 years of age.

We would like to reemphasize that the subjects in whom the nuchocephalic reflex was evaluated were not a representative sample of a sample population. Nonetheless, the data indicate that the nuchocephalic reflex is a useful sign for detecting diffuse cortical dysfunction. A study is currently in progress to investigate the relationship between degrees of dementia and a large battery of neurological signs in an attempt to assemble a brief but effective clinical method for assessing cortical integrity.

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