

Perception of Simultaneous Tactile Stimuli in Normal Children

Max Fink, M.D. and Morris B. Bender, M.D.

Normal adults readily identify and localize tactile stimuli applied simultaneously to the face and the hand (the "face-hand test").¹ While half the subjects perceive stimuli incorrectly on the initial trial, all are accurate by the tenth trial of the test. Young children, however, find the task of identification and localization of two skin stimulations difficult. They report only one of the two stimuli, or, if they report the two, frequently mislocalize one of them. The omission or mislocalization of stimuli is not haphazard but follows a consistent pattern in which stimuli to the face are readily appreciated ("most dominant") while those to the hand are not ("least dominant").

In order to determine the pattern of "dominance" in children and the age at which such tactile perceptual tasks are correctly performed, a study of normal children was undertaken. The responses of children to the face-hand test and to simultaneous tactile tests of other body parts were ascertained.

SUBJECTS AND METHOD

Three hundred normal children between the ages of three and 15 were examined. They were from a neighborhood child care center, from the wards and clinics of Bellevue Hospital, and children of neighbors and friends. They were without manifest disorder of the nervous system. A few children at two and a half years of age were included in the three year age group, but younger children were generally not able to comprehend the test.

The subjects were examined individually, but there were many who were examined in a day-room in full view of other children. The child was engaged in play and when toys were available they were used to gain his confidence and interest. At some time during play, the face-hand test was introduced.

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For the face-hand test, the child was told: "I (examiner) am going to touch you," and he was to "touch the same place I touch." He was asked to close his eyes. The examiner, with the fingers, then touched simultaneously a cheek and the dorsum of the contralateral hand of the subject. The child was asked what he felt, and to point to the sites stimulated. After this response, the child was asked to close his eyes again, and now the opposite cheek and hand were similarly stimulated and the report recorded. If only one response was given to this trial, the child was asked if there had been another stimulus anywhere else.

Following these two trials, the cheek and hand on the same side of the body were tested in a similar fashion. The fifth and sixth trials were not of asymmetric body parts but simultaneous stimulation of both cheeks or both hands. The following various types of stimulation were used: heterologous stimulation of asymmetric body parts on opposite sides, as right cheek and left hand; homolateral stimulation of asymmetric body parts on the same side of the body, as right cheek and right hand; and homologous stimulation of symmetric body parts, as both cheeks or both hands. Such tests were repeated in each child until at least ten trials were recorded. Subsequent tests of other body parts, performed in a similar fashion, were introduced until at least 20 consecutive trials were observed in each subject.

A number of modifications had to be introduced for young children. Many would not play the game with eyes closed, but insisted on keeping their eyes open. In such cases the tests were applied with eyes open. Also, a large number of three and four year old children insisted on pointing to the examiner's hands and face on the initial trials. For these children, a few trials of single touch stimuli applied to the thigh, chest or hand were introduced, until they grasped the concept of pointing to their own bodies after the stimulation. These single trials were carried out with eyes open.

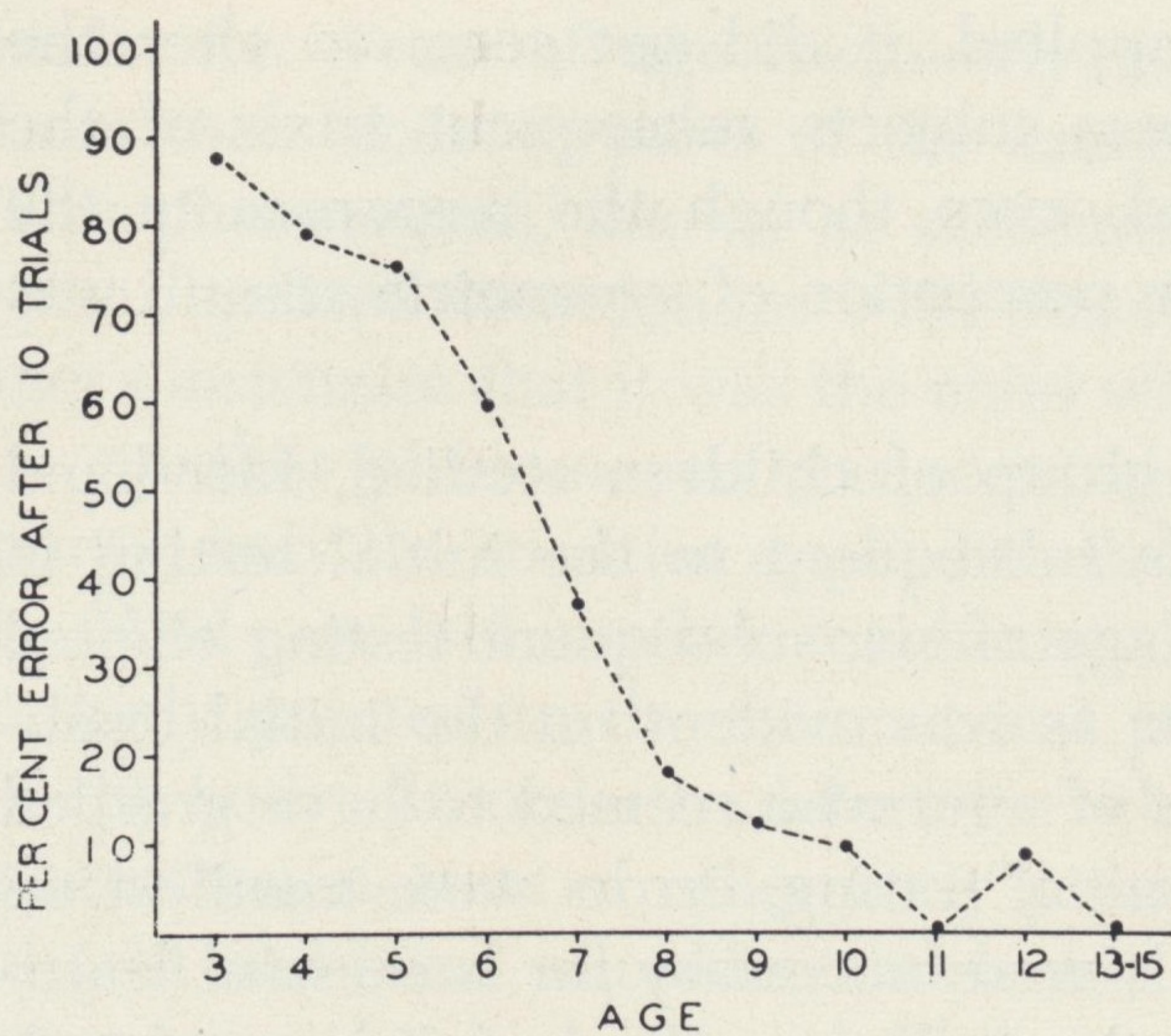
After the series of double simultaneous stimulation tests were completed, single stimuli were applied to various body parts to exclude from the normal group any subjects with focal sensory difficulties.

The children were asked what they had felt and to point to the places stimulated. Verbal reports of the locus of stimulation were not accepted. It was occasionally noted that children would correctly name the parts stimulated, i. e., the cheek and hand, but then point to both cheeks, or to two places on one cheek. It seemed as if naming the locus yielded more accurate responses than did pointing.

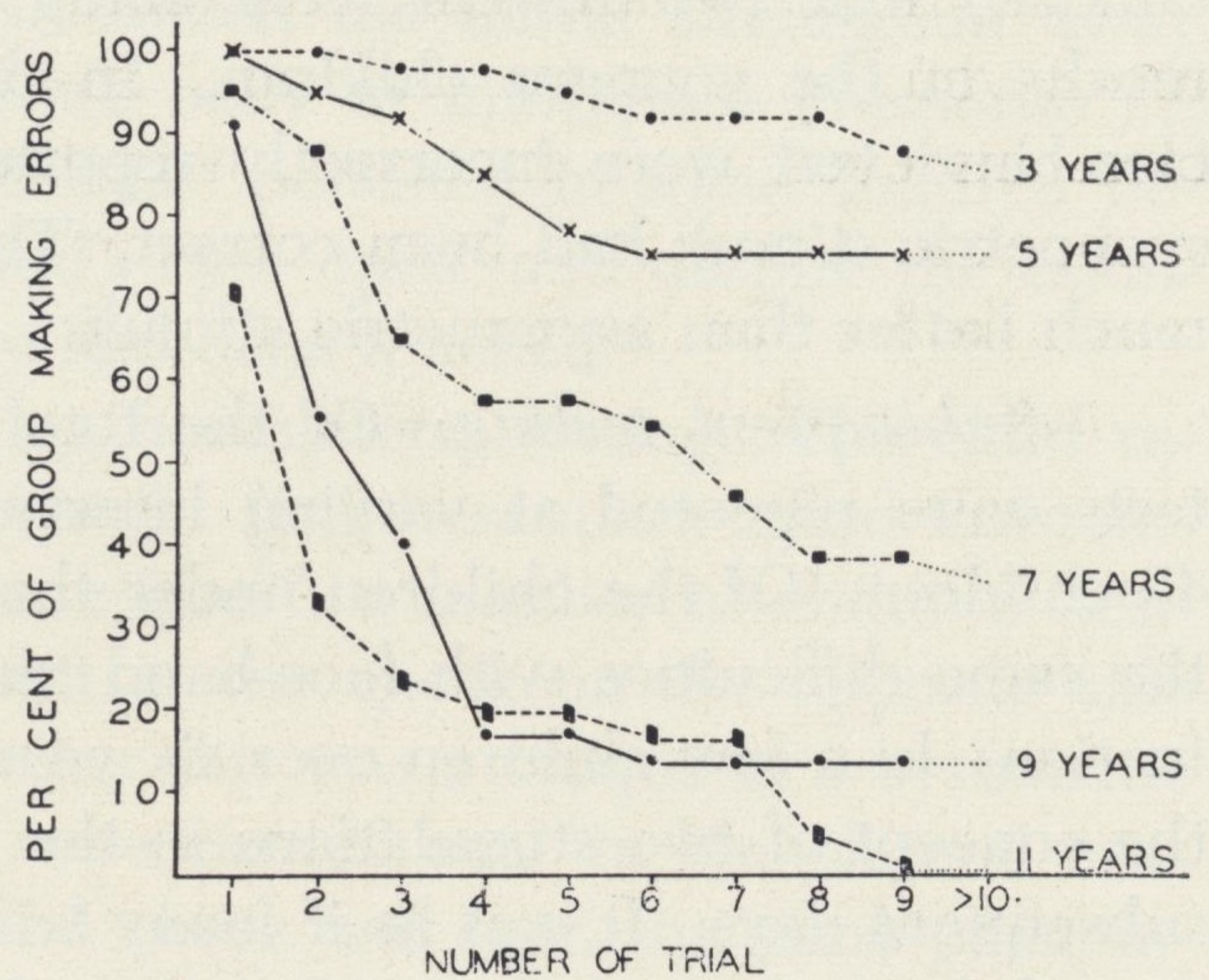
These tactile tests were repeated on consecutive days, or subsequently after a lapse of a few days or weeks in some children. At such times, cutaneous stimuli other than light touch were added to the testing. These included repetitive touch (rubbing), single pin prick, and repetitive pin pricks.

RESULTS

Incidence of errors: Young children made many errors on face-hand tests. Eighty per cent of children under the age of six failed to localize both stimuli



Graph 1.



Graph 2.

during the initial ten trials of the face-hand test; many of these even with eyes open. In the older children the number of failures fell sharply (graph 1) so that only 2 per cent of children in the 11 to 15 year age groups continued to make errors after the initial ten trials. Apparently the ability to identify two simultaneously applied tactile stimuli was directly related to the age of the child. This ability was also related to the number of previous trials of the face-hand test. In table 1 the trial of the test after which the child was consistently correct is recorded. The last column of the table includes all the subjects who made errors in the first ten trials, and on many trials of the test beyond the tenth. Graph 2 illustrates this relation for selected age groups.

Type of testing: In these studies homolateral and heterologous stimulations were carried out at random. Errors were made by subjects of all age groups in tests of either type. Homologous tests, such as both cheeks, or both hands, randomly interspersed in the testing after the fourth trial, elicited correct responses in nearly all cases. While this served as a clue to some of the older

TABLE 1
NUMBER OF TRIALS OF THE FACE-HAND TEST NECESSARY FOR PERSISTENT
CORRECT RESPONSES
(Touch Stimuli)

Age	Total Number of Subjects	Trial Correct									Errors Beyond 10 Trials
		1	2	3	4	5	6	7	8	9	
3	39	-	-	1	-	1	1	-	-	2	34
4	34	-	-	1	-	2	2	-	1	-	28
5	37	-	2	1	3	2	1	-	-	-	28
6	36	-	-	1	2	5	4	-	2	-	22
7	26	1	2	6	2	-	1	2	2	-	10
8	22	4	6	3	-	2	1	-	2	-	4
9	23	2	8	4	5	-	1	-	-	-	3
10	20	2	6	5	4	-	1	-	-	-	2
11	21	6	8	2	1	-	1	-	2	1	0
12	24	3	7	4	6	1	-	1	-	-	2
13-15	29	4	10	6	4	2	1	-	-	2	0

children that two stimuli were being applied, it did not seem to alter the results in the younger children. In these subjects subsequent trials of the face-hand test were incorrectly reported, even though the responses to the symmetric stimuli had been correct. The perception of symmetric stimuli was much better than asymmetric stimuli.

Subsequent testing: Of the total group of children studied, face-hand tests were repeated at varying intervals subsequent to the initial testing in 40 children. Of the children under the age of six, subsequent testing elicited the same difficulties with face-hand tests as was evident on the initial examination. In a few children over six years of age, who seemed to have grasped the concept of two stimulations in the initial testing, errors were manifest on subsequent days. It was as if many trials were necessary for successful learning of the task, and then, even though the task was successfully completed, the learning was temporary. These observations are in contrast to those made in normal adults, in whom subsequent testing did not elicit the errors of the initial test.¹

Type and pattern of responses: The errors (table 1) made by children on repeated trials of the face-hand test were of six types: (a) a touch on the cheek only, implying no perception in the hand; (b) a touch on each cheek, implying a mislocalization of the stimulus applied to the hand; (c) a touch on the cheek, and a second touch on the shoulder, neck or elbow, implying a partial mislocalization of the stimulus applied to the hand; (d) a touch on the hand only, implying no perception in the cheek; (e) a touch on each hand implying a mislocalization of the cheek stimulus to the hand; and (f) one or two touches on the examiner's body, implying a mislocalization away from the child's body.

Face dominance (responses *a*, *b*, *c*) was apparent in all age groups. It was most manifest as extinction* of the stimulus to the hand (response *a*), and was seen in 62 per cent of the errors. Mislocalization of the hand stimulus to the cheek (displacement) was observed in 31 per cent of the errors. While most of the displacements were observed in tests involving cheek and hand on opposite sides of the body, 7 per cent of the errors were displacements from the hand to the cheek in the simultaneous stimulation of homolateral body parts, e. g., right cheek and right hand. At such times the child pointed to the cheek once, saying "a touch here," and then, moving his fingers 2 to 3 centimeters lower on the cheek, saying "and here."

Other types of displacement were infrequent. There were partial displacements from the hand to the shoulder or neck. Mislocalization of a stimulus across the midline of the body, known as allesthesia,³ was occasionally apparent in the stimulus to the hand on heterologous testing. Furthermore, children

*The failure to report one of two simultaneous stimulations has been called "extinction" of a stimulus.² The mislocalization of a percept to the homologous body part of the second stimulus is called "displacement." The mislocalization of a percept in the direction of the second stimulus is called "partial displacement." In each instance, the stimulus which is correctly reported is said to be "dominant."

under five years of age frequently mislocalized the initial stimulation away from their body to parts of the examiner's body or into space (response *f*). This phenomenon, known as exosomesthesia,⁴ persisted in some children despite repeated stimulations with the child's eyes open, and despite the examiner's insistence that it was the child who had been touched.

Another phenomenon was seen during homolateral testing. The child reported only the stimulus applied to the cheek. If the examiner asked insistently, "Did you feel another touch anywhere else?", a number of children hesitatingly pointed to the symmetrical point in the cheek on the opposite side of the body. In order to determine whether this was a unique or a systematic phenomenon, tests of other body parts were carried out. In homolateral tests of foot and hand, shoulder and hand, and cheek and foot, the same phenomenon was observed. The child first reported only the foot, the shoulder or the cheek—and then, when the examiner insisted on a second locus, pointed to the opposite foot, shoulder or side of the face.

Furthermore, in some young children the phenomenon appeared on single stimulation. Single stimuli applied to any body part were localized correctly. If the examiner then insisted that there had been a second stimulus, the child pointed hesitatingly to the symmetric part on the opposite side of the body.

As already indicated, hand dominance (responses *d* and *e*) was infrequent. It was observed in 7 per cent of the errors on face-hand tests. In all subjects in whom it was apparent, subsequent trials of the face-hand test manifested the pattern of face dominance.

Relation of hand and foot: In tests of parts of the body other than the face and hand, the hand was always least dominant and the cheek the most. Simultaneous tests of foot and hand, the foot-hand test, were introduced after the initial ten trials of the face-hand test in most children. In the foot-hand test, foot dominance was apparent in 51 per cent of the responses (see table 2). It was demonstrated by hand extinction, by displacement of hand stimuli to the foot, and by partial displacement to the thigh, knee and leg.

TABLE 2
FOOT-HAND TEST
(Touch Stimuli)

Stimulation	Total Trials	Responses					
		Correct	Foot	Hand	Foot-Foot	Partial Ft.-Ft.	Hand-Hand
Bilateral	53	21	17	1	10	2	2
Ipsilateral	48	23	16	3	3	3	0

Other stimuli: A small group of children who made errors in tests repeated at varying intervals were examined with other cutaneous stimuli. Extinction and displacement phenomena were present in face-hand tests using pin prick, repetitive pin prick and repetitive touch (rubbing) stimulations. While the number of errors with these stimuli were fewer than with touch stimuli, the

pattern of face dominance and hand extinction was still apparent.

DISCUSSION

The ability to identify and localize simultaneous stimuli separated from each other at some distance is a complex function which gradually develops during the first decade of life. It is a relatively unstable ability, for many changes in the state of the organism can disturb such discriminations. Focal cerebral disease as in hemiplegia⁵ or parietal lobe lesions,² spinal cord lesions,² and diffuse brain diseases such as toxic states, senility and inflammatory conditions⁶ can so alter tactile discrimination that the phenomena of extinction and displacement become prominent. Errors in simultaneous tactile tests are apparent in normal adults during the initial few trials of the test—during the period of learning.¹ Persons subjected to large doses of barbiturates,⁶ electroshock therapy⁶ or anesthesia⁷ also manifest such inability.

A prominent feature in all groups is the uniformity of face dominance. When discrimination of simultaneous stimuli is interfered with, for whatever reason, the errors are made in the stimuli to the hand and not in the stimuli to the face. The corollary of "face dominance" is "hand extinction." It, too, is apparent in all subjects and under the variety of conditions studied. Furthermore, in an "order of dominance" other body parts are between these two limits. Studies in patients with hemiplegia⁵ and patients with severe mental changes as a result of brain disease⁶ have revealed an order of dominance of face-shoulder-trunk-thigh-foot and hand. Insofar as these other body parts were studied in these children, a similar order was observed. Since dominance is evident in young children, it appears that the pattern of dominance is an inherent function of the organism. This childlike way of responding to simultaneous tactile stimuli is exposed and exaggerated in adults under a variety of pathologic conditions.

Recently Cohn has suggested a theory of rostral dominance to explain these observations.⁸ Our observations are not in accord with such a theory. The dominance of the foot to the hand in children, as well as the dominance of penis, buttock, foot and thigh to the hand in two large series of patients with diffuse brain dysfunction,^{6,9} make such an explanation untenable.

Comparison of findings in normal children with findings in patients with organic mental syndrome: On comparing the findings in children with those previously reported in patients with severe mental changes due to brain dysfunction,⁶ a close similarity in performance is observed. In both groups the ability to discriminate simultaneous stimuli is limited. On non-homologous tactile tests, such as the face-hand test, errors are made on initial and subsequent trials. While extinction of a stimulus is the most frequent error, displacement is common. In both children and patients, errors occur with a variety of cutaneous stimuli. Furthermore, testing may frequently be done with eyes open, and in many instances with repeated verbal clues that there are two stimuli, and still errors are made. The factor of learning is not prominent since testing on subsequent days will elicit the previous patterned errors.

In Gestalt terms, patients with organic mental defects and children have difficulty in extracting a complex sensory "figure" from the "background" of the total sensory "field." Significantly in each group there is no difficulty in identifying simultaneous stimuli if the stimuli are applied in symmetric regions of the body, such as each hand or both sides of the face. Here, each stimulus figure has a common background in terms of body image, namely the hand.¹⁰

Face dominance is apparent in both groups. It is manifest not only on tests of face and hand but also on tests of face and other body parts. Also, insofar as it was tested, the order of dominance for other body parts is similar.

While extinction and displacement are the most frequent types of error, other phenomena are elicited in both children and patients. Partial displacements, e. g., the mislocalization of the percept from the hand to the shoulder or neck on the face-hand test, are occasionally observed. The phenomena of allesthesia and exosomesthesia are seen in the more severely affected patients and in the youngest children; both are frequently associated in the same subjects. In allesthesia, the subjects usually localize the cheek stimulus correctly but mislocalize the hand stimulus to the opposite hand or elbow. In exosomesthesia, the stimuli are mislocalized either to space in front of the subject or to the examiner's body. This phenomenon was frequent in the youngest children, and despite the examiner's urging that the child point to its own body, the child persisted in such mislocalizations until a trial of the face-hand test was performed with eyes open.

In addition to these phenomena which appear spontaneously, patients with organic mental syndrome also manifest another response to simultaneous stimulation first noted in children, i. e., on homolateral testing only one stimulus (the cheek) is spontaneously reported; but when the examiner insists, the second is mislocalized to the opposite cheek. Since the patients show so many similarities to young children in their responses, it was predicted that they would also show this phenomenon. In a series of patients with severe mental changes, homolateral tests of the cheek, hand, foot, shoulder and thigh were applied. When only one stimulus was reported, the examiner asked for the locus of the second stimulus. Responses were obtained in 20 per cent of the patients, and in each one the second stimulus was mislocalized to the symmetric body part. Furthermore, in some subjects the same phenomenon was observed with single stimulation.

This phenomenon appears to be similar to the completion phenomenon described in Gestalt literature as "closure" and "good continuation." These are usually described for other sensory modalities. When a circle is tachistoscopically exposed in the visual field so that half falls on a hemianopic field, or if a cross is exposed so that the center falls in the blind spot, many subjects report a complete circle or cross. This "completion" occurs for "good" figures. In simultaneous tactile studies, symmetric figures appear to be the "good" or "strong" figures.

CONCLUSIONS

1. Ability to identify and localize asymmetric simultaneous tactile stimuli develops gradually during the first decade of life, and is present in 80 per cent of normal children by the age of eight. Symmetric stimuli are more readily localized and this ability is well developed in normal three year old children.

2. The errors on asymmetric (bilateral and ipsilateral) stimulation involve either extinction (only one of the two stimuli is reported), or displacement (one or both stimuli are mislocalized). Whenever extinction and displacement occur, stimuli to the face tend to be correctly reported. This face dominance is found at all age levels tested.

3. One can conclude that extinction and displacement of tactile stimuli, as well as face dominance, constitute a normal and consistent pattern of response in children. In addition to these responses one can observe, in children under six years of age, the phenomena of allesthesia, exosomesthesia and partial displacement as normal reactions to simultaneous tactile stimulation.

4. The difficulties in recognition of simultaneous tactile stimuli, as shown by young children, reappear in the same fashion in adult patients with focal or diffuse dysfunction of the brain. The abilities of tactile discrimination acquired by the child during growth are lost by the adult who develops mental changes as a result of cerebral damage.

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DEVELOPMENT OF PERCEPTION
OF SIMULTANEOUS TACTILE STIMULI IN NORMAL CHILDREN*

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**Aided by a Fellowship from the National Foundation for Infantile Paralysis.

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INTRODUCTION:

Normal adults readily identify and localize tactile stimuli applied simultaneously to the face and the hand (the "face-hand test") (1). While half the subjects are incorrect on the initial trial, all are correct by the tenth trial of the test. Young children, however, find this task of identifying and localizing two skin stimulations difficult. They report only one of the two stimuli, or if they report the two, frequently mislocalize one of them (1). The omission or mislocalization of stimuli is not haphazard but follows a consistent pattern in which stimuli to the face are readily appreciated ("most dominant") while those to the hand are not ("least dominant").

In order to determine the age at which such tactile perceptual tasks are correctly performed and the pattern of "dominance" in children, a study of normal children was undertaken. The responses of children to the face-hand test, and to simultaneous tactile tests of other body parts, were ascertained.

SUBJECTS AND METHOD:

Three hundred normal children between the ages of three and fifteen were examined. They were children from a neighborhood child care center, from the wards and clinics of Bellevue Hospital, and children of neighbors and friends. They were without manifest disorder of the nervous system. A few children at two and a half years of age were included in the three year age group, but generally, younger children were not able to comprehend the test.

The children were examined individually, but there were many who were examined in a day-room in full view of other subjects. The child was engaged in play and when toys were available they were used to gain the child's confidence and interest. At some time during

the play, the face-hand test was introduced.

For the face-hand test, the child was told: "I (examiner) am going to touch you," and he was to "touch the same place I touch." He was asked to close his eyes. The examiner, with his fingers, then simultaneously touched a cheek and the dorsum of the contralateral hand of the subject. The child was asked what was felt, and to point to the sites stimulated. After this response, the child was asked to close his eyes again, and now the opposite cheek and hand were similarly stimulated, and the report recorded. If only one response was given to this trial, the child was asked if there had been another stimulus "anywhere else."

Following these two trials, the cheek and hand on the same side of the body were tested in a similar fashion. The fifth and sixth trials were not of asymmetric body parts but simultaneous stimulation of both cheeks or both hands. These various types of stimulation were used - "heterologous" stimulation of asymmetric body parts on opposite sides, as right cheek and left hand; "homolateral" stimulation of asymmetric body parts on the same side of the body, as right cheek and right hand, and "homologous" stimulation of symmetric body parts, as both cheeks or both hands. Such tests were repeated in each child until at least ten trials were recorded. Subsequent tests of other body parts, performed in a similar fashion, were introduced until at least 20 consecutive trials were observed in each subject.

A number of modifications had to be introduced for young children. Many would not play the game with eyes closed, but insisted on keeping their eyes open. In such cases the tests were applied with eyes open. Also, a large number of three and four year old

children insisted on pointing to the examiner's hands and face on the initial trials. For these children, a few trials of single touch stimuli applied to the thigh, chest or hand were introduced, until they grasped the concept of pointing to their own body after the stimulation. These single trials were carried out with eyes open.

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These tactile tests were repeated on consecutive days, or subsequently after a lapse of a few days or weeks in some children. At such times, cutaneous stimuli other than light touch were added to the testing. These included repetitive touch (rubbing), single pin prick, and repetitive pin pricks.

RESULTS:

Incidence of Errors: Young children made many errors on face-hand tests. Eighty per cent of children under the age of six failed to localize both stimuli during the initial ten trials of the face-hand test; many of these even with eyes open. In the older children, the number of failures fell sharply (Graph I) so that

only 2% of children in the eleven to fifteen year age groups continued to make errors after the initial ten trials. Apparently the ability to identify two simultaneously applied tactile stimuli was directly related to the age of the child.

This ability was also related to the number of previous trials of the face-hand test. In Table I, the trial of the test after which the child was consistently correct is recorded. The last column of the Table includes all the subjects who made errors in the first ten trials, and on many trials of the test beyond the tenth. Graph II illustrates this relation for selected age groups.

Type of Testing: In these studies homologous and heterologous stimulations were carried out at random. Errors were made by subjects of all age groups in tests of either type. Homologous tests, such as both cheeks, or both hands, randomly interspersed in the testing after the fourth trial, elicited correct responses in nearly all cases. While this served as a clue to some of the older children that two stimuli were being applied, it did not seem to alter the results in the younger children. In these subjects subsequent trials of the face-hand test were incorrectly reported, even though the responses to the symmetric stimuli had been correct. The perception of symmetric stimuli was much better than asymmetric stimuli.

Subsequent Testing: Of the total group of children studied, face-hand tests were repeated at varying intervals subsequent to the initial testing in 40 children. Of the children under the age of six, subsequent testing elicited the same difficulties with face-hand tests as was evident on the initial examination. In a few children over 6 years of age, who seemed to have grasped the concept of two stimulations in the initial testing, errors were manifest on

subsequent days. It was as if many trials were necessary for successful learning of the task, and then, even though the task was successfully completed, the learning was temporary. These observations are in contrast to those made in normal adults, in whom subsequent testing did not elicit the errors of the initial test (1).

Type and Pattern of Responses: The errors (Table I) made by children on repeated trials of the face-hand test were of six types: (a) a touch on the cheek only, implying no perception in the hand; (b) a touch on each cheek, implying a mislocalization of the stimulus applied to the hand; (c) a touch on the cheek, and a second touch on the shoulder, neck or elbow, implying a partial mislocalization of the stimulus applied to the hand; (d) a touch on the hand only, implying no perception in the cheek; (e) a touch on each hand implying a mislocalization of the cheek stimulus to the hand, and (f) one or two touches on the examiner's body, implying a mislocalization away from the child's body.

Face "dominance" (responses a, b, c) was apparent in all age groups. It was most manifest as extinction* of the stimulus to the hand (response a), and was seen in 62% of the errors. Mislocalization of the hand stimulus to the cheek (displacement) was observed in 31% of the errors. While most of the displacements were observed in tests involving cheek and hand on opposite sides of the body, 7% of the errors were displacements from the hand to the cheek in the

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simultaneous stimulation of homolateral body parts, e.g. right cheek and right hand. At such times the child would point to the cheek once, saying "a touch here," and then, moving his fingers 2-3 cms. lower on the cheek, say, "and here."

Other types of displacement were infrequent. There were partial displacements from the hand to the shoulder or neck. Mislocalization of a stimulus across the midline of the body, known as allesthesia (3) was occasionally apparent in the stimulus to the hand on heterologous testing. Furthermore, children under five years of age frequently mislocalized the initial stimulation away from their body to parts of the examiner's body or into space (response f). This phenomenon, known as exosomesthesia (4), persisted in some children despite repeated stimulations with the child's eyes open, and despite the examiner's insistence that it was the child that had been touched.

Another phenomenon was seen during homolateral testing. The child would report only the stimulus applied to the cheek. If the examiner asked insistingly, "Did you feel another touch anywhere else?" a number of children would hesitatingly point to the symmetrical point in the cheek on the opposite side of the body. In order to determine whether this was a unique or a systematic phenomenon, tests of other body parts were carried out. In homolateral tests of foot and hand, shoulder and hand, and cheek and foot, the same phenomenon was observed. The child first reported only the foot, the shoulder or the cheek - and then, when the examiner insisted on a second locus, pointed to the opposite foot, shoulder or side of the face.

Furthermore, in some young children, the phenomenon appeared on single stimulation. Single stimuli applied to any body part would be correctly localized. If the examiner now insisted that

there had been a second stimulus, the child pointed hesitatingly to the symmetric part on the opposite side of the body.

As already indicated, hand dominance (responses d and e) was infrequent. It was observed in 7% of the errors on face-hand tests. In all subjects in whom it was apparent, subsequent trials of the face-hand test manifested the pattern of face dominance.

Relation of Hand and Foot: In tests of parts of the body other than the face and hand, the hand was always least dominant and the cheek the most. Simultaneous tests of foot and hand, the foot-hand test, were introduced after the initial ten trials of the face-hand test in most children. In the foot-hand test, foot dominance was apparent in 51% of the responses (see Table II). It was manifest by hand extinction; by displacement of hand stimuli to the foot; and by partial displacement to the thigh, knee, and leg.

Other Stimuli: A small group of children, who made errors in tests repeated at varying intervals were examined with other cutaneous stimuli. Extinction and displacement phenomena were present in face-hand tests using pin prick, repetitive pin prick and repetitive touch (rubbing) stimulations. While the number of errors with these stimuli were fewer than with touch stimuli, the pattern of face dominance and hand extinction was still apparent.

DISCUSSION:

The ability to identify and localize simultaneous stimuli separated from each other at some distance is a complex function which gradually develops during the first decade of life. It is a relatively unstable ability, for many changes in the state of the organism can disturb such discriminations. Focal cerebral disease

as in hemiplegia (5) or parietal lobe lesions (2); spinal cord lesions (2a); and diffuse brain diseases as toxic states, senility and inflammatory conditions (6) can so alter tactile discrimination that the phenomena of extinction and displacement become prominent. Errors in simultaneous tactile tests are apparent in normal adults during the initial few trials of the test -- during the period of "learning" (1). Persons subjected to large doses of barbiturates (6), electro-shock therapy (6) or anesthesia (7) also manifest such inability.

A prominent feature in all groups is the uniformity of face dominance. When discrimination of simultaneous stimuli is interfered with, for whatever reason, the errors are made in the stimuli to the hand and not in the stimuli to the face. The corollary of "face dominance" is "hand extinction." It, too, is apparent in all subjects and under the variety of conditions studied. Furthermore, in an "order of dominance" other body parts are between these two limits. Studies in patients with hemiplegia (5) and patients with severe mental changes as a result of brain disease (6) have revealed an order of dominance of face-shoulder-trunk-thigh-foot and hand. Insofar as these other body parts were studied in these children, a similar order was observed. Since dominance is evident in young children, it appears that the pattern of dominance is an inherent function of the organism. This childhood way of responding to simultaneous tactile stimuli is exposed and exaggerated in adults under a variety of pathological conditions.

Recently Cohn has suggested a theory of rostral dominance to explain these observations (8). Our observations are not in accord with such a theory. The dominance of the foot to the hand in

children, as well as the dominance of penis, buttock, foot and thigh to the hand in two large series of patients with diffuse brain dysfunction (6, 9) make such an explanation untenable.

Comparison of Findings in Normal Children with Findings in Patients with Organic Mental Syndrome:

On comparing the findings in children with those previously reported in patients with severe mental changes due to brain dysfunction (6), a close similarity in performance is observed. In both groups the ability to discriminate simultaneous stimuli is limited. On non-homologous tactile tests, such as the face-hand test, errors are made on initial and subsequent trials. While extinction of a stimulus is the most frequent error, displacement is common. In both children and patients, errors occur with a variety of cutaneous stimuli. Furthermore, testing may frequently be done with eyes open, and in many instances, with repeated verbal clues that there are two stimuli and still errors are made. The factor of learning is not prominent since testing on subsequent days will elicit the previous patterned errors. In Gestalt terms, patients with organic mental defects and children have difficulty in extracting a complex sensory "figure" from the "background" of the total sensory "field." Significantly in each group there is no difficulty in identifying simultaneous stimuli if the stimuli are applied in symmetric regions of the body, such as each hand or both sides of the face. Here, each stimulus figure has a common background in terms of body image, namely, the "hand." (10).

In both groups, face dominance is apparent. It is manifest not only on tests of face and hand but also on tests of face and other body parts. Also, insofar as it was tested, the order of dominance for other body parts is similar.

While extinction and displacement are the most frequent types

of error, other phenomena are elicited in both children and patients. Partial displacements, e.g. the mislocalization of the percept from the hand to the shoulder or neck on the face-hand test, are occasionally observed. The phenomena of "allesthesia" and "exosomesthesia" are seen in the more severely affected patients and the youngest children; both are frequently associated in the same subjects. In allesthesia, the subjects usually localize the cheek stimulus correctly but mislocalize the hand stimulus to the opposite hand or elbow. In exosomesthesia, the stimuli are mislocalized either to space in front of the subject or to the examiner's body. This phenomenon was frequent in the youngest children, and despite the examiner's urging the child to point to its own body, the child persisted in such mislocalizations until a trial of the face-hand test was performed with eyes open.

In addition to these phenomena which appear spontaneously, patients with organic mental syndrome also manifest another response to simultaneous stimulation first noted in children, i.e., on homolateral face-hand testing only one stimulus (the cheek) is spontaneously reported; but when the examiner insists, the second is mislocalized to the opposite cheek. Since the patients show so many similarities in their responses to young children, it was predicted that they would also show this phenomenon. In a series of patients with severe mental changes, homolateral tests of the cheek, hand, foot, shoulder and thigh were applied. When only one stimulus was reported, the examiner asked for the locus of the second stimulus. Responses were obtained in 20% of the patients, and in each one the second stimulus was mislocalized to the symmetric body part. Furthermore, in some subjects the same phenomenon was observed with single stimulation.

This phenomenon appears to be similar to the completion phenomenon described in Gestalt literature as "closure" and "good continuation." These are usually described for other sensory modalities. When a circle is tachistoscopically exposed in the visual field so that half falls on a hemianopic field, or if a cross is exposed so that the center falls in the blind spot, many subjects report a complete circle or cross. This "completion" occurs for "good" figures. In simultaneous tactile studies, symmetric figures appear to be the "good" or "strong" figures.

CONCLUSIONS:

1. Ability to identify and localize asymmetric simultaneous tactile stimuli develops gradually during the first decade of life, being present in 80% of normal children by the age of eight years. Symmetric stimuli are more readily localized and this ability is well developed in normal three year old children.
2. The errors on asymmetric (bilateral and ipsilateral) stimulation involve either extinction (only one of the two stimuli is reported), or displacement (one or both stimuli are mislocalized). Whenever extinction and displacement occur, stimuli to the face tend to be correctly reported. This "face dominance" is found at all age levels tested.
3. One can conclude that extinction and displacement of tactile stimuli, as well as face dominance, constitute a normal and consistent pattern of response in children. In addition to these responses one can observe, in children under six years of age, the phenomena of allesthesia, exosomesthesia and partial displacement as normal reactions to simultaneous tactile stimulation.
4. The difficulties in recognition of simultaneous tactile stimuli, as shown by young children, reappear in the same fashion

in adult patients with focal or diffuse dysfunction of the brain. The abilities of tactile discrimination acquired by the child during growth are lost by the adult who develops mental changes as a result of cerebral damage.

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TABLE I

Number of Trials of the Face-Hand Test Necessary for Persistent
Correct Responses.

(Touch Stimuli)

Trial Correct

<u>Age</u>	<u>Total No. of Subjects</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>Errors Beyond 10 Trials</u>
3	39	-	-	1	-	1	1	-	-	2	34
4	34	-	-	1	-	2	2	-	1	-	28
5	37	-	2	1	3	2	1	-	-	-	28
6	36	-	-	1	2	5	4	-	2	-	22
7	26	1	2	6	2	-	1	2	2	-	10
8	22	4	6	3	-	2	1	-	2	-	4
9	23	2	8	4	5	-	1	-	-	-	3
10	20	2	6	5	4	-	1	-	-	-	2
11	21	6	8	2	1	-	1	-	2	1	0
12	24	3	7	4	6	1	-	1	-	-	2
13-15	29	4	10	6	4	2	1	-	-	2	0

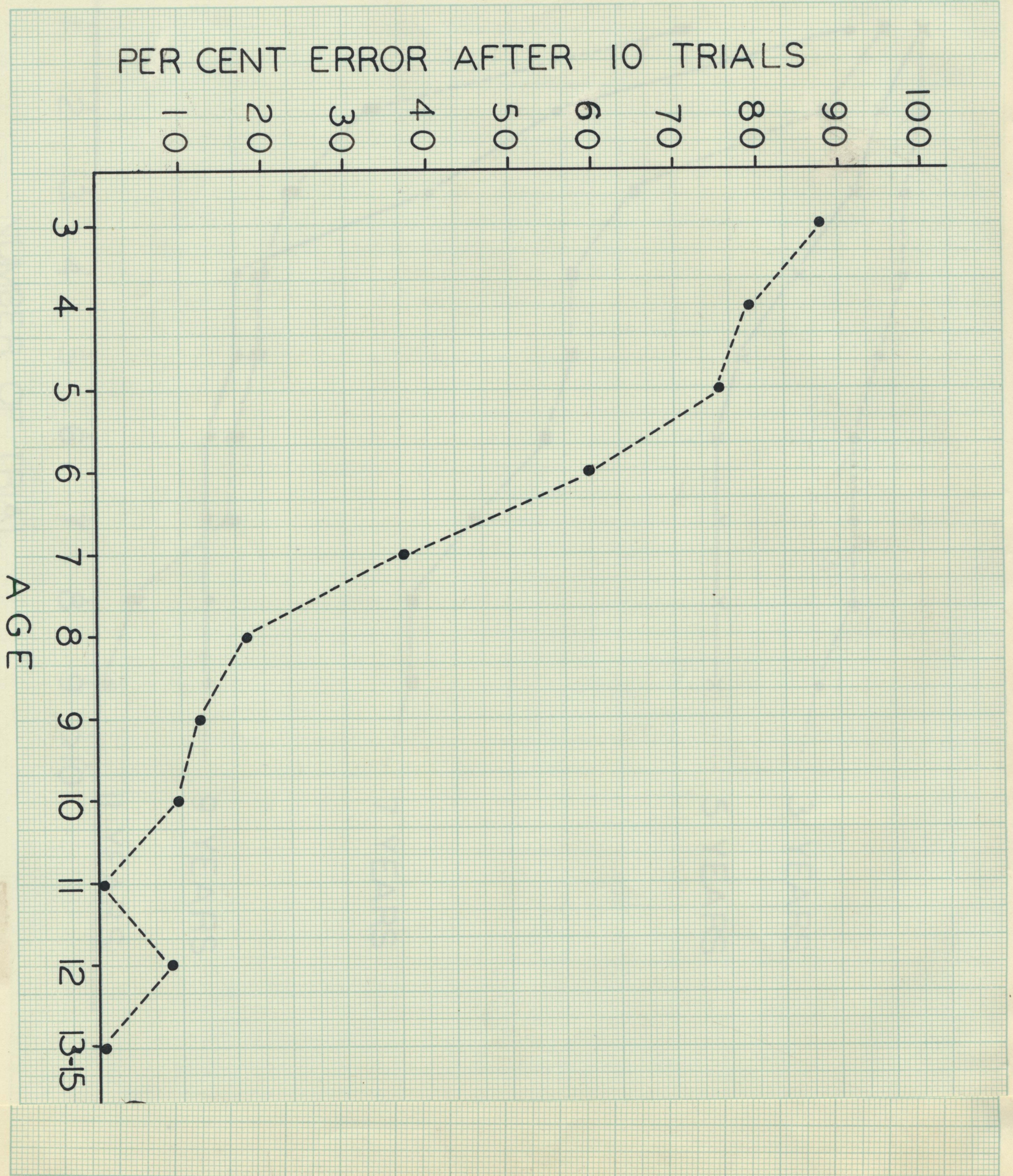
TABLE II

Foot-Hand Test
(Touch Stimuli)

STIMULATION	TOTAL TRIALS	RESPONSES					
		Correct	Foot	Hand	Foot-Foot	Partial Ft.-Ft.	Hand-Hand
Bilateral	53	21	17	1	10	2	2
Ipsilateral	48	23	16	3	3	3	0

PER CENT OF GROUP MAKING ERRORS

Relation of Age to Errors on Multiple Trials of the Face Hand Test



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Per Cent of Children by Age Groups Making Errors on Successive Trials of Face Hand Tests

THE MOUNT SINAI HOSPITAL
NEW YORK CITY

MONTHLY NEUROLOGICAL RESEARCH SEMINAR

TUESDAY

NOVEMBER 27, 1951

8:30 P. M.

BOARD ROOM - 2nd FLOOR ADMINISTRATION BUILDING

PROGRAM

THE PERCEPTION OF MULTIPLE STIMULI

I. DR. MAX FINK AND DR. MARTIN GREENE: PATTERNS OF RESPONSES ON
TACTILE D.D.S.

II. DR. ROBERT L. KAHN AND DR. EDWIN A. WEINSTEIN: (UNTITLED PAPER)

DR. W. S. BATTERSBY
CHAIRMAN

REPORT OF ACTIVITIES

1951

Maximilian Fink, M.D.

Submitted to Palis Foundation
1 Feb. 1952

The responses of various subjects to newly devised tests of tactile perception formed the major part of my studies under the fellowship grant from the National Foundation for Infantile Paralysis during 1951. Previously, Dr. Morris B. Bender had introduced the method of double simultaneous stimulation into the technic of the neurological examination.* In a report to the American Neurological Association in 1950, a simple tactile test - the face-hand test - was described (1). In this test, a cheek and a hand of the subject are simultaneously stimulated by pin prick or light touch stimuli. Half of normal adult subjects fail to correctly identify and localize the two stimuli on the initial trial of the test. The errors are of two types: (a) failure to report one of the stimuli ("extinction"); (b) mis-localization of one of the stimuli, usually from the hand to the cheek ("displacement"). On subsequent trials of the face-hand test, fewer normal subjects make errors - until by the tenth trial, less than 1% persist in making errors.

In contrast to this ability of normal adults to identify and localize simultaneous tactile stimuli are the responses of very young children and of patients with diffuse brain dysfunction. More than 85% of these subjects fail to identify and localize the two stimuli through many trials of the test. Extinction and displacement phenomena are prominent, occasionally even with the eyes open.

These observations were first published in summary form in the 1950 Transactions of the American Neurological Association (1). A detailed report appeared subsequently (2). This report formed the background for my studies during 1951.

The work may be summarized according to the subjects studied: (I) patients with organic mental syndrome; (II) normal children; (III) mentally retarded adults; and (IV) patients with hysteria, depression and anxiety.

I. Organic Mental Syndrome

(a) The Face-Hand Test as a Diagnostic Sign:

The organic mental syndrome - defined as loss of memory and orientation, difficulties in calculation, concreteness in thinking and emotional lability - can be caused by a wide variety of agents. Subjects suffering from cerebral trauma, intracranial neoplasm or bleeding, intoxications, cerebrovascular diseases, and inflammatory states including central nervous system syphilis were studied. Their difficulties with tactile tests were found to be similar. It was concluded that the difficulty in identifying the stimuli was not related to the cause of the organic mental syndrome, but rather to its severity and duration.

Since patients with organic mental syndromes persist in making errors on multiple trials of the face-hand test, and normal adults do not, it was believed that this test could be of diagnostic value. In the original study (1), patients with schizophrenia and aphasia without

*Bender, M.B.: The Advantages of the Method of Simultaneous Stimulation in the Neurological Examination, Med. Clin. North America, 32:755, 1948.

organic mental changes had been examined and found to respond like normal adults. A large number of patients with other psychotic and severe psychoneurotic reactions were studied at Bellevue Hospital. Their responses to multiple trials of the face-hand test were found to be like the responses of normal adults (cf. section IV below).

To appraise the value of the face-hand test in the diagnosis of organic mental syndromes, a trial study was instituted. Fifty consecutive patients entering Bellevue Hospital were examined in the admitting room. The face-hand test was applied as the initial item of the interview. In each case where errors were persistent on repeated trials of the test, the diagnosis of organic mental syndrome was made. In every such instance this conclusion was supported by subsequent psychiatric interview.

These observations on the face-hand test as a diagnostic sign of organic mental syndrome were presented at the meeting of the Academy of Neurology on April 11, 1951, and subsequently submitted for publication (3).

(b) Type of Responses: Patients with organic mental changes made many errors, and the type of errors varied. Extinction was most common, occurring in all patients. Displacement phenomena were seen less frequently, and four types may be described. Complete displacement, or mislocalization of the percept in the hand to the cheek occurred in 40% of patients. Partial displacement, or mislocalization from hand to shoulder, elbow or neck was occasionally reported. Displacement across the midline (allesthesia) from a hand to the opposite hand, or to the opposite cheek or shoulder was rare. In a lesser number of patients -- about 3% of those studied -- the patients mislocalized the stimuli out into space or to the body of the examiner. The phenomenon was not haphazard but consistent, patterned and predictable. As this phenomenon was not previously described, it was named "exosomesthesia" and a report is now in preparation (4).

(c) Effect of Drugs: While studies were carried out to determine a relation between any of the elements of the organic mental syndrome and persistent errors on the face-hand test, no such relation was noted. There was a relation between the severity of the syndrome and the frequency and type of errors. The less common varieties of displacement (partial displacement, allesthesia and exosomesthesia) were apparent only in the more severely ill patients.

Sodium amytal was administered intravenously to patients with mild mental changes who made few errors on the face-hand test. With increasing drowsiness, the errors on the tactile tests increased, and displacements became frequent. Allesthesia and exosomesthesia appeared where these phenomena had previously been absent. Also, as the effect of the drug diminished, the displacement phenomena diminished and disappeared.

Intravenous sodium amytal was administered to normal adults in an effort to induce an organic mental syndrome. While none of the subjects became persistently confused or disoriented, extinction and occasionally displacement of percepts were reported on multiple trials of the face-hand test. The alteration in performances of normal adults and patients by barbiturate intoxicants was reported in part (3) and will be submitted in detail (5).

(d) Effect of Different Stimuli: While most of these observations were made with light touch stimuli, a number of patients were subjected to extensive studies with other cutaneous stimuli. Pin prick, repetitive pin prick, tuning fork, and temperature tube stimulations were used. Patients who made repeated errors of extinction and displacement to touch stimuli, also persisted in making errors with these stimuli. The incidence of errors varied, as did the types of responses, but similar patterns of responses were observed. A detailed analysis of these findings has not been made, although they have been reported in part (1,2,3).

(e) Effect of Different Body Parts: Although the original test described was a test of face and hand, many tests of other body combinations were carried out. Simultaneous tactile stimulation of parts like foot and hand, or shoulder and thigh also yielded responses of extinction and displacement. A statistical study was undertaken to determine whether such errors occurred at random in each combination, or whether errors were more prominent in one body part than another. Eleven body parts were tested -- cheek, shoulder, breast, abdomen, thigh, foot, hand, penis or female pubis, buttock, and back. Errors were not haphazard but bore a distinct relation to the combination of parts tested. Most errors were made in the face-hand combination, and in this combination almost all the errors were in the percept in the hand. A like number of errors were made in tests of penis and hand, and pubis and hand. Here, too, the errors were in the percept in the hand. In every combination of body parts involving the hand the errors were significantly more frequent in the hand. In every combination of body parts involving the cheek, the penis, or the pubis, there were significantly fewer errors in these parts. The cheek, penis and pubis are therefore said to be "most dominant" parts of the body, and the hand the least dominant, on simultaneous tactile tests. This order of dominance - of cheek, penis, pubis, shoulder, trunk (breast, abdomen, back), buttock, foot, thigh and hand - seen in patients with organic mental syndrome, is the same order as previously reported for patients with hemiplegia.* It is also apparent in children and mental defectives (cf. sections II, III below). A report of this statistical study is now in preparation (6).

II Normal Children

Three hundred normal children between the ages of three and fifteen years were examined. The face-hand test, and simultaneous tactile tests of other body parts, were applied in each subject. Like the patients with organic mental syndrome, the young children made persistent errors on these tests. The phenomena of extinction and displacement were prominent, but exosomesthesia, allesthesia and partial displacement were also observed. In the tabulation of the results, 89% of three year old children made persistent errors. Many of these made errors of localization and identification even with eyes open. With increasing age, the number of children making persistent errors fell off sharply until 80% of children at the age of eight years could identify the two stimuli correctly within 10 trials.

The errors were persistent for asymmetric stimuli (i.e., face and hand, foot and hand). Symmetric simultaneous stimuli (e.g. hand-hand)

*Bender, M.B., Shapiro, M.P. and Schappell A.W.: Extinction Phenomenon in Hemiplegia., Arch.Neurol.&Psychiat., 62: 717, 1949.

were correctly identified by three year old children.

Face dominance was prominent. While tests of other body parts were not consistently carried out, tests of foot and hand were. In this combination foot dominance was significant.

It was concluded that extinction and displacement of tactile stimuli, as well as face and foot dominance, constitute a normal and consistent pattern of response in young children. Also the special types of displacement are normal reactions in children under six years of age. These findings were compared with the findings in patients with organic mental syndrome and it was concluded that the abilities of tactile discrimination acquired by the child during growth, are lost by the adult who develops mental changes as a result of cerebral disease.

This report will be presented at the spring meetings of the Academy of Neurology (April 23-24, 1952) in Louisville, Kentucky, and will be submitted for publication in the Journal "Neurology" (7).

III. Mental Deficiency:

A similar study was carried out in 57 adult mental defectives at the Letchworth Village, New York. The subjects had mental ages of 2 years 6 months to 9 years 8 months, with chronological ages over 13 years. The face-hand test, and tests of other body parts were applied in these subjects. Their performances were strikingly similar to the performances of young children, rather than the performances of adults. They persisted in making errors beyond the ten trials, and displacements and extinction phenomena were prominent. There was a direct relation of the persistence of errors to the mental age of the subject was observed, i.e., the lower the mental age the more errors reported. It was concluded that the face-hand test reflected the same performance ability as did the Stanford-Binet test.

Furthermore, the order of dominance -- of cheek, shoulder, foot, thigh, and hand -- is similar to the order in the patients and children. These observations are now being prepared for publication (8).

IV. Psychiatric States:

As part of the original study, the face-hand test was applied to a small group of schizophrenic patients. Their responses were much like normal adults (2). In the evaluation of the test as a diagnostic aid, patients with hysteria, amnesia, psychic depression and severe anxiety were studied. Their responses, also, were more like normal adults than the responses of patients with organic psychoses. Patients with depression or schizophrenia, subjected to electro-convulsive therapy were examined. It was noted that the treatment induced changes in performance on the face-hand test which were transient. Patients subjected to frontal lobe "topectomy" operations also manifested transient changes in performance on these tests. The observations in these psychiatric subjects were reported in the inaugural issue of the Journal of the Hillside Hospital (9).

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Spinal Fluid Findings Following Cerebral Angiography

Joseph M. Stein, M.D. and Max Fink, M.D.

WITH increasing use of cerebral angiography, the problem arose as to whether the procedure, of itself, produced changes in the cerebrospinal fluid. Forty-eight hours after angiography a spinal fluid examination in a patient suspected of a brain tumor revealed a cloudy fluid with 3,000 white blood cells per cu. mm. Prior to angiography the fluid had been clear, colorless and without any cells. As no information concerning the relationship of pleocytosis to angiography was available, it was decided to study the changes in the spinal fluid by the usual clinical methods.

Spinal fluids from 21 patients were examined prior to and following angiography. Lumbar punctures prior to angiography were done at various intervals, but all punctures following angiography were performed between 12 and 24 hours after the procedure. In each instance the spinal fluid was examined for color, cell count and total protein content.

All angiograms were percutaneous, using 35 per cent Diodrast as the contrast medium. Maximal Diodrast volume was 70 ml. at one procedure. While the majority of patients were subjected to unilateral carotid punctures, bilateral punctures were done in four, and combined bilateral carotid and vertebral punctures in one patient. Either intravenous Pentothal (14 cases) or local procaine (seven cases) anesthesia was used.

RESULTS

Of the 21 subjects, significant changes in the spinal fluid following angiography were seen in only two cases. In one, a patient with a cerebral arteriovenous malformation and multiple aneurysms, 5,000 red blood cells per cu. mm. were seen in a pink spinal fluid. In the second, a patient with a chromophobe adenoma of the pituitary gland, the protein content of the spinal fluid changed from 89 to 151 mg. per cent; also, seven lymphocytes per cu. mm. were recorded when previously there had been none.

In all other subjects, changes in color, protein content and cell count were not significant. Three subjects showed transient hemiparesis following an-

From the department of neurology and psychiatry, New York University College of Medicine and the neurologic service (third division) and psychiatric division, Bellevue Hospital, New York City.

giography, and in none of these were there significant changes in the spinal fluid. Since Diodrast can cause changes in membrane permeability,¹ and the spinal fluid reflects such changes, it could be postulated that a relationship between complications following angiography and changes in the spinal fluid might exist. Such changes were not demonstrated in the present cases. Further investigations with more exacting techniques for protein determination and protein differentiation are indicated.

CONCLUSIONS

Neither a marked pleocytosis nor a marked increase in protein content of the spinal fluid are usual concomitants of Diodrast angiography. It may be concluded that when such spinal fluid changes are found they are unrelated to the procedure.

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Published 2/53

Spinal Fluid Findings Following Cerebral Angiography

Joseph M. Stein M.D. and Max Fink M.D.

With increasing use of cerebral angiography we were soon confronted with the problem of whether the procedure, of itself, produced changes in the cerebrospinal fluid. Forty-eight hours after angiography, a spinal fluid examination in a patient suspected of a brain tumor, revealed a cloudy fluid with 3000 white blood cells per cubic milliter. Prior to angiography the fluid had been clear, colorless and without any cells. As no information concerning the relationship of pleocytosis to angiography was available, it was decided to study the changes in the spinal fluid by the usual clinical methods.

Spinal fluids from twenty-one patients were examined prior to and following angiography. Lumbar punctures prior to angiography were done at various intervals, but all punctures following angiography were performed between 12 and 24 hours after the procedure. In each instance the spinal fluid was examined for color, cell count and total protein content.

All angiograms were percutaneous, using 35% diodrast as the contrast medium. Maximal diodrast dosage was 70cc at one session. While the majority of patients were subjected to unilateral carotid punctures, bilateral punctures were done in four patients and combined bilateral carotid and vertebral in one. Either intravenous pentothal (14 cases) or local procaine (7 cases) anesthesia was used.

Results:

Of the twenty-one subjects, significant changes in the spinal fluid following angiography were seen in only two cases. In one, a patient with a cerebral angiomatous malformation and multiple aneurysms, 5000 red blood cells per cubic milliter were seen in a pinkish colored spinal fluid. In the second, a patient with a chromophobe adenoma of the pituitary gland, the protein content of the spinal fluid changed from 89 milligram per cent to 151 milligram per cent. Also, seven lymphocytes per cubic milliliter were recorded when previously there had been none.

In all other subjects, changes in color, protein content and cell count were not significant. Three subjects suffered transient hemiparesis, and in none were there significant changes in the spinal fluid. In two subjects, the spinal fluid remained unchanged. In the third, few crenated red blood cells and two lymphocytes per cubic milliliter were noted, where none had been seen prior to the procedure. Since diodrast can cause changes in membrane permeability (1), and the spinal fluid reflects changes in this membrane, it may be postulated that a relation between complications and such changes exists. Such changes were not demonstrated here. Further investigations with more exacting techniques for protein determination and protein differentiation are indicated.

Conclusion:

Neither a marked pleocytosis nor a marked increase in protein content of the spinal fluid are usual concomitants of diodrast angiography. It may be concluded that when such spinal fluid changes are found, they are unrelated to the procedure.

Reference

Olsson, O.: Cerebral Angiography: Tolerance for Contrast Media of Diodrast Type, J. Neurol., Neurosurg., & Psychiat. 12:312-316, (Nov.) 1949.

Dr. Costello, Members, and Guests of the Academy:

In the course of sensory studies by the method of double simultaneous stimulation, we learned that normal adults readily identify and localize the two stimuli within the initial ten trials of the test. Young children, however, seemed to make persistent errors. They could not identify both stimuli, or if identifying the two stimuli, they could not localize them. In order to study the responses and their relation to the age of the subjects, face-hand tests--the prototype of simultaneous tactile tests--were applied to 300 normal children ranging in ages from 3 to 15 years. The children were all without manifest disorder of the nervous system, and were from child care centers, hospital clinics and children of neighbors and friends.

In the course of some play with each child, the examiner introduced the face-hand test. In this test, the child closes his eyes, and the examiner, with his fingers, simultaneously touches the subject's cheek and dorsum of his contralateral hand. The child is asked to point to the places where he perceived the stimuli, and the report is recorded. Again the child is asked to close his eyes, and the test repeated--with opposite cheek and hand stimulated. Subsequently cheek and hand on the same side of the body and simultaneous stimulation of both sides of the face, or both hands are included. At least ten consecutive trials of the face-hand test are recorded for each child.

Eighty percent of children under six years of age failed to localize both stimuli correctly during the initial ten trials. The number of errors fell off sharply among the older children, so that only 2% of children in the 11-15 year age groups continued to make errors after the tenth trial. This is represented in the first graph--.. Apparently the ability to localize two simultaneously applied tactile stimuli is directly related to the age of the subject.

This same relationship is represented in the second graph. The percent of the subjects in each age group making errors on each trial of the test is compared for representative age groups. The older children manifest an ability to learn from previous trials of the test while the younger children do not.

The incorrect responses of all children were of two types--failure to identify one of the two stimuli, called "extinction", or, identifying two stimuli but mislocalizing one of them termed "displacement". Extinction of hand stimuli was observed in 62% of the errors, while displacement was in 31%. The preponderance of errors were in the perception of the stimulus to the hand. The stimulus to the cheek was almost always correctly reported. This ability to identify the cheek stimulus in preference to the stimulus to the hand was previously observed in normal adults and termed "face dominance." Such face dominance was uniformly apparent in the children of all age groups in the series.

The errors were apparent in tests involving the cheek and hand on opposite sides of the body as well as cheek and

hand on the same side of the body. While errors were frequent in tests of face and hand, children made no errors in identifying symmetric stimuli, as both cheeks. In the younger children, partial displacement from hand to homolateral shoulder or neck, or displacements from a hand to the opposite hand (allesthesia), or even into space in front of the child (exosomesthesia) were seen. The incidence of these displacements was less than 4%.

Since these phenomena were so apparent in younger children and became less frequent with increasing age, it was concluded that extinction and the varieties of displacement are normal phases in the development of the response to simultaneous tactile stimuli. In normal adults and older children, such phenomena are apparent during the initial few trials only.

From these studies it was concluded that the phenomena of extinction and displacement are normal phases in the development of the perception of simultaneous tactile stimuli. Face dominance is observed at all age levels and is an inherent pattern of organization of function. The perception of simultaneous tactile stimuli is directly related to chronological age, being gradually developed in the first decade of life, and being well developed in 80% of children by the age of 8 years.

Perception of Simultaneous Tactile Stimuli in Normal Children

Max Fink, M.D. and Morris B. Bender, M.D.

Normal adults readily identify and localize tactile stimuli applied simultaneously to the face and the hand (the "face-hand test").¹ While half the subjects perceive stimuli incorrectly on the initial trial, all are accurate by the tenth trial of the test. Young children, however, find the task of identification and localization of two skin stimulations difficult. They report only one of the two stimuli, or, if they report the two, frequently mislocalize one of them. The omission or mislocalization of stimuli is not haphazard but follows a consistent pattern in which stimuli to the face are readily appreciated ("most dominant") while those to the hand are not ("least dominant").

In order to determine the pattern of "dominance" in children and the age at which such tactile perceptual tasks are correctly performed, a study of normal children was undertaken. The responses of children to the face-hand test and to simultaneous tactile tests of other body parts were ascertained.

SUBJECTS AND METHOD

Three hundred normal children between the ages of three and 15 were examined. They were from a neighborhood child care center, from the wards and clinics of Bellevue Hospital, and children of neighbors and friends. They were without manifest disorder of the nervous system. A few children at two and a half years of age were included in the three year age group, but younger children were generally not able to comprehend the test.

The subjects were examined individually, but there were many who were examined in a day-room in full view of other children. The child was engaged in play and when toys were available they were used to gain his confidence and interest. At some time during play, the face-hand test was introduced.

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For the face-hand test, the child was told: "I (examiner) am going to touch you," and he was to "touch the same place I touch." He was asked to close his eyes. The examiner, with the fingers, then touched simultaneously a cheek and the dorsum of the contralateral hand of the subject. The child was asked what he felt, and to point to the sites stimulated. After this response, the child was asked to close his eyes again, and now the opposite cheek and hand were similarly stimulated and the report recorded. If only one response was given to this trial, the child was asked if there had been another stimulus anywhere else.

Following these two trials, the cheek and hand on the same side of the body were tested in a similar fashion. The fifth and sixth trials were not of asymmetric body parts but simultaneous stimulation of both cheeks or both hands. The following various types of stimulation were used: heterologous stimulation of asymmetric body parts on opposite sides, as right cheek and left hand; homolateral stimulation of asymmetric body parts on the same side of the body, as right cheek and right hand; and homologous stimulation of symmetric body parts, as both cheeks or both hands. Such tests were repeated in each child until at least ten trials were recorded. Subsequent tests of other body parts, performed in a similar fashion, were introduced until at least 20 consecutive trials were observed in each subject.

A number of modifications had to be introduced for young children. Many would not play the game with eyes closed, but insisted on keeping their eyes open. In such cases the tests were applied with eyes open. Also, a large number of three and four year old children insisted on pointing to the examiner's hands and face on the initial trials. For these children, a few trials of single touch stimuli applied to the thigh, chest or hand were introduced, until they grasped the concept of pointing to their own bodies after the stimulation. These single trials were carried out with eyes open.

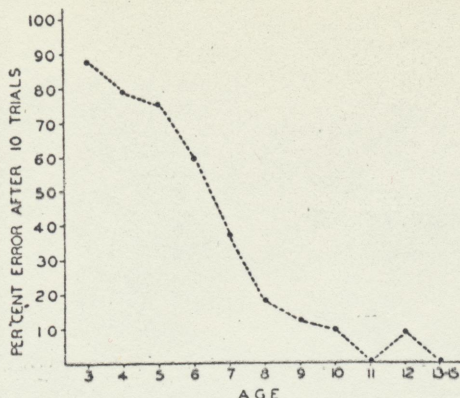
After the series of double simultaneous stimulation tests were completed, single stimuli were applied to various body parts to exclude from the normal group any subjects with focal sensory difficulties.

The children were asked what they had felt and to point to the places stimulated. Verbal reports of the locus of stimulation were not accepted. It was occasionally noted that children would correctly name the parts stimulated, i. e., the cheek and hand, but then point to both cheeks, or to two places on one cheek. It seemed as if naming the locus yielded more accurate responses than did pointing.

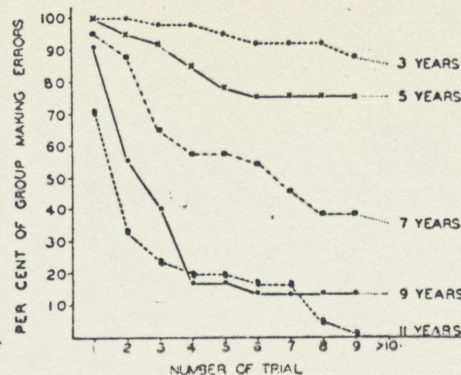
These tactile tests were repeated on consecutive days, or subsequently after a lapse of a few days or weeks in some children. At such times, cutaneous stimuli other than light touch were added to the testing. These included repetitive touch (rubbing), single pin prick, and repetitive pin pricks.

RESULTS

Incidence of errors: Young children made many errors on face-hand tests. Eighty per cent of children under the age of six failed to localize both stimuli



Graph 1.



Graph 2.

during the initial ten trials of the face-hand test; many of these even with eyes open. In the older children the number of failures fell sharply (graph 1) so that only 2 per cent of children in the 11 to 15 year age groups continued to make errors after the initial ten trials. Apparently the ability to identify two simultaneously applied tactile stimuli was directly related to the age of the child. This ability was also related to the number of previous trials of the face-hand test. In table 1 the trial of the test after which the child was consistently correct is recorded. The last column of the table includes all the subjects who made errors in the first ten trials, and on many trials of the test beyond the tenth. Graph 2 illustrates this relation for selected age groups.

Type of testing: In these studies homolateral and heterologous stimulations were carried out at random. Errors were made by subjects of all age groups in tests of either type. Homologous tests, such as both cheeks, or both hands, randomly interspersed in the testing after the fourth trial, elicited correct responses in nearly all cases. While this served as a clue to some of the older

TABLE 1
NUMBER OF TRIALS OF THE FACE-HAND TEST NECESSARY FOR PERSISTENT
CORRECT RESPONSES
(Touch Stimuli)

Age	Total Number of Subjects	Trial Correct									Errors Beyond 10 Trials
		1	2	3	4	5	6	7	8	9	
3	39	-	-	1	-	1	1	-	-	2	34
4	34	-	-	1	-	2	2	-	1	-	28
5	37	-	2	1	3	2	1	-	-	-	28
6	36	-	-	1	2	5	4	-	2	-	22
7	26	1	2	6	2	-	1	2	2	-	10
8	22	4	6	3	-	2	1	-	2	-	4
9	23	2	8	4	5	-	1	-	-	-	3
10	20	2	6	5	4	-	1	-	-	-	2
11	21	6	8	2	1	-	1	-	2	1	0
12	24	3	7	4	6	1	-	1	-	-	2
13-15	29	4	10	6	4	2	1	-	-	2	0

children that two stimuli were being applied, it did not seem to alter the results in the younger children. In these subjects subsequent trials of the face-hand test were incorrectly reported, even though the responses to the symmetric stimuli had been correct. The perception of symmetric stimuli was much better than asymmetric stimuli.

Subsequent testing: Of the total group of children studied, face-hand tests were repeated at varying intervals subsequent to the initial testing in 10 children. Of the children under the age of six, subsequent testing elicited the same difficulties with face-hand tests as was evident on the initial examination. In a few children over six years of age, who seemed to have grasped the concept of two stimulations in the initial testing, errors were manifest on subsequent days. It was as if many trials were necessary for successful learning of the task, and then, even though the task was successfully completed, the learning was temporary. These observations are in contrast to those made in normal adults, in whom subsequent testing did not elicit the errors of the initial test.¹

Type and pattern of responses: The errors (table 1) made by children on repeated trials of the face-hand test were of six types: (a) a touch on the cheek only, implying no perception in the hand; (b) a touch on each cheek, implying a mislocalization of the stimulus applied to the hand; (c) a touch on the cheek, and a second touch on the shoulder, neck or elbow, implying partial mislocalization of the stimulus applied to the hand; (d) a touch on the hand only, implying no perception in the cheek; (e) a touch on each cheek and implying a mislocalization of the cheek stimulus to the hand; and (f) one or two touches on the examiner's body, implying a mislocalization away from the child's body.

Face dominance (responses *a, b, c*) was apparent in all age groups. It was most manifest as extinction^o of the stimulus to the hand (response *a*), and was seen in 62 per cent of the errors. Mislocalization of the hand stimulus to the cheek (displacement) was observed in 31 per cent of the errors. While most of the displacements were observed in tests involving cheek and hand on opposite sides of the body, 7 per cent of the errors were displacements from the hand to the cheek in the simultaneous stimulation of homolateral body parts, e. g., right cheek and right hand. At such times the child pointed to the cheek once, saying "a touch here," and then, moving his fingers 2 to 3 centimeters lower on the cheek, saying "and here."

Other types of displacement were infrequent. There were partial displacements from the hand to the shoulder or neck. Mislocalization of a stimulus across the midline of the body, known as allesthesia,³ was occasionally apparent in the stimulus to the hand on heterologous testing. Furthermore, children

¹The failure to report one of two simultaneous stimulations has been called "extinction" of a stimulus.² The mislocalization of a percept to the homologous body part of the second stimulus is called "displacement." The mislocalization of a percept in the direction of the second stimulus is called "partial displacement." In each instance, the stimulus which is correctly reported is said to be "dominant."

under five years of age frequently mislocalized the initial stimulation away from their body to parts of the examiner's body or into space (response *f*). This phenomenon, known as exosomesthesia,⁴ persisted in some children despite repeated stimulations with the child's eyes open, and despite the examiner's insistence that it was the child who had been touched.

Another phenomenon was seen during homolateral testing. The child reported only the stimulus applied to the cheek. If the examiner asked insistently, "Did you feel another touch anywhere else?", a number of children hesitatingly pointed to the symmetrical point in the cheek on the opposite side of the body. In order to determine whether this was a unique or a systematic phenomenon, tests of other body parts were carried out. In homolateral tests of foot and hand, shoulder and hand, and cheek and foot, the same phenomenon was observed. The child first reported only the foot, the shoulder or the cheek—and then, when the examiner insisted on a second locus, pointed to the opposite foot, shoulder or side of the face.

Furthermore, in some young children the phenomenon appeared on single stimulation. Single stimuli applied to any body part were localized correctly. If the examiner then insisted that there had been a second stimulus, the child pointed hesitatingly to the symmetric part on the opposite side of the body.

As already indicated, hand dominance (responses *d* and *e*) was infrequent. It was observed in 7 per cent of the errors on face-hand tests. In all subjects in whom it was apparent, subsequent trials of the face-hand test manifested the pattern of face dominance.

Relation of hand and foot: In tests of parts of the body other than the face and hand, the hand was always least dominant and the cheek the most. Simultaneous tests of foot and hand, the foot-hand test, were introduced after the initial ten trials of the face-hand test in most children. In the foot-hand test, foot dominance was apparent in 51 per cent of the responses (see table 2). It was demonstrated by hand extinction, by displacement of hand stimuli to the foot, and by partial displacement to the thigh, knee and leg.

TABLE 2
FOOT-HAND TEST
(Touch Stimuli)

Stimulation	Total Trials	Responses					
		Correct	Foot	Hand	Foot- Foot	Partial Ft.-Ft.	Hand- Hand
Bilateral	53	21	17	1	10	2	2
Ipsilateral	48	23	16	3	3	3	0

Other stimuli: A small group of children who made errors in tests repeated at varying intervals were examined with other cutaneous stimuli. Extinction and displacement phenomena were present in face-hand tests using pin prick, repetitive pin prick and repetitive touch (rubbing) stimulations. While the number of errors with these stimuli were fewer than with touch stimuli, the

pattern of face dominance and hand extinction was still apparent.

DISCUSSION

The ability to identify and localize simultaneous stimuli separated from each other at some distance is a complex function which gradually develops during the first decade of life. It is a relatively unstable ability, for many changes in the state of the organism can disturb such discriminations. Focal cerebral disease as in hemiplegia⁵ or parietal lobe lesions,² spinal cord lesions,² and diffuse brain diseases such as toxic states, senility and inflammatory conditions⁶ can so alter tactile discrimination that the phenomena of extinction and displacement become prominent. Errors in simultaneous tactile tests are apparent in normal adults during the initial few trials of the test—during the period of learning.¹ Persons subjected to large doses of barbiturates,⁶ electroshock therapy⁶ or anesthesia⁷ also manifest such inability.

A prominent feature in all groups is the uniformity of face dominance. When discrimination of simultaneous stimuli is interfered with, for whatever reason, the errors are made in the stimuli to the hand and not in the stimuli to the face. The corollary of "face dominance" is "hand extinction." It, too, is apparent in all subjects and under the variety of conditions studied. Furthermore, in an "order of dominance" other body parts are between these two limits. Studies in patients with hemiplegia⁵ and patients with severe mental changes as a result of brain disease⁶ have revealed an order of dominance of face-shoulder-trunk-thigh-foot and hand. Insofar as these other body parts were studied in these children, a similar order was observed. Since dominance is evident in young children, it appears that the pattern of dominance is an inherent function of the organism. This childlike way of responding to simultaneous tactile stimuli is exposed and exaggerated in adults under a variety of pathologic conditions.

Recently Cohn has suggested a theory of rostral dominance to explain these observations.⁸ Our observations are not in accord with such a theory. The dominance of the foot to the hand in children, as well as the dominance of penis, buttock, foot and thigh to the hand in two large series of patients with diffuse brain dysfunction,^{6,9} make such an explanation untenable.

Comparison of findings in normal children with findings in patients with organic mental syndrome: On comparing the findings in children with those previously reported in patients with severe mental changes due to brain dysfunction,⁶ a close similarity in performance is observed. In both groups the ability to discriminate simultaneous stimuli is limited. On non-homologous tactile tests, such as the face-hand test, errors are made on initial and subsequent trials. While extinction of a stimulus is the most frequent error, displacement is common. In both children and patients, errors occur with a variety of cutaneous stimuli. Furthermore, testing may frequently be done with eyes open, and in many instances with repeated verbal clues that there are two stimuli, and still errors are made. The factor of learning is not prominent since testing on subsequent days will elicit the previous patterned errors.

In Gestalt terms, patients with organic mental defects and children have difficulty in extracting a complex sensory "figure" from the "background" of the total sensory "field." Significantly in each group there is no difficulty in identifying simultaneous stimuli if the stimuli are applied in symmetric regions of the body, such as each hand or both sides of the face. Here, each stimulus figure has a common background in terms of body image, namely the hand.¹⁹

Face dominance is apparent in both groups. It is manifest not only on tests of face and hand but also on tests of face and other body parts. Also, insofar as it was tested, the order of dominance for other body parts is similar.

While extinction and displacement are the most frequent types of error, other phenomena are elicited in both children and patients. Partial displacements, e. g., the mislocalization of the percept from the hand to the shoulder or neck on the face-hand test, are occasionally observed. The phenomena of allesthesia and exosomesthesia are seen in the more severely affected patients and in the youngest children; both are frequently associated in the same subjects. In allesthesia, the subjects usually localize the cheek stimulus correctly but mislocalize the hand stimulus to the opposite hand or elbow. In exosomesthesia, the stimuli are mislocalized either to space in front of the subject or to the examiner's body. This phenomenon was frequent in the youngest children, and despite the examiner's urging that the child point to its own body, the child persisted in such mislocalizations until a trial of the face-hand test was performed with eyes open.

In addition to these phenomena which appear spontaneously, patients with organic mental syndrome also manifest another response to simultaneous stimulation first noted in children, i. e., on homolateral testing only one stimulus (the cheek) is spontaneously reported; but when the examiner insists, the second is mislocalized to the opposite cheek. Since the patients show so many similarities to young children in their responses, it was predicted that they would also show this phenomenon. In a series of patients with severe mental changes, homolateral tests of the cheek, hand, foot, shoulder and thigh were applied. When only one stimulus was reported, the examiner asked for the locus of the second stimulus. Responses were obtained in 20 per cent of the patients, and in each one the second stimulus was mislocalized to the symmetric body part. Furthermore, in some subjects the same phenomenon was observed with single stimulation.

This phenomenon appears to be similar to the completion phenomenon described in Gestalt literature as "closure" and "good continuation." These are usually described for other sensory modalities. When a circle is tachistoscopically exposed in the visual field so that half falls on a hemianopic field, or if a cross is exposed so that the center falls in the blind spot, many subjects report a complete circle or cross. This "completion" occurs for "good" figures. In simultaneous tactile studies, symmetric figures appear to be the "good" or "strong" figures.

CONCLUSIONS

1. Ability to identify and localize asymmetric simultaneous tactile stimuli develops gradually during the first decade of life, and is present in 80 per cent of normal children by the age of eight. Symmetric stimuli are more readily localized and this ability is well developed in normal three year old children.

2. The errors on asymmetric (bilateral and ipsilateral) stimulation involve either extinction (only one of the two stimuli is reported), or displacement (one or both stimuli are mislocalized). Whenever extinction and displacement occur, stimuli to the face tend to be correctly reported. This face dominance is found at all age levels tested.

3. One can conclude that extinction and displacement of tactile stimuli, as well as face dominance, constitute a normal and consistent pattern of response in children. In addition to these responses one can observe, in children under six years of age, the phenomena of allesthesia, exosomesthesia and partial displacement as normal reactions to simultaneous tactile stimulation.

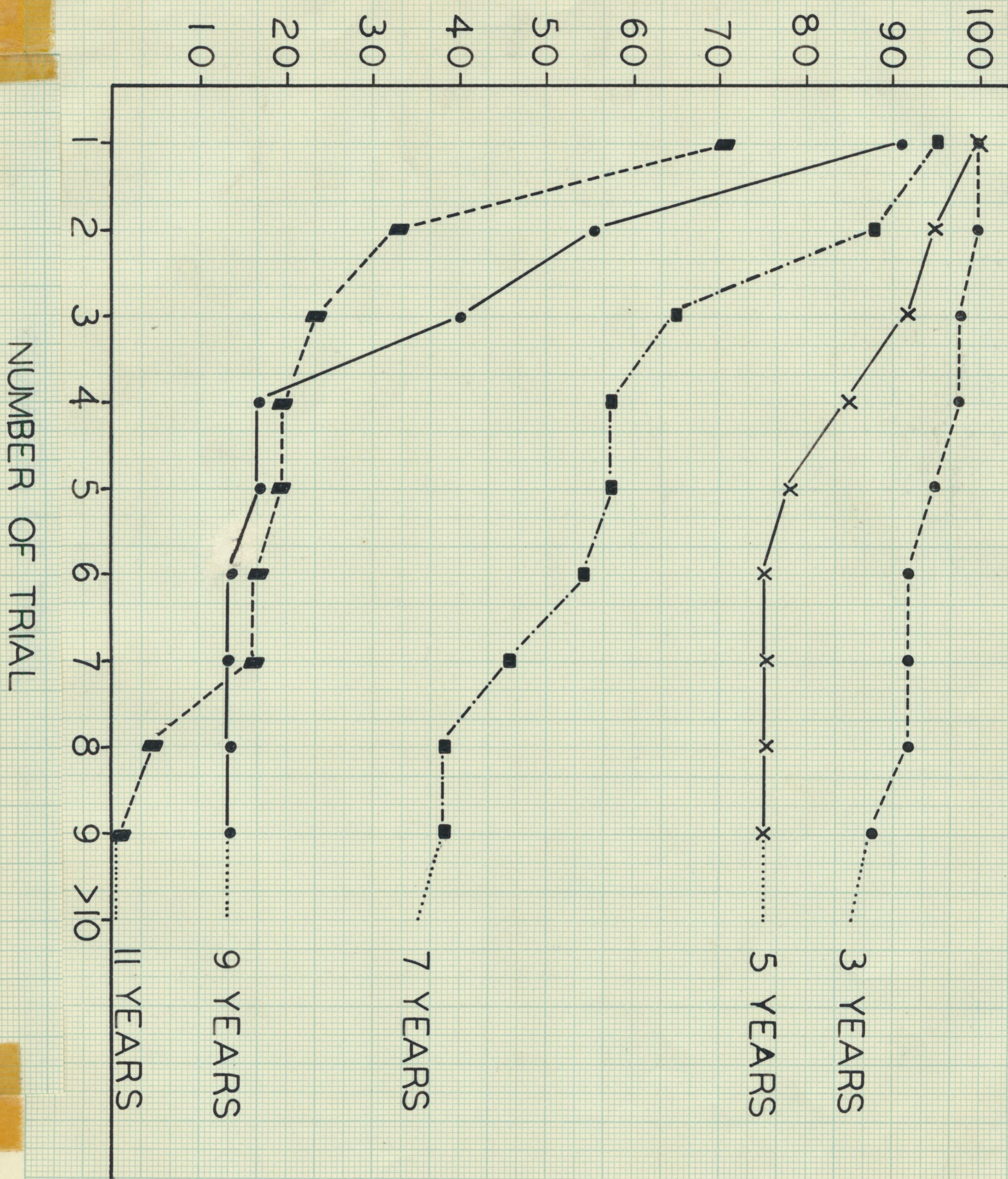
4. The difficulties in recognition of simultaneous tactile stimuli, as shown by young children, reappear in the same fashion in adult patients with focal or diffuse dysfunction of the brain. The abilities of tactile discrimination acquired by the child during growth are lost by the adult who develops mental changes as a result of cerebral damage.

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DSS - Diagnosis
Perception (Tactile) - Normal

PER CENT OF GROUP MAKING ERRORS



Per Cent of Children by Age Groups Making Errors on Successive Trials of Face Hand Tests