

LOSS OF SPATIAL ORIENTATION, CONSTRUCTIONAL APRAXIA AND GERSTMANN'S SYNDROME.

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IN recent years important additions to the knowledge of the symptomatology in cases with involvement of the parietal lobe have been made. Both constructional apraxia (Kleist, 1922) and Gerstmann's syndrome, consisting of finger-agnosia, disturbance of right-left orientation, agraphia and acalculia (1924) have been related to lesions of the angular gyrus of the dominant hemisphere. Before the description of those symptoms, a loss of spatial orientation had been described in cases with lesions of the same localization. Balint (1910), Riddoch (1917), and others had observed that symptom in single cases, but the most comprehensive description was given by Gordon Holmes (1918), who studied it in a case-material of war injuries. When Holmes and his co-workers published their observations, constructional apraxia and Gerstmann's syndrome were still unknown. Loss of spatial orientation as a fully developed symptom is rare, while the other two disorders are not uncommon. For this reason the psychopathological relationship of those symptoms is still insufficiently understood. The following case offers an opportunity for studying the problem:

Mrs. F. M.—, nurse, aged 40, was admitted on May 14, 1943. She had been healthy until August, 1937, when in the fifth month of her first pregnancy she fell ill with eclampsia. Premature labour was induced. On the following day she could not talk or respond to questions put to her. After a week she began to talk, though she had difficulty in finding words. The patient recovered her speech during the following months and since 1938 her condition has been stationary. Ever since the onset of her illness she has been unable to find her way about. She ran into things, as if she could not see. Reading and writing were gravely impaired. Since 1938 she has had occasional fits of the major epileptic type, the last one 18 months prior to admission.

The patient, who was a most co-operative and willing witness, corroborated those statements. Her speech was intact except for an occasional slight difficulty in word-finding. She always named objects correctly. In conversation no impairment was noticeable. Memory and retention were unimpaired, provided the tests did not imply spatial orientation or the use of numbers. Her general physical condition was satisfactory. Respiratory and cardiovascular systems healthy, B.P. 150/90. Apart from exaggeration of the knee and ankle jerks, right more than left, and the symptoms described below, the neurological findings were negative. Acuity of vision normal; fundi normal; no defects in the visual fields tested on the Bjerrum screen. Blinking reflex either diminished or absent both sides. No ocular palsy. The accommodation for near objects was often lacking; the patient as a rule failed to converge on approaching objects. She did this, however, quite well when the object was her finger or when she looked at the tip of her nose.

The patient moved about slowly and cautiously, like a blind person who is moving in completely strange and even dangerous surroundings. However, she did not use her hands freely to find her way with the help of touch. She usually kept her arms bent, and used her hands only for touching near objects. She was constantly afraid of knocking into things—which actually happened on many occasions. When asked to sit on a chair she often sat beside it, taking up a squatting position. She could sit down only after she had orientated herself with the help of touch. Her ability to estimate distances was severely disturbed. In trying to grasp objects she usually underestimated the distance. In walking up and down steps she had to feel her way with the tips of her toes and missed both the height and depth of the steps. She was generally unable to orientate and localize correctly in space objects which she saw. She committed errors in pointing to an object that was in her central vision, and failed even more when the object was in the periphery of her visual fields. This defect could be observed in all actions of her ordinary life in which she relied on visual guidance. She had no difficulty in localizing by touch. She brought her finger to any point of her own body that was touched by the examiner,

but when the stimulus was of the nature of a stroke she failed in recognizing its direction and extension. She equally failed in appreciating the correct sites of two or more simultaneous or successive stimuli on her skin. She was at a loss when requested to point to corresponding parts of another person's body. The patient did not as a rule confound above and below in her ordinary behaviour.

In addition to the disturbance of absolute localization, i.e. the ability to determine the position of objects in space in relation to herself, there was a disturbance of the relative localization, i.e. the ability to estimate correctly which of several objects was nearer to her. The appreciation of length and size was defective. Lines of different sizes appeared equal to her unless they were parallel. She did not fail, however, when the difference was very considerable. She could not demonstrate the length of familiar measures, such as a yard or an inch. Estimation of weights was equally disturbed, but when requested to compare two weights she could say which was the heavier one. The patient was unable to survey a multiplicity of objects. She could see at a time only one and sometimes two of several objects, but she was unable to state their number when it exceeded three. The topographical memory was gravely impaired. The patient lost her way in the ward and hardly ever found her bed in the dormitory. She could not give a description of the situation of her bed or the furniture in the room. Though she could describe correctly single objects shown to her, she failed when requested to visualize and describe familiar objects. When asked to describe the human body she named the extremities, but was unable to say what was between the upper and lower limbs. She equally failed when describing a tramcar, etc.

The right-left orientation was disturbed. When asked to turn to either side or to point to objects on her right or left she failed. However, she turned in the direction of a sound without error, though she was unable to point to the direction from which it came. The recognition of movements was defective. She was uncertain whether an object approached her or receded from her. This difficulty was responsible for her helplessness in traffic. The size of the object and its relation to her visual axis did not seem to make an appreciable difference. Vision in depth, though inaccurate, was not grossly disturbed. She never described a tridimensional object as flat.

The orientation on her own body was intact, except for the right-left orientation and the fingers and toes. While she was able to point to her eyes, her nose, shoulder, etc., and could name them without difficulty, she was unable to do so when individual fingers or toes were concerned. However, she never failed to recognize them as fingers or toes. She sometimes succeeded in naming the thumb and little finger. Naming, recognizing and presenting a particular finger were equally impaired, and the same applied to other persons' fingers and toes. She was unable to perform specified movements of her fingers to order or to imitate such movements. The same difficulty was encountered when she had to carry out to order or imitate movements with the arms and legs. She appeared to be unable to operate with her extremities in space, and this difficulty was obviously responsible for her inability to carry out certain purposeful movements.

Two sets of matches were laid out, each consisting of 5 which were either parallel or converging like the fingers of the hands; the patient was requested to choose one particular match, e.g. the middle match of the right set, etc. In this test she was equally helpless as when requested to choose a particular finger on her own or another person's hand or on a diagram of a hand. She also failed when she had to choose between the matches of one set only.

On examination for apraxia the patient succeeded in carrying out actions to order, except for those in which the orientation in outer space and the position of her extremities played a prominent part, e.g. when asked to carry out a military salute or to beckon or wave to a person she raised her extended hand and fumbled about helplessly. Her ability to recognize and use objects when shown them and the representation of the use of objects without seeing them was undisturbed, but there, again, difficulties arose when the position of objects in space was involved. In addition, she showed difficulties in handling a multiplicity of objects. Specimen responses: Use of key with and without object—correct. Button and unbutton a coat—correct. Lighting a cigarette in the examiner's mouth—movements correct, but she was unable to find the tip of the cigarette though she saw it. Putting on spectacles—correct on herself, but she failed in putting them on the examiner's nose owing to her inability to bring them into correct position. Shuffling of pack of cards—she was unable to hold the cards correctly in space. She failed when requested to demonstrate playing on an imaginary violin. When asked to hold her hands in prayer attitude she held them in the horizontal plane. Expressional movements were carried out correctly. The patient was unable to lay the table; she never succeeded in laying the cloth correctly and in putting knife, fork and spoon in their proper places. The actions carried out with the left hand nearly always presented a mirror image of her right-hand actions.

Constructional tests.—The patient was incapable of laying even the simplest geometrical figures with matches or bricks, or of copying such figures. When requested to copy a simple angle she would on occasion succeed, but its position in space was always wrong and often her construction represented a mirror image of the original one. She could not lay to order or copy a closed geometrical figure. As a rule she used both hands in those constructions. When requested to use one hand only she was even more helpless, irrespective of which hand she used. The right-hand work was always different from that of the left hand, the latter usually presenting a mirror image of the former. Her performances in these tests were very inconsistent.

Drawing.—The patient was unable to draw simple objects and figures, and she equally failed in copying drawings. When trying to copy simple lines she drew them in a wrong position in space, mixed up above and below, and usually produced something smaller. She sometimes succeeded in drawing a circle or oval, but always failed in drawing a figure consisting of several strokes. The perpendicular lines drawn by her were usually slightly sloping to the right when drawn by the right hand and to the left when drawn by the left hand. Asked to draw a compass she drew a triangle. When requested to fill in the missing part in a sketch of a face she first failed to recognize that anything was missing, and when this was pointed out to her she was unable to put the missing part in its proper place. When trying to connect two dots by a straight line she succeeded only when she put a finger on the dot she was aiming at. In attempting to copy Roman block letters she succeeded only with those which consisted of one line, such as I, S or O, but she failed when the letter consisted of several strokes, such as E, T or A. Then she produced a few strokes disconnected with each other. In drawing, too, the left hand usually produced a mirror image of the right. There was not only mirroring in the right-left axis, but also in the perpendicular and other planes.

Whenever a task involved the conception of right-left the patient was embarrassed and often asked, "What do you mean?" Her behaviour suggested that that conception did not exist for her. When asked whether the heart was on the left or right her first reaction was to put her hand over her heart, but she was at a loss to answer the question correctly. As a rule she made a guess whereby she more often described an object being on her right. She often would say first, "It is near."

The patient's knowledge of the relative position in the vertical axis of parts of the body or of familiar objects was unimpaired. She would point with approximate accuracy to the top and bottom ends of a long stick. However, she consistently failed when confronted with simple geometrical units. When asked which of two dots or strokes was above or below the other she was at a complete loss, and it was obvious that under those conditions the conception of above and below had no meaning to her. This was evident in drawing and construction. Her performance showed certain consistent features. When asked to draw a vertical line upwards or downwards she did it correctly, apart from the slight sloping. Requested to draw an arrow pointing upwards with either hand she drew a vertical line upwards, but consistently added the acute angle forming the head of the arrow on or near the bottom end of the line. When the arrow was to point downwards the head was put at the upper end.

The patient was completely at a loss when she was shown on the blackboard or on paper a horizontal line with a dot or cross above or below it and was asked to describe their relative positions. She was equally helpless when, instead of a dot, a coin was used. Specimen responses: A dot 2 in. above the horizontal stroke. (Examiner: "Is the dot above or below the line?") "It is near." Dot 2 in. below the line: "This one is higher than the stroke; no, it is nearer." A sketch of a house is drawn on a horizontal line. The patient recognizes the house at once: "It is under the line." ("What does that mean?") "I don't know." When told to imagine that the line was the ground on which the house stood, she said quickly, "The house stands as it ought to be," but she was still unable to say whether it stood on or under the line. The patient was quite unable to point out the directions of the compass on a map. When asked to point out north, south, etc., she pointed somewhere to the centre. She also failed in reading the time from the clock face whereby mirror-mistakes were noticeable, e.g. 2.40 was read as 20 to 3, 12.55 as 5 to 11, etc.

Writing.—The patient could write a short letter spontaneously, choosing mostly monosyllabic or di-syllabic words of a familiar nature, but she was unable to write successive words in a straight line. The words were written either successively higher or lower. When given a sheet of paper she would start anywhere and write successive words somewhere at random, often over the margin of the sheet. On many occasions she wrote one word over the other. The configuration of individual letters was correct except for those which make more than one single movement necessary. She failed in crossing her t's and dotting her i's. The t stroke or the dots of the i were found at the end, under, or in the middle of the word. The number of m and n strokes was often incorrect. The spelling was gravely impaired, especially for polysyllables, e.g. "moth, nouth" for mouth; "recest" for recent; "intesten" for interesting; "ontonaygyi" for occupied; "Jornburn" for Jordanburn; "longeh, lonthoho" for livelihood, etc. The spelling corresponded closely to the writing. Only words which were written correctly were spelled without mistakes. It was never possible to improve the written spelling by making the patient spell orally.

The patient was quite unable to put even the simplest words together from single block letters. She could not arrange them in the correct position and sequence, and failed in the same manner as in constructional tests. She was equally helpless in arranging single digits to a higher figure.

With the left hand the patient *mirror-wrote* in a rather imperfect manner, though fluently. She was quite unable to write normally with the left hand. She had never tried mirror-writing before, and was greatly surprised at her inability to write with the left hand in the same manner as with the right.

Single digits were written correctly except for the 5, the upper horizontal stroke of which was put somewhere to the right of the main part of the figure in writing with the right hand and to the left when she wrote with the left hand.

Writing on a line.—When asked to write on a horizontal line either on the paper or on the blackboard the patient always wrote below the line when writing with the right hand and always mirror-wrote above the line when using the left hand. When the line was vertical and she was requested to write on it she never turned the paper, but always wrote with the right hand at the right side of the line starting near it, and with the left hand she mirror-wrote away from the left aspect of the line. The same happened when the line was oblique. When asked to write under the line she did just the same as when asked to write on it. The conception of above and below did not seem to convey anything to her under those conditions. Closing of one eye made no difference. The patient always spontaneously expressed dissatisfaction with her performance, but could not explain what was wrong. When asked whether a word she had written was above or below the line she was unable to answer that question, but only said, "It is near the stroke."

The patient failed completely in typing, though she had been a good typist prior to her illness. She found individual letters only after a long search, and was unable to type even very short words.

Reading.—The patient could, as a rule, read single words correctly, irrespective of the number of their syllables, but she could not read consecutive words in their context with others. In this she sometimes succeeded when a short isolated sentence in big print was presented to her. Otherwise she left out words. When she had to read print in a book or newspaper she could not keep to the lines, but picked out words from consecutive lines at random. When the examiner pointed to the word following one she had just read this did not help her, nor could she point to it accurately herself. When requested to read a single word to which the examiner was pointing with his finger or a pencil she as a rule read some other word in the neighbourhood. The patient was aware of her inability to read normally. In fact, this was the symptom she felt most keenly.

Sometimes she failed even in reading single words, though she had grasped their meaning. The following specimen responses were typical of that deficiency. (Negative films): "Negative—I know what it is but I cannot say it. It is what you send to the Infirmary." When told the word she exclaimed, "Of course I knew it." (Leslie Howard): "He is a well known actor, but I cannot say his name." (Farm labourer): "Farm—it is not worker, but something like it." The patient was quite unable to read even short words backwards. The reading of numbers will be dealt with in the paragraph dealing with calculation.

The spelling of read words was often faulty. The patient mixed the letters up, putting them in the wrong sequence and often inserting letters which did not appear in the word. The patient understood the meaning of punctuation signs and common abbreviations.

Reading and writing of figures; counting; calculation.—The patient could read simple digits correctly and rarely failed in reading numbers below 20. With higher numbers she frequently made mistakes, mixing up the order of the digits; 43 she would read as 34, etc. Such mistakes became more obvious in figures of 3 and 4 digits. She seemed to succeed more often when the digits were written closely together than when there was some space between the digits constituting a higher number. She made similar mistakes in writing numbers. Single digits were written correctly, apart from the difficulty in writing the 5. In higher figures the position of the digits was often faulty and sometimes she would even write completely wrong digits, which on closer analysis proved to be the result of a tendency to write according to the spoken word or to perseveration, while in some she wrote wrong digits at random. The following specimens, written on dictation, illustrate these mistakes: 525 for 225; 755 for 754; 116 for 816; 10050 for 1450; 10044 for 1040, etc. When requested to put single digits written on cards together to a figure of several digits she failed in the same way as she did in putting together words from block letters. She could not read or write decimals; she treated them like other figures without taking notice of the decimal point.

Counting in normal sequence was correct up to 20, after which she left out numbers and got completely mixed up. She could count back only from 10 to 1. Asked to count from 1 to 20 leaving out every second number she made only one or two mistakes, but failed completely from 20 upwards.

The patient was unable to carry out in writing or orally even the simplest calculations, e.g. $11 - 3 = 7$, $7 - 5 = 11$, $3 \times 16 = 16$, $12 - 4 = 3$, etc. She was puzzled by the signs, and would often mistake plus for minus. She read the multiplication sign as the letter x and did not appreciate the meaning of the fraction stroke. She was unable to do everyday sums with pennies or shillings. The sense of numbers appeared quite generally affected. She estimated the population of London at about 100,000.

The patient could not count correctly more than three objects. When asked to count five flowers standing in front of her she said either three or four. She always under-estimated. The difficulty in counting objects was obviously co-determined by the difficulty in surveying and exploring surfaces. This was shown by the fact that she did not succeed in pointing successively to each of several objects in front of her, while to some she would point twice.

In memory tests she failed in reproducing numbers in the same way as she did in reading and writing tests. Her memory was not impaired otherwise.

Sorting tests.—There was no difficulty in sorting objects according to colour, material and practical use, but the patient failed when trying to sort objects according to their shapes and sizes.

Musical sense and sense of rhythm.—The patient had never been regarded as musical nor had she learned to play an instrument. She recognized familiar songs without difficulty, and she did not fail to notice when they were played or sung out of tune. She could sing folk-songs correctly unaccompanied or accompanied. She failed, however, in imitating simple rhythms. She missed the number of bars as well as the rhythm.

Awareness of the deficiencies.—The patient was fully conscious of all her deficiencies. However, the knowledge of her inabilities did not help her, though she was most anxious to do well and to correct her mistakes. As a rule she was satisfied when she had succeeded in the task.

Progress notes.—The patient remained in hospital for three months, during which period she had systematic training in writing and reading. When she left her writing had somewhat improved, especially with regard to the spelling, but on the whole there was no material change.

DISCUSSION.

The most remarkable feature of this case was the combination of loss of spatial orientation, constructional apraxia and Gerstmann's syndrome. Each of those disorders has originally been described as an isolated feature. This case, in which they were united to one master syndrome, suggests that they have a common denominator which has not presented itself equally clearly in the cases reported in the literature. The symptomatology of this patient has much in common, though it is not identical with that of the cases of constructional apraxia studied by Mayer-Gross (1935, 1936). There is, at least in this case, no doubt as to the leading symptom, which is the loss of orientation in space. The question arises which is the basic disorder underlying that deficiency. According to Holmes there is in those cases a loss of the local signature of visual impressions. Considering that many other functions besides that of visual localization are disturbed, the loss of the local signature of visual impressions cannot be regarded as the primary deficiency. Holmes's cases, like those of other authors and the case described here, had disturbances in writing, reading and calculation, and it is very likely that, had they been examined for constructional apraxia and Gerstmann's syndrome, those disorders would have been found to be present. Balint (1910) and Holmes (1918) attributed great importance to "the loss of visual attention," expressing itself in the inability to focus more than one object at a time. However, it is doubtful whether one is justified in describing those patients who are always aware of their deficiency and try their best to overcome it as inattentive. The analysis of their various disabilities invites a different interpretation. For acting purposefully in our environment it is necessary to comprehend the outer world as it presents itself visually as an organized whole, wherein objects are related to each other and to ourselves according to certain laws learned by experience. From the total of that environment we relate by a process of abstraction certain parts to each other and to ourselves. Thus, in the terms of the Gestalt psychology, purely geographical environment becomes behavioural environment (Koffka, 1935). The patients with loss of orientation in space seem to be unable to perform the above process, with the result that a single object apparently unrelated to its environment seems to absorb their whole attention. They behave like infants in that early stage of development in which the spatial relations of external objects have still to be learned by experience. In that stage the infant begins to build up the knowledge of the organization of the outer world by first relating single objects to himself only. There is in those patients no loss of visual attention, but an inability to direct and spread it in a purposeful manner.

A fuller understanding of this patient's behaviour can be gained by considering not only her deficiencies in terms of negative symptoms, but by analysing the actual performances and thus arriving at the positive symptoms in Jackson's sense. This patient had replaced the complex organization of spatial relations in the environment by a very primitive one. The only measure in that system is nearness, which she tried to estimate by the aid of touch. She was constantly afraid of objects which might be too near and endanger her physical safety. This primitive conception of spatial relations also appeared, possibly by a process of projection, in her notions of spatial relations of external objects to each other. Here, too, nearness was the only relationship which she could comprehend. She could not arrange objects according to other rules. She could only put them close together.* It has often been noticed that patients who showed a similar type of agraphia as this case would scribble words together in a

* The Gestalt psychologists have described the primitive tendency to group objects closely together (Köhler, 1935).

narrow space and over each other. Mayer-Gross (1935) has drawn special attention to this feature, which he called the "closing-in symptom." The primitive conception of space in which objects are only related by proximity explains this behaviour. It also may have been partly responsible for the consistent peculiarity which this patient showed when requested to write on a line. In that task there were two given points of relation, the one her own body, the other the line. By writing under the line she placed the written words nearest to both those objects while the writing with the left hand represented a mirror image of the right-hand writing. In addition, it seems likely that here the same mechanism was at work which forced her into mirror-writing and mirror-acting, and that a stroke represented the line of demarcation between the right and left activity spaces.* This became clear when the line was turned from the horizontal into the vertical plane, and the spaces below and above the line became the spaces to the right and left of the line respectively. That test demonstrated the presence of a strong tendency towards keeping apart the right- and left-hand activity spaces, viz. of an inability to fuse them into one. Possibly some awareness of the midline of the body was projected into the outer world. Schilder (1935) has pointed out that the awareness of the midline is often very strong in patients with brain lesions, and makes them hesitate to cross the midline in their activities. The mirror-writing and mirror-acting in our case suggests that under certain conditions of brain lesion the activity spaces of the two hands are strictly separated, and that obligatory mirror-writing may be due to the inability on the part of the left hand to adopt right-hand activities. The inability to fuse right- and left-hand actions must have a disturbing influence in all activities where success depends on such a fusion. The analysis of similar cases may throw light on the understanding of the physiological mirror-writing which, as Critchley (1928) suggested, may be due not only to latent left-handedness, but also to left "eyedness." There were no signs of latent left-handedness in this patient, nor did closing of one eye improve her performance. It would be interesting to apply the test of writing on a line with the right and left hand successively in other cases with mirror-writing and disorder of localization in space.

The constructional apraxia as well as the other features of apraxia which were apparent in this case were clearly derived from the loss of orientation in space as analysed above. It is equally obvious that apractic features in tasks implying the comprehension and control of spatial relations are the result of the same impairment. Those features which do not fit into any of the well-known sub-groups of apraxia may perhaps be fittingly called "spatial apraxia," of which constructional apraxia is an expression. The apractic symptoms which Holmes and Smith (1916) observed, in their case with loss of spatial orientation seem to have been of that order. The dependence of constructional apraxia on space disturbance has been stressed by van der Horst (1934) and further elaborated by Mayer-Gross (1935, 1936), who studied the relations of that symptom to visual agnosia and to apraxia in Liepman's sense.

The problem of the psychopathological significance of Gerstmann's syndrome has given rise to a good deal of speculation. It is not intended on this occasion to quote the very considerable literature on that subject. The reader is referred to the bibliography provided by Gerstmann in his recent articles (1940, 1943). Gerstmann maintains that finger agnosia is primarily a specific type of autotopagnosia, i.e. a loss of body orientation restricted to the fingers. However, it is worthy of note that in cases of finger agnosia typical features of autotopagnosia involving other parts of the body never appear. Schilder (1935) has drawn attention to the fact that, apart from finger agnosia, autotopagnosia has been observed only in cases with diffuse brain lesions ever since it was described by Pick (1898). The fact that finger agnosia as a rule appears together with constructional apraxia suggests that it is the result of a space disturbance rather than a primary symptom. Lange (1930) attempted to deduce finger agnosia from the loss of the category "direction in space." Our patient presented a typical finger agnosia which extended to the toes, while otherwise the body orientation was intact. The orientation for fingers and toes was affected in the same way as the orientation for external objects. Lange (1933) and Muncie (1935), in discussing finger agnosia, have drawn attention to an interesting conception of Grunbaum (1930). This author, in review-

* The term "activity space" as describing the sphere in which an action is carried out was introduced into clinical nomenclature by Mayer-Gross (1935).

ing apractic phenomena, postulated a concrete and abstract activity in personal space and outer space. The automatic activities of healthy people recognize no frontier between the two. The hand holds a peculiar intermediate position between the two spaces. It belongs to the "dynamic body scheme," but is at the same time something comparatively independent, acting outside the body, connecting personal and outer space. This conception states clearly the peculiar position of the fingers, which in acting become to a certain extent external objects. The analysis of finger agnosia in this and other cases shows that there is in fact no agnosia for fingers. The patients never fail to recognize a finger as such correctly, but they are unable to distinguish between them, i.e. to judge their relative positions, just as our patient was unable to do with objects of the outer world or with individual digits forming a higher number. One might speak of a loss of the local value or of the local signature of the individual finger. Finger agnosia is the inability to appreciate the position of individual fingers amongst its fellows, and is an instance of the inability to locate correctly a part of a multiplicity of objects forming an organized whole. That this inability was not confined to fingers was shown by the test with the two sets of matches. The writer has found that patients with finger agnosia generally fail in this test.

The question arises whether we are justified in regarding the disturbance of the right-left orientation as an independent symptom. This also seems doubtful. Patients with such a disorder are unable to relate their hands to each other and to external objects in a scheme of spatial relations. The agraphia, too, can be regarded in this case as the result of the inability to arrange a multiplicity of units in space correctly, and of a secondary tendency towards filling the gaps at random. The spelling mistakes seem to be of the same origin.

The failure to relate a multiplicity of parts of an organized whole to others according to certain rules is responsible for the disturbance of reading which was characterized by the inability to follow the lines. There was in this case an additional feature in the disturbance of reading which deserves special comment. The patient would sometimes be able to grasp the meaning of the word, yet fail in reading it correctly. It can be assumed that normally when reading we instinctively form a general picture of the whole of a word or sentence before we proceed to direct our attention to the constitution of those units. Both those processes are obviously necessary for correct reading. The second involves an operation which was impaired in this patient, so that she was sometimes left with not more than a general idea of the meaning of the word. One can produce a similar failure in normals by exposing in the tachystoscopic experiment a word or sentence for a fraction of a second only.

One of the most interesting features of Gerstmann's syndrome is the association of finger agnosia with acalculia. This combination recalls the fact that the child learns counting and calculating with the help of the fingers. The usage of the word "digit" reflects that connection quite clearly. The fingers present the earliest and most easily accessible example of a multiplicity of objects, and many grown-ups still use them instinctively for simple arithmetic. Strauss and Werner (1939) have demonstrated the coincidence of a mild degree of finger agnosia with a retardation in the development of the primary number concept in mentally defective children. It would, however, be erroneous to derive the acalculia from the finger agnosia, which, as has been suggested above, is itself the result of a more general disorder. It has been pointed out by Bergson and others that arithmetical operation imply some kind of spatial visualization. This can be corroborated by self observations. The patient's mistakes in writing and reading numbers demonstrate that the difficulty lies in the correct assessment of the position of the individual digits constituting the figure. A similar participation of the spatial element may have been responsible for the difficulty in reproducing simple rhythms. The fact that we control our environment chiefly by the sense of vision results in a participation of the spatial element in nearly all perceptive functions and their disturbance by loss or reduction of that element.

It may be argued that the derivation of Gerstmann's syndrome and constructional apraxia from the inability to relate objects to each other in space is not applicable to those cases in which the symptoms appear isolated, without a comprehensive loss of spatial orientation. Considering, however, that in our case those symptoms were quite typical, though clearly parts of a wider syndrome, one is justified in

assuming that in this patient a function was severely affected which in other cases had suffered only partially. Cases such as the one presented in this paper suggest that constructional apraxia and Gerstmann's syndrome, when occurring isolated, are incomplete or abortive appearances of the syndrome exhibited by our case. Clinical experience shows that Gerstmann's syndrome rarely, if ever, occurs unassociated with symptoms of constructional apraxia, which is an expression of a disorder in utilizing space. The view that loss of spatial orientation, constructional apraxia and Gerstmann's syndrome are closely related is strengthened by the anatomical findings reported in the literature. Constructional apraxia and Gerstmann's syndrome were found to be associated with lesions of the angular gyrus of the dominant hemisphere, while in cases with loss of spatial orientation the same localization of the lesion was found bilaterally. It can be inferred, therefore, that the intact right gyrus angularis prevents the full syndrome from developing and allows only parts of it to appear. Why the incomplete syndrome should express itself by constructional apraxia or Gerstmann's syndrome or both is a problem the discussion of which is beyond the scope of this article.

In the absence of anatomical findings no statements on the localization of the lesions in this case can be made. The anatomical findings of Holmes justify the assumption that the symptoms were due to symmetrical vascular lesions affecting the gyrus angularis in both hemispheres. Thrombosis of cerebral vessels resulting from eclampsia is not very uncommon, and the bilateral distribution of localized lesions is often seen in vascular cerebral disease.

CONCLUSIONS.

A case has been described in which a syndrome consisting of loss of spatial orientation, constructional apraxia and Gerstmann's syndrome had developed as a result of vascular lesions in eclampsia. It has been demonstrated that both constructional apraxia and Gerstmann's syndrome are derived from the same basic disorder which underlies the loss of spatial orientation, i.e. the inability of the patient to relate in space objects which form parts of an organized whole to each other and to himself according to rules acquired by experience. The complex spatial organization of the outer world was replaced by a most primitive one, the only measure of which was nearness. It has been pointed out that the basic disorder is responsible for the constructional inability, for the "finger agnosia," for the characteristic disturbances of writing and reading and the acalculia, as well as certain apractic features which do not fit into the known types of apraxia. A special feature of this case was mirror-acting and mirror-writing, which appeared to be the result of an inability to fuse and co-ordinate right- and left-hand activities.

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REFERENCES.

- BALINT, E. (1909), *Monats. f. Psychiatr.*, **35**, 51.
 CRITCHLEY, M. (1928), *Mirror-Writing*, Psyche Min. Monogr., Med. Series, London.
 GERSTMANN, J. (1940, 1942), *Arch. Neur. Psychiat.*, **44**, 398, and **48**, 890.
 GRUNBAUM, A. A. (1930), *Zeitschr. ges. Neur. Psychiat.*, **180**, 385.
 HOLMES, G. (1918), *Brit. J. Ophth.*, **2**, 352, 449, 506; *idem* (1919), *Brit. Med. J.*, **2**, 230.
Idem and SMITH, S. (1916), *ibid.*, **1**, 437.
Idem and HORRAX, G. (1919), *Arch. Neur. Psychiat.*, **1**, 385.
 KLEIST, K. (1922), *Kriegsverletzungen des Gehirns*. Leipzig, 1934.
 KOFFKA, K. (1935), *Principles of Gestalt Psychology*. London.
 KÖHLER, W. (1930), *Gestalt Psychology*. London.
 LANGE, J. (1930), *Monats. f. Psychiat.*, **76**, 129; (1933), *Zeitschr. ges. Neur. Psychiat.*, **147**, 549.
 MAYER-GROSS, W. (1935), *Proc. Roy. Soc. Med.*, **28**, Pt. 2, 1203; and (1936), *ibid.*, **29**, 66; (1936), *J. Ment. Sci.*, **88**, 744.
 MUNCIE, W. (1935), *Bull. Johns Hopkins Hosp.*, **57**, 330.
 PICK, A. (1898), *Arch. deutsch. psychiat. Univ. Klinik, Prag*.
 RIDDOCH, G. (1917), *Brain*, **40**, 15.
 SCHILDER, P. (1935), *The Image and Appearance of the Human Body*. Psyche Monogr., No. 4, London.
 STRAUSS, A., and WERNER, H. (1939), *Am. J. Psychiat.*, **95**, 1215.
 VAN DER HORST (1934), *J. Nerv. Ment. Dis.*, **80**, 645.