Recovery from Early Blindness
A Case Study

by

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Photograph: Tobias cures his father's blindness - Bernardo Strozzi 1581–1644
[The Metropolitan Museum of Art, Purchase 1957
Mary Wetmore Shively Bequest, in memory of her husband, Henry L. Shively]

Foreword

Although it is nearly 300 years since Molyneux posed his celebrated query, interest in the problem of recovery of vision after early and long-standing blindness is of comparatively recent origin. In 1932, Dr. M. von Senden carefully reviewed the literature on the perception of space and shape in the congenitally blind before and after operation and arrived at some important conclusions. In particular, he stressed the slow, laborious and imperfect way in which the perception of form is acquired by these patients and their liability to emotional "crises" as they come to discover the true extent of their disability as sighted persons. Unfortunately, Dr. von Senden's monograph remained little known to psychologists, at all events in this country, and it was not until 1949, when Dr. Donald Hebb published his fascinating book on *The Organisation of Behavior*, that its significance came to be at all widely appreciated. As every psychologist knows, Dr. Hebb placed considerable weight on Herr von Senden's evidence and believed it to throw important light on the nature of visual perception and its development in infancy. Although there is disagreement regarding the interpretation of this evidence, there can be no doubt as to the fresh and stimulating influence which Dr. Hebb's ideas have had upon contemporary psychological thought.

One of the main obstacles to informed discussion of Dr. Hebb's theories has been the inaccessibility of the clinical evidence. This, it is true, has been remedied to some extent by the publication, in 1960, of an English translation of Dr. von Senden's monograph but even so the position is far from satisfactory. It was never the author's intention to assemble detailed case reports and it is not always easy to distinguish between the facts as recorded by others and the interpretation which Dr. von Senden has placed upon them. If for only this reason, the addition of a fresh and well-studied case to the widely dispersed literature will be warmly welcomed.

The authors of this monograph have provided a full description of the history and progress of a man, effectively blind almost from birth, who underwent two operations for corneal grafting at the age of 52, as a result of which he recovered appreciable sight. As they relate, their attention was first drawn to the case by a newspaper report and it is to their great credit that they followed the matter up. With characteristic enterprise, Mr. Richard Gregory made an approach to the Ophthalmic Surgeon in charge of the case, A. Hirtenstein, Esq., F.R.C.S., of the Wolverhampton and Midland Counties Eye Infirmary, who responded with warm friendliness and generosity. Indeed it is entirely due to his kind permission to study the case and to his encouragement throughout that the work reported in this monograph could be undertaken.

This case study will be of interest to many. To the psychologist, perhaps the most arresting finding is the extent of "transfer" of information from touch to vision which the authors have been able to demonstrate. They point out, too, that much of their patient's difficulty in visual learning can be ascribed to his long-standing reliance on touch and the whole complex of well-engrained habits to which it had given rise. This leads them, in my view rightly, to suggest that great caution should be exercised in drawing parallels between the recovery of vision after operation in adults and the normal development of perception in young children.

The authors would be the last to claim any particular expertise in clinical inquiry. Nevertheless, readers will be impressed by their resourcefulness and determination to proceed wherever possible by the method of experiment. In spite of limited experience, they carried their study through in a manner entitled to warm admiration and respect. Although it is always risky to generalise from a single case, their work undoubtedly serves to throw light on important issues in the development of perception and the cross-modal "transfer" of information. They have presented their case with modesty, skill and warm humanity.

O. L. ZANGWILL.

Contents

Preface

We would like particularly to thank Mr. A. Hirtenstein, F.R.C.S.,the ophthalmic surgeon under whose care the patient was admitted to the Wolverhampton and Midland Counties Eye Infirmary, for his kind permission to study and investigate the case and for his most helpful advice and criticism. Without his co-operation and help this study would not have been undertaken. The staff of the hospital were most helpful, in particular the Matron, Miss Mary Jones.

Through the generosity of the *Daily Express*, we were able to study the patient for several days immediately after his discharge from hospital. Mr. Merrick Winn, the writer, was most helpful with his insightful comments and suggestions.

We would like to thank the patient's wife for her help and comments on many aspects of her husband's life before and after the operation. His sister also provided vital evidence as to his early vision. The Birmingham Royal Institution for the Blind have kindly given permission to publish the case records covering the period the patient attended the Institution.

We are sincerely grateful to Mr. Hirtenstein and Herr M. von Senden for their kind permission to publish correspondence bearing on this case.

Professor D. O. Hebb kindly read the manuscript in draft and we are grateful to him for many valuable comments. It should be said, however, that we alone are responsible for the interpretation placed upon the case. Since completing our study, we have gained much from discussion with Dr. B. R. Gomulicki.

We would especially like to thank Miss Kathleen Watts for her help in preparing the manuscript for the press.

Professor O. L. Zangwill gave most helpful advice and encouragement during the investigation and in the writing of this monograph. We are much indebted to him.

The patient was studied by us jointly, much of the detailed testing being carried out by the junior author. We were both present on all occasions, so that all the observations reported in this monograph have been confirmed by at least two witnesses. The actual writing from our combined notes, is the responsibility of the senior author. One of us (J.G.W.) was supported by a grant from the Medical Research Council, who also kindly provided a small grant for expenses. We gladly acknowledge their assistance.

We wish to thank the publishers, D. van Nostrand Company, Inc., for permission to reproduce Figure 8 from Beardslee and Wertheiner's *Readings in Perception*, Copyright 1958, D. Van Nostrand Company, Inc., Princeton, N.J.

R.L.G.

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1. Introduction

This is the case history of a man born in 1906 who lost effective sight in both eyes at about ten months of age, and after fifty years as a blind person received corneal grafts to restore his sight. Such cases are rare, and few have been investigated in any detail, or have available pre-operative records giving their early history. Since cases of recovery from congenital or early blindness have been discussed by philosophers for over three hundred years, and have more recently attracted the interest of experimental psychologists, we feel justified in presenting in full everything which might be regarded as relevant to the case.

René Descartes (1596—1650) in a famous passage in his *Dioptrics* (1637), considers how a blind man might build up a perceptual world by tapping objects round him with a stick. He first considers a sighted person using a stick in darkness, and says "... without long practice this kind of sensation is rather confused and dim; but if you take men born blind, who have made use of such sensations all their life, you will find they feel things with perfect exactness that one might almost say that they see with their hands ..." Descartes goes on to argue that normal vision resembles a blind man exploring and building up his sense world by successive probes with his stick.

John Locke (1632—1704) once received a letter from Molyneux in which was posed the now celebrated question: "Suppose a man born blind, and now adult, and taught by his touch to distinguish between a cube and a sphere of the same metal. Suppose then the cube and sphere were placed on a table, and the blind man made to see: query, whether by his sight, before he touched them, could he distinguish and tell which was the globe and which the cube? . . . . The acute and judicious proposer answers: not. For though he has obtained the experience of how the globe, how the cube, affects his touch, yet he has not yet attained the experience that what affects his touch so or so, must affect his sight, so or so. . . ." In the *Essay Concerning Human Understanding*, 1690, (Book 11, Chapt. 9, Sect. 8) Locke comments as follows:—" I agree with this thinking gentleman, whom I am proud to call my friend, in his answer to this his problem; and am of the opinion that the blind man, at first, would not be able with certainty to say which was the globe, which the cube. . . ."

Bishop George Berkeley, (1685—1753) in his *A New Theory of Vision* (1709) distinguished carefully between sight and touch as ways of perceiving and knowing, and took the hypothetical case of recovery from blindness in the following way:— "In order to disentangle our minds from whatever prejudices we may entertain with the relation to the subject in hand nothing is more apposite than the taking into our thoughts the case of one born blind, and afterwards, when grown up, made to see. And though perhaps it may not be an easy task to divest ourselves entirely of the experience received from sight so as to be able to put our thoughts exactly in the posture as such a one's: we must nevertheless, as far as possible, endeavour to frame true conceptions of what might reasonably be supposed to pass in his mind" *(op. cit.* Sect. XCII). Berkeley goes on to say that we should expect such a man not to know whether anything was "high or low, erect or inverted.. . for the objects to which he had hitherto used to apply the terms up and down, high and low, were such only as affected or were some way perceived by his touch; but the proper objects of vision make a new set of ideas, perfectly distinct and different from the former, and which can in no sort make themselves perceived by touch" *(op. cit.* XCV). He goes on to say that it would take some time to learn to associate the two.

In 1728 Cheselden presented the celebrated case of a boy of thirteen who gained his sight after removal of the lenses rendered opaque by cataract from birth, but this was not by any means the first successful operation of its kind: the earliest reported dates from A.D. 1020, of a man of thirty operated upon in Arabia. Other cases were reported in: 1668, 1695, 1704 and 1709.[1] After the Cheselden case of *1728*, we find some fifty cases up to the present day, one of the most recent being that of Latta, 1904.[2]

The evidence provided by the famous Cheselden case was discussed by Julien Offray de la Mettrie (1709—1851) in his *Natural History of the Soul* (1746)[3]. De la Mettrie argues that only education

[1] For a summary review of these cases, see von Senden, *Space and Sight* (1960) pp. 326—35.

[2] R. Latta: Notes on a Case of Successful Operation for Congenital Cataract in an Adult. *British Journal of Psychology*, Vol. i, 1904, pp. 135—50.

[3] A description of de la Mettrie's comparatively little known but remarkable work is to be found in *The History of Materialism* by F. A. Lange; Transi. Kegan Paul, Trench Trubner and Co. (1925).

received through the senses makes man man, and gives him what we call the soul, while no development of the mind outwards ever takes place.

The published cases have been collected and described by Herr M. von Senden in his book: *Raum- und Gestaltauffassung bei operierten Blindgeborenen* (1932), which was virtually unobtainable in this country before the recent and most welcome translation, arranged by Miss Sylvia Schweppe and undertaken by Mr. Peter Heath, entitled: *Space and Sight* (Methuen, 1960).

The importance of these cases has been stressed by many classical writers, including Hume and Helmholtz, and most recently by the psychologist D. O. Hebb, in his influential book *The Organisation of Behavior* (1949). Hebb cites the von Senden collection of cases, and makes a great deal of use of them in developing a theory of the development of perception. We shall later consider Hebb's arguments and conclusions.

Operable cases of blindness—strictly *near-blindness* for the retina must be functional and eye tissues are never entirely opaque—are of two kinds: cataract of the lenses and opacity of the corneas. The former was treated from early times by slitting the eye ball and removing the lens; treatment of corneal opacity is recent and involves highly skilled grafting of a donated cornea. All the earlier cases are therefore cases of cataract, while some of the more recent—including the one to be described here— were rendered blind, or nearly blind, by opacity of the corneas.

With improvement in operative technique, and also a more ready supply of corneas, it has become extremely rare to find a case of very early blindness which remains untreated after the first few years of life. The case to be described—that of S.B.— is exceptional because he was regarded for many years as inoperable, until finally an attempt, and a successful attempt, was made when he was fifty-two years of age. We can hardly expect such a case to recur in the near future, and so it is unfortunate that no experimental psychologist was informed of the case until after the corneal grafting took place. If another such case should occur, we hope that it may be possible for an investigation to be initiated some time before the operation is undertaken. A later investigator may be able to learn something from our evident mistakes.

It is unfortunate that very few of the published accounts of recovery from early blindness describe any detailed observations or tests made on the patients. It is also far from clear how much residual vision they had prior to the operation. At the time we undertook the enquiry, we had but the most sketchy knowledge of the literature. We knew of von Senden's work from summaries and accounts, but had not seen the original, which was not then readily available in this country. We did, however, set out to try some reasonably objective tests, though these we had to prepare with only a few days' notice as we were anxious to see the patient as soon as possible.

2. The Case of S.B.

(1) First Considerations

S.B. was born in 1906, of poor parents, and was one of a family of seven, there being three brothers and three sisters. He spent his youth as a resident pupil of the Birmingham Blind School, being admitted in 1915 and leaving in 1923, with a training in boot repairing sufficient for his livelihood and a fair general education.

It is important to note that S.B. received far more education prior to operation than in the previously published cases, with the possible exception of one described by Latta (1904). There is reason to believe that this may be important in evaluating the case. At the time of the corneal grafting—most of the previous cases were for removal of the lens—he was aged 52. We saw him in hospital shortly after the graft operation on the second eye. It is unfortunate that we did not see him earlier, but we did not hear of the case until it was reported in a daily newspaper after the first operation. We were, however, able to get first-hand reports from the hospital staff, who were generous with their time and help, and the surgeon, Mr. Hirtenstein gave us a first-hand report of his observations.

It was from the first clearly of the utmost importance to establish the amount of vision present before the operation, and back to as early an age as possible. The label “congenital cataract” should not be taken to mean that there has been virtually no visual experience preceding operation, or that vision was as limited in the first months or years of life as it was later, when perhaps fuller tests were carried out. A cataract may well increase in opacity during the first months or years, and whether this has happened can hardly be established. There is in fact remarkably little evidence about the extent of early vision in the previously published cases, but it is noteworthy that many of the patients cited by von Senden clearly had appreciable visual capacity immediately prior to operation, and yet still made slow progress in the use of vision after operation.

S.B. was admitted to the blind school not technically as “blind” but as “partially sighted”. The word “blind” signifies to the ophthalmologist “insensitive to light”, though its lay use is rather an absence of *useful* vision. Cases of strict blindness are inoperable, the retina being non-functional, and so we should expect any case such as this to be technically “partially sighted”. The question—a difficult one— is whether S.B. had *useful* vision, or more vision than the earlier cases described by von Senden.

It is most important to be clear that where blindness is literally complete surgery is always out of the question. The retina must be functional, and since the tissues and media of the eyes are never opaque, some effective retinal stimulation must always be expected. This point cannot be over-stressed. The word “blindness” may in normal usage cover cases with sensitivity to light, providing appreciation of form is too poor to be of significant use, but to the ophthalmic surgeon (as became clear to us during discussions) “blindness” is used to denote *total insensitivity to light.* In this sense there are *no cases of recovery from blindness.* This should be borne in mind when these cases are compared with the findings of experiments in which animals are reared in darkness, for then, and then alone, visual experience has been truly absent.

The most that should be claimed for any of these human cases is that vision has been dramatically improved upon operation, but as anyone can verify by practising “seeing” with the eyes closed, under some conditions—particularly bright sunlight—quite a lot of visual experience is possible under conditions similar to the worst lens cataract or corneal opacity. The direction of bright lights can be seen, as can the movement across the eyes of shadows. It could well be that this minimal vision, which we must suppose even the “best” cases to have had, makes them very different from the strictly blind—those whose retinas are dead—and we know nothing of what would happen if *they* could be made to see.

In order to test for retinal function in cases of cataract or corneal opacity, use is made of what are called entoptic phenomena. The entoptic perception of the retinal blood vessels can be readily produced in normal subjects by holding a small light source, such as the naked lamp of an ophthalmoscope, in contact with the closed lid near to one corner of the orbit, and moving it rapidly back and forth with a quite small movement, the eye being dark-adapted. The retinal vessels will be seen as a livid red tree-like pattern, which will fade as soon as the agitation of the light is stopped. They appear because the light entering the side of the eye, through the choroid coat, reaches the light sensitive cells (the rods and cones) *after* travelling through the layers of vessels and nerve fibres, which lie to the *front* of the retina. Under normal conditions they are not seen because they form an image—a shadow image—upon the sensory cells which moves precisely with them as the eyes move, and selective adaptation cancels out the non-uniformities of intensity. Similarly, an optically stabilised image fades out and becomes invisible within a few seconds. The shadow images do shift across the retina with movement of the light source, however,

and this stimulates fresh receptors, and so the image is made visible so long as the light source is kept moving. This technique is used in testing the retinas in order to establish whether an operation is worth attempting. An operation is not attempted unless the patient is able to give satisfactory reports on his entoptically observed retinal vessels.

A study of these entoptic phenomena in cases of congenital “blindness” could prove rewarding, for the study should reveal perception of form where there has been the least possible previous visual experience. Should it be technically possible, it might be of interest to stimulate the central visual system of a totally blind person. We know from the work of Penfield[1] that visual experience can be elicited by electrical stimulation of the occipital cortex, in the course of certain brain operations’. Would it be possible to stimulate the visual mechanisms of the totally blind? The effect of hallucinogenic drugs might also be of interest in this connection, for they may stimulate directly the central components of the visual system, and in the case of the totally blind this might perhaps be accomplished for the first time in the individual’s life.

(2) Amount of Pre-Operative Vision

It will be appreciated that on admission to the blind school, S.B. would have seemed no exceptional case, since his vision at that time was evidently insufficient to be of use to him. As we shall see, we find no reference to useful vision anywhere in the school reports.

Since the matter of degree of sight is now so important to us, we shall give all the evidence at length, and try to assess it. It falls into four classes.

(A) The testimony of S.B. with particular regard to his visual memories.

(B) The testimony of S.B.’s older and surviving sister.

(C) The medical and school reports of the blind school he attended as a boy.

(D) The expert opinion of the surgeon, based on the observed state of the eyes at the time of operation.

The available evidence will be given under these headings, and an attempt will then be made to assess it.

A. The Testimony of S.B.

We questioned him on his early visual experience on several occasions, but particularly at our first interview, (on 26th January, 1959) while he was still a patient in hospital. We asked him to describe just how much vision he had before the first operation. He told us, *firstly*, that he believed he became blind at the age of ten months – the age given in the records of the blind school – and, *secondly*, that the only visual memories he had before the operation were of three colours – red, white and black. He claimed, then, and later, that he remembered no other visual phenomena.

We ascertained that he was able to name these three colours immediately after the operation, but that he tended to be confused over other colours. It is possible that he would have had experience of these three colours as an adult suffering from undoubtedly extremely severe corneal opacity, for some awareness of light and dark would be expected and very brilliant red is, as described above, seen entoptically during the standard ophthalmological examinations. No doubt the ophthalmologists would tend to use the word “red” in trying to communicate under these conditions. This does not, of course, diminish the probability that he also experienced these colours as a small child, as he thinks he did, but this might be overlaid by later experience.

How far can we trust S.B.’s testimony? It may be appropriate to say here a word or two on his character as it appeared to his teachers, and much later, to us.

The school character reports indicate that S.B. was bright and intelligent, if sometimes lazy. There are criticisms of his sense of the truth; thus for: Midsummer 1920: "Unreliable and unstable in character. Sometimes works v. hard (mainly to please!) and then has slack periods. Plausible manner and a clever excuser... has no fixed purpose, and seems bent on doing things with a minimum amount of work attached”. By *Xmas 1920*: “Has improved in conduct and school work. Character more stable”. *July*

[1] W. Penfield and T. Rasmussen: *The Cerebral Cortex of Man* (1950), London, Macmillan.

1921: "... Appears to be trying to overcome unstability but has a crooked streak which 'wangles' out of things". And finally: *Xmas 1921: "*... Has worked hard for is anxious to get into the shops. Strong, sturdy, and pleasant. Plausible and not thoroughly trustworthy".

We do not know what correlation there may be between school reports of "untrustworthiness" and the ability to tell the truth over important matters in later life. Any estimate we may make for normal children and adults might well be misplaced for the specially handicapped.

So far as we could judge, when talking with S.B. or when giving him the various perceptual tests to be described, he was trustworthy. He made his perceptual judgements with unusual care, and was perfectly co-operative in every way. Our tests were performed in the hospital which had just given him sight: he appeared to identify us to some extent with that hospital and the people who had helped him. He seemed to us to be remarkably stable and balanced in his opinions, in his attitude to his experience, and in the interest that was being taken in him. On no occasion did we find that he had told us an untruth (except by omission on one personal matter of no importance to our enquiry) and his remarks or reports seemed not to be biased towards or against what he might have thought we desired from him. Such judgements are bound to be subjective but we state them for what they may be worth. We believe him to be entirely honest in stating that he had no visual memory of form.

B. The Testimony of S.B.'s Elder Sister

We did not for some months know that any friend or relation who might be able to provide evidence on S.B.'s vision as a small child was still living. Finally, S.B. informed us that he had an elder sister, but that as she wished to avoid the publicity the case was attracting in the Press, he had not told us about her. (It might be added that he probably did not realise the importance we attached to finding such witnesses, and it became quite clear that the sister did in fact wish to avoid publicity for a personal reason). It must suffice that S.B.'s sister is some four years older than S.B., that she is married and has a considerably higher standard of living than he had, and that she seemed to us a sensible forthright and honest person. We could see no motive for any deception or exaggeration especially as she was anxious to remain anonymous. We spent an evening at her home, during which she gave us the following details: –

She remembered him clearly as a small child. She used to take him weekly to the clinic, to have his eyes washed. She emphasised that his eyes were in a shocking state, and that there was a severe running discharge. She remembers his head covered by a large bandage, under which the discharge used to seep. Apparently he wore a bandage more or less continuously as a small child.

The family used in effect to test S.B.'s vision, when the bandages were removed, as a game. Her recollection is that as a small child he could "point roughly to large white objects". She thinks that his vision was limited to appreciation of fairly bright large surfaces, apparently without any appreciation of colour. She is confident that his vision was too rudimentary to be useful when the bandages were removed, and he was blind-folded throughout his young childhood, so that what vision he had was generally not available. There seems no doubt, from her statements, but that he led the life of a blind child. This story of the bandages is born out by the report of the Matron of the Blind School for Xmas 1915, which reads: –

> "Admitted this year – eyes in shocking state of discharge. With care and treatment they soon begin to appear quite normal. The condition of his eyes gets much worse during the holiday, and on his return make one feel sick to look at him...."

And also her report for July 1916: "... Eyes always look exceedingly bad after a holiday". This is strong language for a Matron of an institution devoted to diseases of the eyes; discharge from the keratitis must have been unusually severe. It is worth adding that the testimony of S.B.'s sister is independent of the medical report, since she had not access to it. On the cause of S.B.'s blindness, she thought that he went blind at the age of ten months as the result of an infection following vaccination. This was also the belief given in the two medical reports (almost certainly not independent) at admission, but the cause is not known with certainty. According to the Medical officer's report for 1st June 1915, the mother had poor sight, and this was confirmed by S.B.'s sister. It is possible that there was some hereditary factor, but we have no further evidence on the matter.

C. The Medical and School Reports of the Birmingham Royal School for the Blind

We are very fortunate in having full medical and school records, in the original handwriting, for the period 19I5 – 1923, when S.B. was at the Birmingham Blind School as a full time student. We now quote from the Progress Book of the Birmingham Royal Institution for the Blind, by kind permission of the Superintendent.

Date of Birth:	30.5.06.
Date of Admission:	2.6.15.
Condition of Blindness (partial or total)	Partial
Cause of blindness as certified by the Institution's Ophthalmic Surgeon	Keratitis
Position in school on admission	placed in lowest class.
Estimate of attainments on admission	has never attended school before; knows practically nothing
Mental condition	Appears to be a bright intelligent lad.
Physical condition	Normal but for sight.

Medical Officer's Reports

Admitted 1st June, 19I5.

Family History:	Parents living and healthy; father, good sight. Mother, not good. 3 brothers in Army. 3 sisters healthy.
Personal History:	Measles and chickenpox. Eyes bad since 10 months old.
On examination:	Heart and lungs negative. Submaxillary glands enlarged. Skin rough.

Feb. 1918

Complains of pain over front of chest. Heart – *irregular* (tachycardia). No history of rheumatism. No cardiac murmur.

26th Feb., 1918

Two days ago went out with friends – had more exercise – was followed by an attack of pain in precordia for 36 hours. There is now a definite mitral systolic bruit – increased when lying down. Slight irregularity, but tachycardia better.

8th March 1918

Again complained of pain over heart – now no tachycardia, but heart irregular.

Restrictions during this period:

Feb. 1918. Gym and drill suspended. Walking outside school boundary suspended.

March 1918. Piano exercises stopped also.

May 1918. Allowed walking in moderation, and renewal of piano exercises.

1st July, 1918

Influenza – 8th July, convalescent. 20th July. General health much better.

3rd Sept., 1918

Returned looking well – eyes much clearer and cleaner.

6th Sept., 1918

To have drill included now, and to be carefully watched for symptoms of previous attacks. Headmistress informed.

Ophthalmic Surgeon's Reports... taken from the Progress Book.

(Late Mr. Jameson-Evans).

3rd June, 1915:	Keratitis. Eyes bad since 10 months old. ? after vaccination. O/E: Diffuse dense nebulae each eye. Some vascularisation and epithelial xerosis. Conjunctivitis with slight discharging. Dacryocystitis. Some scarring of upper tarsus.
16th June, 1915.	Vision: fingers at one metre.
2nd Sept., 1915:	Eczema of face and forehead. Ectropion of lids. Keratitis.

27th Jan., 1916:	Left cornea vascularised and fleshy.
18th Sept., 1916:	Vision 3/60. Eyes much cleaner and quieter.
22nd Jan., 19I7:	Rt. and Lt. vascular keratitis. No regurgitation from lac. sacs.
11th Oct., 1917:	Left mucopurulent discharge from lac. sac.
22nd Oct., 1919:	Keratitis and xerosis I.S.Q. Regurgitation from lac. sacs.
14th Oct., 1923:	Eyes quieter and cleaner; no regurg. from lac. sacs. Vision: 2/60. Illiterate.
13th Feb., 1923:	Eyes quiet. Xerosis conj. Vision 2/60?
19th Feb., 1923:	Xerosis I.S.Q. Vision: fingers at 9 inches.

From these reports it seems that at that time he had some ("finger") vision when his eyes were free from discharge which, it appears from the sister's testimony and the Matron's report quoted above, was not generally the case at home. We may gain further information from the reports of his school progress, which will also be given in full.

School Reports:

July 1915

Elementary education: has only been in school a few weeks, so no report is possible at this stage. Conduct: good.

Signed: S. Robinson.

Xmas 1915

Reading. BRAILLE: Failed to learn anything for some time, but is making some progress now.
Writing: Too careless to obtain any result.
Arithmetic: Working of sums, slow; but very quick at mental arithmetic.
Composition: Fair.
Literature and recitation: Very good progress made.
History, geography, nature, etc.: This boy is very interested in his work and answers well
Handwork: Works well and has shown great improvement.
Conduct: Very good.

Signed: J. I. Falconer.

July 1916

BRAILLE: Making satisfactory progress in infant reader. Writes Grade 1. Has mastered the signs and can now write them perfectly.
Has done excellent work this term, and now sets his sums down nicely too, in the Taylor Frame.
Composition: Has done excellent work.
History, geography, nature: Answers splendidly and does good work. He takes a keen interest in these subjects.
Handwork: A good little handworker – a careful boy.
Conduct: This boy has gained the class prize this year. A most polite well-mannered boy, and an excellent worker.
Height: 4 ft. 2¾ins.
Weight: 4 st. 8¾ lbs.

Signed: J. I. Falconer.

19th December, 1916

BRAILLE. Reading: Making satisfactory progress—sometimes gets somewhat "mixed".
Writing: Writes Grade 2 to the 6th line.
Arithmetic: Tables to 12 times. Pence tables. Long measures reduction.
Composition: Tells a story well.
Recitation: A most marked improvement to this subject. Enunciation and pronunciation specially improved.
History, geography, nature: Answers well—tries very hard.
Handwork: A good worker.
Cane-seating: Careless—little progress.
Conduct: This pupil's conduct continues to be excellent.
Height: 4 ft. 3½ ins.
Weight: 4 st. 9½ lbs.

Signed: J. I. Falconer.

25th July, 1917

BRAILLE. Reading: Prep. Temple Reader; could do better, but sometimes careless. Out of class two mornings for music.
Writing: Fairly good.

Arithmetic: Has not mastered Long Division; finds a difficulty in "setting down". Two sums right, out of four, in exam.
Composition (Oral): Tells a story well, also retells his lessons well.
Recitation: Excellent.
History, geography and nature: Answers well in all oral lessons. History not so good as other subjects.
Handwork: Cane seating; started double frame. Carpentry: good.
Conduct: This boy still is very little trouble. A good little boy.
Height: 4 ft. 4½ ins.
Weight: 4 st. 10¾ lbs.

Signed J. I. Falconer.

Xmas 1917

BRAILLE. Reading: "Guy of Warwick". S. has improved much this term.
Writing: A marked improvement shown.
Arithmetic: Seems to have more idea of "setting down" now. Factors and their uses learnt. Multiple of £.s.d. factors.
Composition (Oral): Still very good.
Recitation: Excellent.
History, geography and nature: Answers intelligently and thoughtfully.
Handwork: Satisfactory progress shown.
Conduct: A good boy in school, but he sometimes has to be checked for talking too much.

Signed: J. I. Falconer.

July 1918

BRAILLE. Reading: Reads nicely—just a little inclined to guess sometimes.
Writing: Quite good. Grade ii, with a few abbreviations.
Arithmetic: Has done v. good work; all four rules and reduction of money.
Handwork: V. Good. A steady worker. Chain-seating: 6th row patt. Knitting: plain and purl on fine needles; has also made sev. bags and small purses.
Conduct: A useful boy with plenty of "esprit de corps". Works well. Has not been v. strong this Term (see med. report). Rather disobedient over small rules, otherwise a good boy.

Signed: J. I. Falconer and L. H. Best.

Xmas 1918

BRAILLE. Reading: Oxford Reader 4. Has done very satisfactory work.
Writing: Writes Grade 2 with fair amount of accuracy; more contractions used.
Arithmetic: Has done excellent work. Difficult examples with four rules in money, length and weight.
English subjects: Shows much thought and interest in these subjects; has a good fund of information regarding present day affairs. Greatly interested in machinery.
Handwork: Does v. good work in knitting and chair-seating when care is taken; needs to be checked occasionally for hurrying too much.
General: A very helpful and smart boy.

Signed: J. Falconer and L. H. Best.

July 1919

BRAILLE. Reading: Shows slight improvement, but is still far from being good.
Writing: Fair; improving. Composition: plenty of ideas, but cannot express them. Spelling weak.
Arithmetic: Mental, fair; has made some progress with fractions, practice and areas.
English subjects: Interested in these subjects, and satisfactory progress has been made. Literature: inclined to be lazy, and not sufficiently interested.
Handwork: Plasticine, V. good. Cane work, good. Chair-seating, V. good.
General: Good. A smart lad in appearance, and v. anxious to help.

Signed: J. Falconer and G. W. Bloomfield.

Midsummer 1920

Reading: Not much progress; touch poor.
Writing: Revising all braille rules, as written work is v. poor.
Composition: Mainly oral. Anxious to give a good impression—usually shallow.
Arithmetic: Good work done. Improved in fractions. Fairly strong in Unitary Method.
Literature: Has shown interest. Recitation has made more effort.; nice voice.
History and Geography: At times v. good. Lack sustained effort. Sometimes unusually thoughtful.

Xmas 1920

Reading: A weak subject, but touch slowly improving.
Writing: Has revised all contractions in braille to abbreviated words.
Composition: Memory much improved.
Arithmetic: Very pleasing progress. Fractions, percentages, etc.

Midsummer 1920

General Comments:
Boot-repairing: good work for a beginner.
V. active at all sport—a good footballer.
Unreliable and unstable in character. Sometimes works v. hard, (mainly to please!) and then has slack periods.
Plausible manner and a clever excuser.
Nice mannered boy, and affectionate but has no fixed purpose, and seems bent on doing things with a minimum amount of work attached.

Signed J. Falconer.

Xmas 1920

Medium progress-should do well, if more attention were expended.
Still v. keen over games-v. active and alert.
Has improved in conduct and school work. Character more stable.
Is improved in general behaviour and has made decided effort in class work.

Signed: J. Falconer.

July 1921

BRAILLE: Continues to improve, but slow touch. Not yet fully contracted, but still works steadily. Spelling fair. Mental and practical arithmetic fair. Has shown a fair grip of decimals.
Other subjects: Has developed a keen interest in books, but must read more for himself. Concentration improved, but not much activity in class work.
Boot-repairing and making: Work is developing in quality and speed.
A thorough boy where games and mischief are concerned. Rather too talkative and self-opinionated. Appears to be trying to overcome unstability but has a crooked streak which “wangles” out of things. Helpful, obliging, observant. Upright in physique.

Signed: J. Falconer.

Xmas 1921

BRAILLE. Reading: Good—deliberate. Writing: Improving; spelling fair. Composition: Needs developing.
Arithmetic: V. good—quick and accurate.
Other subjects: Pays attention, and is anxious to show that he has understood a lesson. Science: Good.
Boot-repairing and making: V. good progress.
Rather aggressive in manner, but has worked well.
Less noisy but still self-opinionated. Has worked hard for he is anxious to get into the shops. Strong, sturdy, and pleasant. Plausible and not thoroughly trustworthy.

Signed: J. Falconer.

It may be noted that there is no mention of any useful vision. It is only braille reading which is mentioned, and his aptitude for manual skills does not suggest the help of residual vision. This is confirmed by technical training reports for the final year at the blind school when he was taught boot repairing and making as a trade by which to make a living.

Technical Training: (Full Time—resident pupil)

July 1923

Boot-repairing and Boot-making:
Started full-time training in January, 1922. Training proceeding satisfactorily, and may be completed by Xmas 1923.
Quality: ¾
Speed: ½
Independence: 4.
Assessment: 14/— per week (rate of an average sighted worker £2.10.)).
Conduct: Fairly satisfactory. Rather boisterous at times, and over assertive.
Signed: J. Falconer.

Xmas 1923

Boot-making and repairing
Training now completed. To become a home-worker under our auspices, at Burton-onTrent. Shed and equipment to be provided.
Quality: 7/8
Speed:
Independence: 7/8.
Character: Noisy. Self-opinionated. Active. Showy in appearance—loves finery, Difficult to convince, and will rarely make the "amende honorable". Likes to be first, but has not sufficient self-control or balance to be a good leader.

Signed: J. Falconer.

The assessment of 14/— per week against the rate of £2 10s. for an average sighted worker is evidence that his vision was not of an order to be useful even in this comparatively simple trade. This is a point which may be made with some confidence when it is remembered that he was undoubtedly an intelligent boy, and certainly as an adult he has always taken great pride in making things with his hands, as was very clear to us when we visited his workshop and his garden.

D. Expert Opinion on the Immediately Pre-Operative Condition of the Eyes

We now quote from a letter written to us by Mr. Hirtenstein dated 24th November 1959.

> "When I first examined him in November 1957 both cornea were completely opaque with heavy superficial and deep vascularisation; in addition there was bilateral band-shaped keratinisation in the inter-palpebral areas. He had thickened lid margins, with poliosis; the eye movements were full. There was no nystagmus (either before or after the operations.) The iris and pupil could not be visualised on slit-lamp examination nor could the depth of the anterior chamber be estimated. Trans-scleral retinal stimulation produced a normal pattern of retinal vessels in the left eye and this was the main reason I decided to try the operation. The vision in the right eye was reduced to hand movements in front of the eye. The left eye had accurate projection of light only."

(3) Assessment of the Evidence for Early Blindness.

It is clear that S.B. as a child was not blind in the strict sense of being entirely insensitive to light, and this we should expect, given that a successful operation was possible. There is strong evidence to suggest that he wore bandages entirely covering his eyes during most, and possibly virtually all, of his childhood. There is evidence that his vision was not sufficiently good to be of any material use to him for orientation or recognition of objects. He appears from all accounts to have led the life of a blind person throughout his life.

Can we conclude that the case of S.B. may be taken as an example of "recovery from blindness" in the sense used by von Senden or Hebb? It cannot be claimed that this is equivalent to a previous life of total lack of retinal stimulation, as in the case of Riesen's chimpanzees, but was S.B.'s vision at all times after about the tenth month too rudimentary to be his dominant sense, and too rudimentary to aid him appreciably in any task or skill?

We want to know how S.B.'s early vision compared with that of the previously reported patients, but this is difficult to discover as the earlier case reports tend to be exceedingly sketchy and often virtually non-existent, and little trouble seems to have been taken to form any estimate using more indirect evidence. There are plenty of indications that in some cases there was considerable residual vision immediately prior to the operation, and yet progress in using vision was often slow. In his chapter "The Significance of Residual Vision in Cataract Patients for their Consciousness of Space" von Senden (1960, pp. 71—86) refers to patients having prior to operation awareness of (1) brightness; (2) brightness and colours; (3) brightness, colour and shape. He says: (pp. 71—72) "Unfortunately the details as to the vision of the patients before and after operation are extremely fragmentary. . ." and considers that there are only four cases which can definitely be classed as having only brightness vision prior to operation. (These are: Wardrop II (1826): Nunneley (1858): Ahlström (1895): Latta (1904).) Thus von Senden thinks that only four out of nearly seventy cases can be said to have had only brightness vision before operations, (and at least one of these (Latta, 1904) developed useful vision comparatively fast, being comparable with the case of S.B.).

There are several cases in which pre-operative vision was clearly superior to S.B.'s and yet vision was extremely slow to develop after operation. Von Senden attributes this to "their intelligence and will to live

. . . since they were accustomed to make use of everything and had thereby already acquired extensive schematic notions of space, they also made use of their visual capacity and tried experiments on their own account. .. . This may indeed have been partly a game at first, as with Ware and Home; but the important thing was that they thought about impressions gathered from this game, and did not merely enjoy them as qualitative stimuli and accept them as such" *(op. cit.* p. 85, considerably condensed). We see nothing to disagree with in von Senden's view of the matter (though we might not wish to follow his arguments concerning the essential difference between tactual and visual space, with which he is concerned in this section of his book) and we feel that too little weight has been given to the probable importance for visual development of making *effective* use of the information available through the impaired visual channel. To disagree with this, one would have to argue that visual learning is very different from the other kinds of learning we know something about; where progress depends upon use, reward, and relating things—building up, in Bartlett's word, schemata.[1] This involves active processes of selecting and relating and depends largely upon intelligent interest. It is a tragic fact that blind people (particularly before there were good schools for the blind), tend to be generally lacking in intelligent interest. To take a striking illustrative example, the case of a seven year old boy[2] :—" The boy appears initially to be devoid of all concepts relating to knowledge of objects, mathematical figures, etc. He cannot even tell by feeling whether a thing is round, square or triangular; here too it is primarily a deficiency in his mental upbringing." (Uhthoff, 1890, quoted by von Senden *op. cit.* p. 112).

We consider that although S.B. was once reported as having finger vision in early boyhood, his residual vision was certainly less than in the cases described by von Senden, including many which took months to gain useful vision. Our main reason for this conclusion is that although S.B. was of at least average intelligence and education he did not, according to the available records, get any assistance from residual vision. This we believe for two reasons: (1) The absence of any comment in the school report of any help from vision in reading, crafts or other skills, combined with the rather low final assessment; (2) The fact that throughout his life he lived the life of a blind man, and developed the special skills, such as orienting himself by echoes, which are necessary to those who lack effective sight if they are to live active lives. S.B.'s residual vision was apparently insufficient, even for a man of his intelligence and training, to serve him in any simple or complex task, and so we conclude that the case of S.B. may be considered with the classical cases.

The following differences from most of von Senden's cases should be noted.

(1) The operation was for opacity of the cornea and not for cataract of the lens, as in most of the earlier cases.

(2) So far as we know, S.B.'s vision was entirely normal up to the age of ten months.[3]

(3) S.B. had the advantage over almost all the previously reported patients in that he received specialised and careful education, including the reading and writing of braille.

(4) So far as we can judge, S.B.'s general level of intelligence, and also his sense of curiosity were above average.

(5) A most unusual feature was absence of nystagmus, both before and after operation. No reason is advanced for this, unless it be his visual experience as a baby, though this seems unlikely. Nystagmus is an almost invariable feature in these patients, though occasionally it is absent.

We shall now describe our observations on the case.

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[1] F. C. Bartlett, (1932) *Remembering*. Cambridge University Press.

[2] Uhthoff, W. (1890) *Helmholtz-Festschrift z. 70 Geburtstag*. (Special edition, Hamburg, 1891)

[3] This may not be very different from the earlier cases, for the state of the eyes in infancy has not previously been recorded. We should expect opacity in lens or cornea to increase in infancy, and it is unlikely that vision is ever absent in the early weeks or months in operable cases of blindness.

3. Observations at the Wolverhampton and Midland Counties Eye Infirmary (January 1959)

(1) Introduction to the Case

We first heard of the case of S.B. through a short report in a daily paper, which stated that a man blind from birth, had upon operation immediately recovered his sight. Having read something of earlier cases of recovery from congenital blindness, and being impressed by their significance for contemporary perceptual theory (in particular Hebb's writing on the subject) we determined to try to investigate this case. We wrote immediately to the Hospital Secretary (the name of the surgeon was not given in the press) and received the following picture of the case, and invitation to investigate it, from the surgeon, Mr. A. Hirtenstein, F.R.C.S.

> 16th January I959
>
> Dear Mr. Gregory,
>
> Thank you for the letter regarding a patient of mine, who, as you know, underwent a corneal graft operation a month ago.
>
> I have myself been very interested to note how quickly he readjusted himself to the vision he gained after operation. Prior to the operation he only had light perception in the first operated eye; in the other eye he could perceive vague hand movements close to his face. He lost his sight at the age of ten months after smallpox vaccination, and was trained as a blind person from the age of seven to eighteen years, at the Birmingham Blind Institute. I am contacting the Secretary of the Institute to find what records they have of his early years.
>
> After the operation he seemed to have absolutely no difficulty with spatial perception, and he could recognise faces and ordinary objects (i.e. chairs, bed, table, etc.) immediately. He learned the names of colours very quickly, and seemed to have no difficulty in recognising cars, windows, doors, etc. His explanation is that, though he could not see any of these things before, he had a definite and accurate mental image of all things he was able to touch; in the case of a car, for instance, he used to wash his brother-in-law's car, and thus he had a good idea of its shape. He was working as a boiler-scraper, and although he hasn't yet seen a boiler, he assures me that he would be able to recognise one immediately, as his mental picture of its shape is very accurate.
>
> As you know I operated on his second eye a fortnight ago, and I hope the visual result will be equally satisfactory for him. His present vision is, of course, not very good yet, but I hope it will improve after further operations, as the first ones were only preparatory ones.
>
> He will probably be staying another week or so in the Wolverhampton Eye Infirmary, and if you would like to see him yourself, and carry out any tests you might wish to do, you would be more than welcome. Do let me know if you are able to come up, as I would very much like to meet you if possible. Thank you very much for enclosing the two interesting articles of yours. I look forward to discussing Mr. B.'s case with you.
>
> Yours sincerely,
>
> *Signed*: A. Hirtenstein (F.R.C.S.)

We are most grateful to Mr. Hirtenstein, and the Matron and staff of the *Wolverhampton a»d Midland Counties Eye Infirmary,* who gave us all the facilities we requested, and helped in every way possible. We were given the use of a quiet and well lighted room for our investigations, and were left entirely undisturbed.

It is unfortunate that this case was not examined earlier from the psychological point of view, but it is understandable that it seemed to be of no very special interest to those who were involved in eye operations every working day of their lives. Special investigations take time, and time is obviously a precious commodity in a busy hospital geared to treatment rather than to research. We saw S.B. while still in the hospital, and interviewed members of the staff to obtain details about what had happened before we saw him. These were trained and careful people, and indeed had far more experience in dealing with, and observing, blind people than we had.

S.B. received a corneal graft on his left eye on 9th December, 1958, and on the right eye on 1st January, 1959. We first examined him on 26th January—48 days after the first operation. The first

examination was carried out in a quiet private room in the hospital, lit by winter daylight, and lasted about 3½ hours.

We first saw S.B. walking confidently along a corridor. He guided himself through a door without the use of touch, and he struck us immediately as a cheerful, rather extravert and confident, middle-aged individual. At first impression he seemed like a normally sighted person, though differences soon became obvious. When he sat down he would not look round or scan the room with his eyes; indeed he would generally pay no attention to visual objects unless his attention were called to them, when he would peer at whatever it was with extreme concentration and care, finally making some almost oracular comment. He never said anything silly or hysterical, and answered every question with unusual care. He never evaded a question, and showed an intelligence and sense of curiosity very much higher than a sighted man of his trade would be expected to show. He displayed an unusual dislike of being surprised by anything. He had a matter-of-fact attitude to his situation and his experience, and disliked not knowing things known as a matter of course to sighted people. At no time did he dramatise his situation, or exaggerate his lack of knowledge, as one might have expected if he were trying to impress us with his past blindness. He was proud of his independence as a blind man, and indeed he was unusual in his independence. He would go for long cycle rides, holding the shoulder of a friend, and he was fond of gardening, and making things in his garden shed, provided by the blind school for his trade as a cobbler.

He had no nystagmus. Searching eye movements were minimal, and when they did move over a large amplitude, they did so in larger than normal saccadic jerks which were plainly visible. No records were taken of his eye movements.

It was very soon apparent that his vision was far. from rudimentary: he could name almost any object in the room. Much to our surprise, he could even tell the time by means of a large clock on the wall. We were so surprised at this that we did not at first believe that he could have been in any sense blind before the operation. However he proceeded to show us a large hunter watch with no glass, and he demonstrated his ability to tell the time very quickly and accurately by touching the hands. It appears that he always used this method of telling the time before the operation.

We were even more surprised when he named correctly a magazine we had with us. It was in fact *Everybody's* (for January 17th, 1959), and had a large picture of two musicians dressed in striped pullovers. Although he named the magazine correctly, he could make nothing of the picture. We at once asked him how he knew which magazine it was, and he said that although he could not read the name, he could recognize the first two letters, though not the rest, and he guessed that the *Ev* belonged to *Everybody's.* Further questioning revealed that he could recognise any letter in upper case, though not in lower case, and it so happens that the title of the magazine was written with only the first two letters in upper case, thus:

He then told us that he had learned capital letters by touch, these being inscribed on blocks and taught at the blind school. Lower case letters were not taught.[1] This was particularly interesting, for it suggested direct transfer from touch experience. It also showed how he could guess correctly from comparatively little evidence. We were, after this early experience, continuously on our guard for intelligent guessing covering up perceptual abnormality.

His colour naming was not at that time by any means perfect. He told us that his only visual memories were of red, white and black. He could name these correctly, and apparently could do so very shortly after the operation. When we saw him he was uncertain about yellow, complaining of the large number of kinds of yellow. Latta's patient responded with great displeasure to yellow. S.B. did not show *dislike* for any colour, but seemed to prefer greens and blues, for example when seen in kodachrome projections, even when he could not name the objects. He liked bright colours, and later often expressed disappointment when things were "dingy".

[1] The upper case letters were taught since they often occur embossed on name plates, and they are useful to the blind, whereas lower case letters are seldom used in embossed form and so were not taught.

When we established that he could distinguish upper case letters, cars from lorries as seen in the distance through the window, and name such objects as trees and tables, we realised that more sophisticated tests were called for. Fortunately we had brought everything we could think of in the time available, including the tests to be described.

(2) First Visual Experiences after Operation

S.B.'s first visual experience, when the bandages were removed, was of the surgeon's face. He described the experience as follows:— He heard a voice coming from in front of him and to one side: he turned to the source of the sound, and saw a "blur". He realised that this must be a face. Upon careful questioning, he seemed to think that he would not have known that this was a face if he had not previously heard the voice and known that voices came from faces.

At the time we first saw him, he did not find faces "easy" objects. He did not look at a speaker's face, and made nothing of facial expressions. On the other hand, he very rapidly (apparently within a couple of days) distinguished between passing lorries and cars, and would get up at six each morning to look at them some way off. He "collected" different types of lorry, and took much pleasure recognising vans, articulated lorries, and so on. His particular interest in cars and lorries may have been in part that they made familiar sounds, which helped in identification; that they could only be driven by sighted people, and so held out particular promise to him. He had spent many hours trying to visualise the shape of cars while washing them, particularly his brother-in-law's car, which he frequently washed down.

He told us that he did not suffer particularly from giddiness when he first opened his eyes.

As in previous cases (Latta, 1904), he experienced marked scale distortion when looking down from a high window. In the famous Cheselden case, objects were at first reported to be touching the eye[1]; this was not true for S.B. but he found that when looking down from a high window (about 30—40 feet above the ground) he thought he could safely lower himself down by his hands. When later he saw the same window from outside, he realised that this would be impossible.

On the whole, his early estimates of the size of objects seem to have been quite accurate providing they were objects already familiar to him by touch. Thus buses seemed to him to be too high but the right length. This may well have been because he was used to walking their length but not feeling their height, adding the separate tactile sensations of the height of each step and adding enough above the stair-case would be a comparatively difficult and unfamiliar task. In drawings of buses, to be given later, he emphasised the features familiar to touch but ignored the bonnet, which would not normally have been touched by him.

He may well have made many mistakes of identification of objects which we did not hear about, but from the beginning he was proud of his ability to name objects correctly, and took no pleasure in allowing others to find out that he made mistakes.

It was very soon obvious (as we had to some extent anticipated) that merely to ask questions about what he saw would not give us much information about his visual capacity. In fact the only example of a curious and interesting mistake was described to us by the Matron, who said that about three days after the operation he saw the moon for the first time. At first he thought it a reflection in the window, but when he realised, or was told, it was the moon, he expressed surprise at its crescent shape, expecting a "quarter moon" to look like a quarter piece of cake! It is noteworthy that this is the only clear instance of an expression of surprise, or of a clear error of this sort. That it should occur with an object he could not have touched is perhaps significant. It also shows—when it is remembered that the full moon only subtends 0.5°—that his visual acuity must have been reasonably good at that time, a few days after the first operation.

It is also worth noting that reflections fascinated him and continued to do so for at least a year after the operation.

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[1] Although this is often quoted at its face value, it is worth remembering that normally a strong light, particularly if painful, is not regarded so much as "out there" as in the eye itself. The same is true for intense (and unusual?) stimuli in any sense modality. E.g. a very loud sound is a sensation *in the ear*.

(3) Perceptual Tests

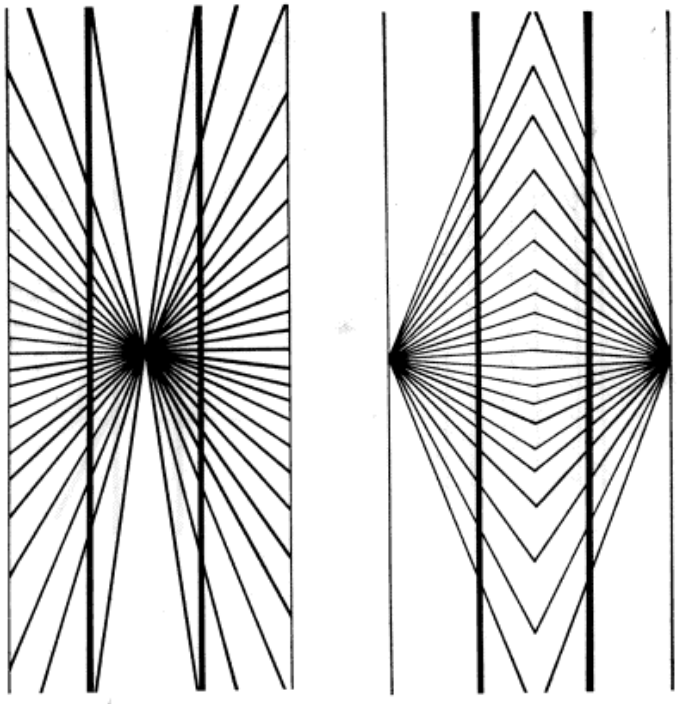
One of the difficulties about trying to discover the perceptual world of the blind is that they use the normal words of the sighted, even though they cannot always have the meanings we attach to them. Thus a blind man will say, "I saw in the paper to-day. . . when he reads it by touch in braille. When S.B. named an object correctly (say a chair or a vase of flowers) we could not discover what special features he used to decide what object it was. It was obvious that facial expressions meant nothing to him, and that he could not recognise people by their faces, though he could immediately do so by their voices, but we could learn little more.

We tried to get some insight into his previous world by getting him to say what surprised him when vision returned. The attempt failed almost completely, as he seldom admitted to any surprises.

We would have liked to obtain accurate measures of such things beloved by the experimental psychologist as the visual Constancies, but this was not practicable, for he tired easily, and we were anxious not to upset either him or the hospital staff. We decided to get him to look at various well-known visual illusions, about which a great deal is known for normal observers, even though explanations for many of them are lacking. The lack of explanation of these illusions did not worry us greatly, for with more knowledge, which is bound to come with further research in perception, they will surely be explained, and then any findings should be relatable to general perceptual issues[1]. It seemed to us that this would be the best way of getting some reasonably objective information as to his perceptual capacities and peculiarities.

The first three tests to be described here were given on the morning of 26th January 1959, and the remainder on the same afternoon when the first three were repeated.

Test 1. Hering Illusion



(a) (b)

Fig. 1. The Hering Illusion. (a) First form. (b) Second form.

[1] Since undertaking this investigation, we have made an intensive investigation of the geometrical illusions, and have come to the conclusion that they arise from discrepancy between estimated distance and degree of constancy evoked by such perceptual features as perspective lines. The illusion figures presented here seem to produce distortion of visual space by evoking constancy which is inappropriate to the flat plane (visible as a textured surface) on which the figures lie. On this view, we might say that the anomalous results obtained for S.B. show that these figures did not serve to evoke constancy scaling for him, and thus the illusions were absent.

This is shown in Fig. 1a, in which it will be seen that although the heavy vertical lines are in fact straight and parallel, they appear to diverge in the middle. This figure was presented to S.B. printed in heavy black lines on a white card of size 10½" x 4". He held it close to his eye, and studied very carefully in silence.

Result. First he said the lines were straight. He then became doubtful, and thought that they might be further apart at the top and middle. When shown the figures again, in the afternoon, he first said: "One goes out in the middle" and ended by saying that both were straight. We may conclude that the illusion was, if present, considerably less marked than in normal observers. Fig. 1b. gave a similar result.

Test 2. The Zolner Illusion

Normally, the verticals look non-parallel and may fluctuate in their positions (Fig. 2).

Result. He reported the verticals, after careful study, as all parallel, and after questioning about variation [jazzing] he said it was "all calm".

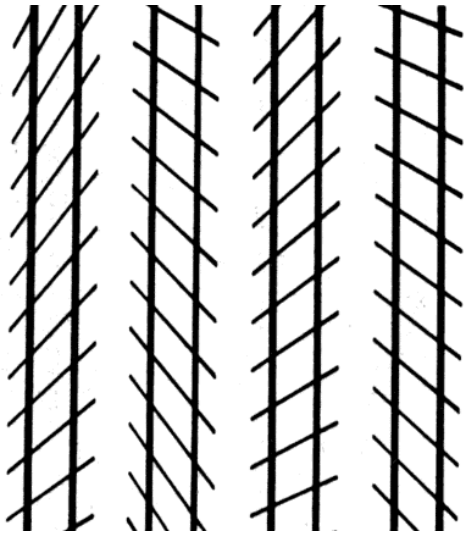


Fig. 2. The Zolner Illusion.

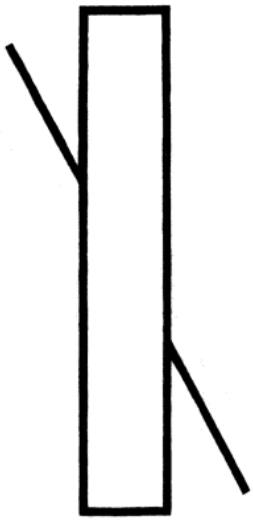


Fig. 3. The Poggendorf Illusion.

Test 3. The Poggendorf Illusion

Normally, the right-hand section of the slanting line appears to lie below the continuation of the left hand section. (Fig. g).

Result. S.B. reported it as: "all one line".

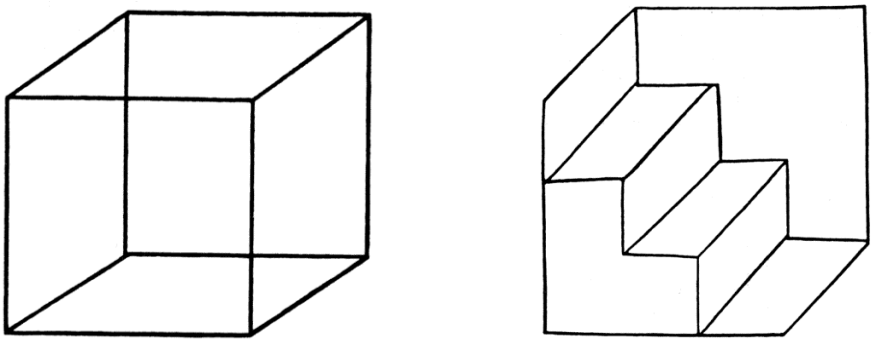
Test 4. Ambiguous Depth Illusions (reversing figures)

(a) The Necker Cube. This also is a very well-known illusion: it was shown as presented in Fig. 4a. It was displayed on a card 10 cm. x 15 cm. the figures being 5.2 cm x 8.0 cm. Normally, this figure is seen to reverse at intervals, the side representing the front being ambiguous.

Result. This gave a most unusual, possibly unique, result. The figure was evidently *not seen in depth* and it *did not reverse*.

"We took the greatest possible care to ensure that he understood what we meant by "depth" and "reversal," after he asked us "What is depth?" We did this by showing him (after first obtaining negative answers to our question as to whether it reversed or was seen in depth), a child's wooden brick we had brought along, and pointed out that it receded from him by pointing out the depth with a finger, and getting him to touch it while looking at it. When he looked again at the picture cube he said that he could

not see depth, and that, “it looks quite different [from the brick].” He tried, rather unsuccessfully, to draw a cube, but unfortunately this drawing is lost.



(a) (b)

Fig. 4. Ambiguous Depth Illusions. (a) Necker Cube. (b) Staircase Illusion.

(b) *The Staircase Illusion.* This is similar ‘to the Necker cube in that it also is a figure reversible in depth. It was presented on a card. (Fig. 4b).

Result. The result was the same; evidently no depth, and no ambiguity was observed.

Test 5. The Müller—Lyer Illusion

This famous illusion is shown in Fig. 5. When the shafts of the arrows are in fact of equal length, the arrow with diverging fins is seen as longer than that having converging fins. This was presented to S.B. as two arrows end to end, and was so arranged that it could be varied, and continuously adjusted by the observer, who holds the device in his hand. The length of the fixed arrow was 74 cm., and the movable arrow is normally observed to be *shorter* than this. S.B. adjusted the arrow for apparent equality of length four times, each time with great care.

Fig. 5. Müller—Lyer Illusion.

Result. His estimate of length on the four successive readings were as follows:

1. 10.0
2. 16.5
3. 17.0
4. 16.0

These figures meaning the *under-estimation of length* from the standard of 74 cm. His average illusion is thus 14.12 cm, in the normal direction. This may be compared with the mean obtained on ten normal observers on the same apparatus of 20 cm. The extent of the illusion as measured for S.B. is unusually small, though some “normal” observers can be found with a similar degree of illusion.

Test 6. Perspective Size Changes

Figure 6 shows four men, all actually the same size, but normally appearing of increasing size as the apparent distance, due to perspective, increases.

Result. S.B. reported: “They don’t look far away, it’s just as though the men were standing underneath (? the buildings). The first man looks smaller, but the last three look the same.” It should be made clear that these comments were in answer to a request for a description of the relative sizes of the men, and we

had to state that the objects depicted *were* men. As will be seen later he was hardly able to identify drawings of such objects as men.

Fig. 6. Perspective Size Illusion.

Test 7. Figure and Ground

One of the classical problems in the study of perception is how "figure" is distinguished from "ground" and whether the distinction is innate or learned. Normally objects stand out against a hardly perceived background, for example the objects in a room against the walls, even when highly decorated, but this can be perceptually ambiguous, as when at dusk the sky is sometimes seen as "object," with the black roofline as unimportant "background". Similarly, looking at a map, the land or the sea can be seen as "object" or "background".

The only example given to S.B. was Fig. 7.

Fig. 7. Figure and Ground Effect.

Result. S.B. made little of it; after some time he said, of the black curved part:

"Is it the case of a fan—a turbine fan?" He meant by this, as questioning elicited, part of the boiler equipment on which he worked. This is particularly interesting, for he had not at that time seen this equipment; he was however certain that he knew what it would look like, from his experience with touch plus his recent visual experience. He gave no response indicating figure—ground fluctuation, and could make nothing of the white part, even when the face" was pointed out in detail.

Test 8. The Ames Distorting Room

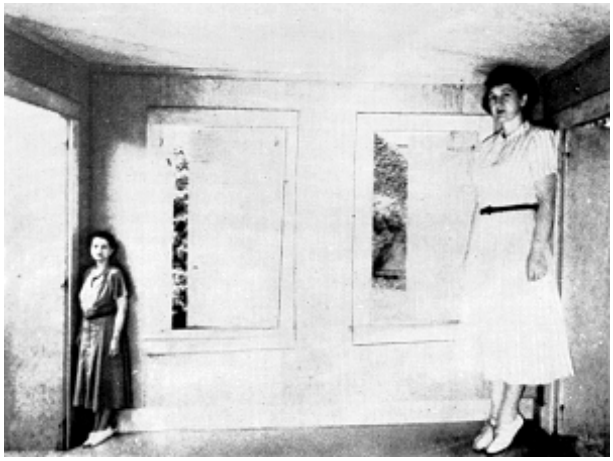


Fig. 8. Apparent Size of Objects in Ames Distorting Room

The Ames distorting rooms are of importance for studies on "visual framework". They emphasise that many judgements of size, shape or distance which may seem to be absolute are relative in the sense that they depend on other features in the visual field.

The rooms are non-rectangular, but are so made that they give, from a chosen viewing position, a retinal image corresponding to a rectangular room. Clearly they *must* appear rectangular from the chosen position, since no information is available to indicate otherwise, but they become interesting when objects are introduced into the rooms, for objects in fact at different distances may appear to be the same distance from the observer. When this is so, objects of the same size and the same *apparent* distance will give different sized retinal images. To the normal observer the objects will appear of different sizes even when this is quite contrary to all their past experience. For example, a child can be made to look larger than an adult, as in Fig. 8, which is taken in an Ames room. It would seem that, at least in a Western culture, where most rooms are rectangular, the walls serve as a reference frame for deciding the ever-present perceptual question: is it a large object far away or a small near object giving this size of retinal image?

We should expect S.B. to see an Ames room as rectangular—or at any rate he should not find its shape surprising—but it was an open question what he would see when identical objects were placed in such a room at actually different distances though at apparently the same distance.

To test S.B.'s reactions to this special situation, we used a small model Ames room, into which he looked, using one eye.

Result. He reported the room to be rectangular (in fact the rear wall receded from him to the right), and this result in no way surprised us since the resulting retinal image would be the same as for a truly rectangular room, or box. We then held a half-penny in each of the two windows in the back wall, one window being in fact further from the observer than the other, this distance not being apparent. S.B. reported that the right hand coin looked smaller than the left. When the right hand coin was replaced by a penny piece, and this compared with a half-penny in the left window, he reported that they were of the same size. This response is quite normal for observers using the particular model Ames room we used for this test. We were, rightly or wrongly, considerably surprised by the result.

Test 9. After-Effects of Movement

The well-known after-effect of perceived movement, often called the "waterfall effect" is a marked apparent movement of stationary objects viewed immediately after exposure of the retina to moving stimuli. A familiar example is the apparent movement of the bank of a river when seen after the moving water has been fixated for half a minute or so. The effect may most readily be observed by fixating the centre of a gramophone record while it is rotating, and then stopping the turntable. It will be seen to rotate in the opposite direction, the effect lasting for up to at least twenty seconds.

We tested S.B. for this effect using in place of a simple rotating display, a large spiral mounted on a turntable. Normally after this is viewed rotating slowly, a marked after-expansion or contraction is seen. This is a particularly good display to use because the effect cannot be due to eye movements, since the after-effect is symmetrical round the centre of rotation of the spiral.

Result. First we switched on the motor and asked S.B. to tell us what he saw. He was unable to say, and we discovered that he did not understand or appear to know the words “contract” or “expand”. After several exploratory trials we got him to watch carefully for 30 seconds, and to tell us what he saw when the disc was stopped. He reported: “stationary”. He appeared to get no after-effect under conditions when a normal observer would experience an expansion lasting 15—20 seconds. This was probably not due to lack of acuity, for he did appear to see real movement of the spiral. Language was, however, inadequate for this bizarre situation, and we may have been mistaken in thinking that he obtained no after-effect of any kind, though this appeared to be the case.

Test 10. Rorschach Ink Blots

We showed S.B. cards I and X of the Rorschach test. Our purpose was not to test his personality, but rather to see whether vague and quite unfamiliar shapes would evoke any interesting response.

Result

Card I (no colour). He said: “It is just a design—I can’t see what.” We asked him: “Does part of it show something?” He answered: “I haven’t the slightest idea.” Even after the most leading questions he was quite unable to make anything of it.

Card X (coloured). This time he said. “Is this a wallpaper design, or a cushion cover? It looks like a design for something. I can see colours but not what they are—there aren’t any flowers are there? I thought it was something of a plant, but there are no flowers, so I thought it was a design.” This response is interesting in being one of the few cases where he is evidently thinking aloud. Colour always stimulated him: his greater interest in the coloured card is typical.

Test 11. Kodachrome Projections of Scenery

We showed S.B. several kodachrome transparencies of objects and scenes familiar to sighted people but never seen by him. They were shown by projection.

Slide 1. *The Interior of a Cathedral (Hereford).* He said: “Is it a building with lights in it? What’s all that gold, is it the sun?” (The lighting was in fact rather gold-coloured sunlight). He took a stained glass window to be a door in a church. (This might have been from the common gothic carving to be found in Victorian churches and school doors.) He was rather puzzled by what he thought was a door, and asked: “Why should it have lines down it?”

Slide 2. The Cambridge “Backs” showing River and King’s Bridge. He made nothing of this. He did not realize that the scene was of a river, and did not recognise water or bridge. We named the water and the bridge to him, pointing them out.

Slide 3. Evening Scene of Malvern Hills. “This is a landscape is it? I can only tell fields by the colour. What’s this gold colour?” He liked the green, but could name nothing on the picture.

Slide 4. The Cambridge “Backs” showing Trinity Bridge. This time he immediately, though with a trace of uncertainty, identified the water as water, and pointing to the double arched bridge said: “Are those bridges again?”

So far as we could tell S.B. had no idea which objects lay in front of or behind other objects in any of the colour pictures. He showed pleasure at green foliage, but could make very little of buildings or other objects. We formed the impression that he saw little more than patches of colour.

Test 12. The Ishihara Colour Vision Test

We gave S.B. the whole of the standard Ishihara Colour Vision Test. That we had brought it along with us turned out to be peculiarly fortunate, for the result was remarkable.

Result. We presented the book of test cards in the normal order, and asked him to try to make out any numbers or letters among the coloured dots. To our extreme surprise he read *every single number correctly, as for normal colour vision.* That his colour vision would thus appear nearly normal is of secondary importance here, what amazed us was that he was able to make out figures without the aid of any high-contrast outlines. He made only one correction from a 1 to a 7, which is normally found rather difficult to distinguish.

He also succeeded, quite easily, in tracing out the “mazes” on the final test cards, after we showed him what was required using the small paint brush provided as a pointer which does not harm the cards.

It seems very difficult to avoid the inference that he used earlier tactile experience of number shapes. He had never had this or any similar test administered, as we established from the hospital staff.

The fact that he succeeded in reading these numbers is of particular interest as they have no contours, in the ordinary sense, but consist of dots coloured slightly differently from other dots which are of various colours. It would seem impossible for him to have followed outlines with his eyes, since he could not know which colour was relevant until *after* he had recognised each figure. We noted that he did not attempt to follow the figures with his finger, or make any related movements with his hands or fingers. He read the numbers out quite confidently and quickly, without apparent unusual mental effort. This seems to us the most interesting observation which we made in the study of S.B.

This observation that he was able to read the characters even though masked in the coloured dots of the Ishihara test displays, seems to provide very strong evidence for transfer from earlier tactile experience. This is surprising in view of Riesen's findings that trans-modal transfer does not seem to occur in chimpanzees kept while young in the dark.

(4) The Patient's First Drawings

We asked S.B., on the same day that the visual tests already described were administered, whether he would try to draw for us. He said that he had not so far tried to draw, though he had tried to write, and indeed he produced a laboured but just legible version of his own name, which he produced with great pride. (His wife had recently given him a ball point pen—his first writing instrument—and he had written his name to show to Mr. Hirtenstein.)

(A) *A Hammer* (Fig. 9) was a subject of his own choosing—a *cobbler's chipping hammer*. This seems to be the first drawing that he ever made. He was most doubtful of his ability to draw, but once started, he enjoyed it, and attacked it with great concentration. He placed his head very close to the paper, using only his preferred (right) eye, and checking the results from time to time holding the paper further away.

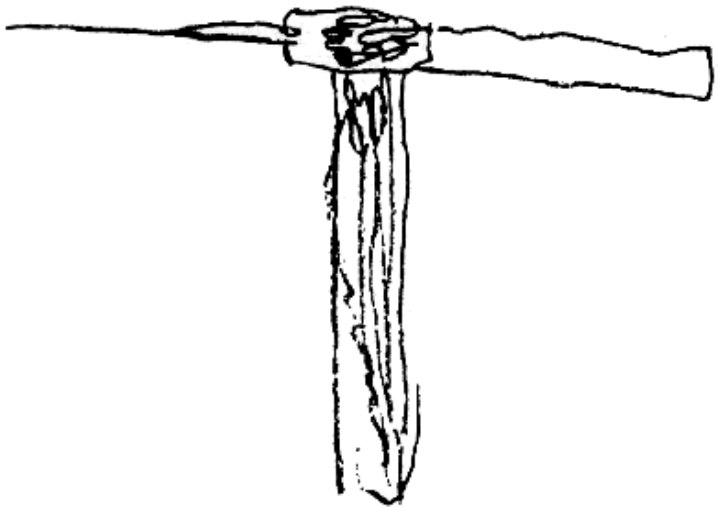
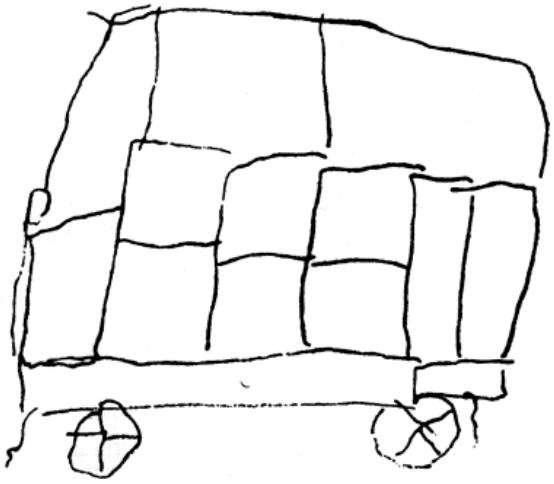


Fig. 9. The Patient's First Drawing: This drawing of a cobbler's chipping hammer was made in our presence on the 48th day after the first operation.

(B) *A Bus* (Fig. 10). This was a subject which we suggested to him—a bus. We chose it because he was familiar with buses as a blind man, and all transport interested him. We also had some evidence that at first buses seemed to him too tall, though of the correct length, and this seemed a matter of some interest. He had seen several buses since his operation—also cars and lorries—and it was clear that he thought this an interesting task.



(a)

Fig. 10. Drawing of a Bus (48 days after the first operation).

He expressed dissatisfaction with his drawing because he found himself quite unable to draw the bonnet, or radiator. This is striking for it would be the principal part that he would not have touched to any great extent when blind. The rather exaggerated windows might well represent the tactual conception of them, perhaps as felt from the inside. The wheels, it may be noted, are shown as having spokes. We questioned him on this and he replied that he knew that buses had hub wheels, but that he was more familiar with the feel of cart wheels. Evidently the more striking tactile impression would be of a wheel having spokes, and this seemed to mean "wheel" for him. He also said that he did not know how to draw a hub wheel, without spokes, so he "made them simply like cart wheels". He said that he knew the shape of hubs quite well, for he often washed his brother-in-law's car, and then he tried to picture it as it seems by sight. He drew buses later (Fig. 14a and b) and these we discuss below.

When he had drawn the bus and had discussed it, we left him to choose his own subject.

(C) *A Farm House* (Fig. 11). He said that this was meant to be the gable end of a farm house, with a path leading up to the house from a gate. It represented his idea of the Archers' House in the radio serial, to which he listened regularly.

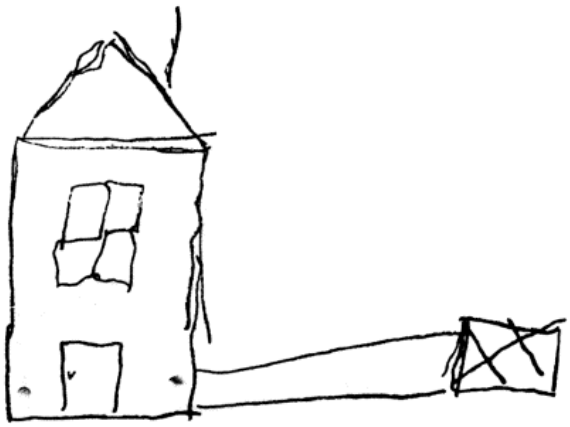


Fig. 11. Drawing of Farm House.

(D) *S.B.'s House* (Fig. 12). This was his own choice. The archway at the right hand side represents the entry to a passage round the side to the back of the house. He was worried by his inability to represent the pavement.

Fig. 12. Patient's Drawing of his Own House.

(5) A Man (Fig. 13). (No man in particular). He first drew the head, spending a long time on the mouth. We asked him to add the body, so any distortion of scale between the head and body should not be taken as important. When he had finished the body he said "I'm afraid I forgot to put him any knees".

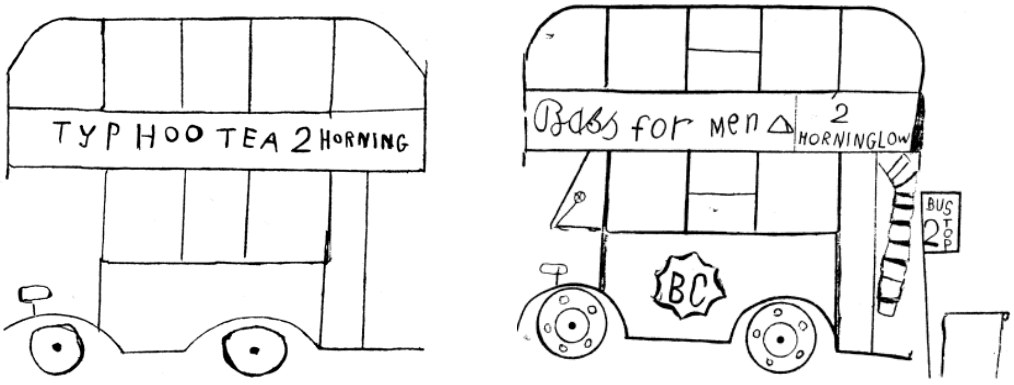
Fig. 13. Drawing of a Man. (48 days after the first operation).

(5) Discussion on S.B.'s Drawings

It is well known that some blind people are capable of drawing objects familiar to them by touch.[1] Typically, the characteristic tactile features appear to us exaggerated and perhaps they can give us some information as to how objects appear to the blind. It is interesting that S.B.'s early drawings are all typical of drawings of the blind. He introduces no features which he had not known previously by touch, although at that time (48 days after the first operation) he could name these objects confidently from vision alone. Thus although he could use vision to recognise objects he seemed incapable of recalling the specifically visual information and to represent it in his drawings.

The hammer, (his first drawing) was quite certainly drawn from touch memory as he had never seen it. The first drawing of a bus (Fig. 10) is revealing in showing importation of a characteristic tactile feature which was not in fact present in the buses he saw in the period after the operation: the spokes of the wheels. The buses he had seen had disc wheels, but to him a wheel characteristically has spokes and he imported these and added them to his bus, which he drew, as with the other drawings, sitting in the hospital room without having the object present to draw from.

The farm house (Fig. 11) represents his imagined house in a radio serial (the Archers) and incorporates only features known to him by touch. It may be noticed that the window is identical with drawings of the windows of this own house (Fig. 12). It may seem surprising that he should have a touch image of an object as large as a house, but in fact he painted his own house, using a ladder, and feeling the brush along the woodwork, which he did fairly competently. It may be noted that the roof is ambiguously represented.



(a) (b)

Fig. 14. Drawings of a Bus. (a) 6 months later; (b) one year later.

He took longer to draw the man (Fig. 13) finding it difficult, and was dissatisfied with the result. Blind people like exploring other people's faces with their fingers, and at that time he knew that his previous conception of faces was highly inadequate, but his vision did not serve to give him recognition of individuals from their faces or of the significance of facial expression. He seemed to have a feeling of inadequacy and disappointment over this. After doing this drawing he looked worried and apparently could make little of his own drawing. He ended by saying: "I'm afraid I forgot to put him any knees", and relinquished it with a sigh.

(6) Addendum: Later Drawings

The later drawings of a bus (Figs. 14a and b) were done six months and a year later respectively. They give some indication of the patient's increasing ability to use specifically visual information. There are several points of interest. In all cases the radiator is omitted, and this would not have been known by touch as the front of a bus is a position of danger to a blind man. The mirror is shown in all three drawings and mirrors always fascinated him. One suspects that he is representing the windows as he knew them by touch from the inside. The spokes, imported from touch in the first drawing, are absent in the second and a much more sophisticated version of the wheels is given in the third. There is no writing present in the first drawing. This appears in the second but is only upper case lettering, which he already

[1] See G. Revesz, (1950) *Psychology and Art of the Blind* (Transi. H. A. Wolff) London, Longman's.and V. Lowenfeld, (1952) *The Nature of the Creative Activity* (Transi. O. A. Oeser) Routledge.

knew by touch, while in the third drawing lower case lettering is beginning to appear: this he learned only after he gained his sight.

Finally, it will be noticed that in all three cases the buses are shown in profile and facing to the left. As a blind man he would only touch buses when they presented this aspect to him (since traffic is on the left hand side of the road in this country), and he retains this aspect even in the last drawing.

These drawings illustrate the general finding that although S.B. came to use vision, his ideas of the world arose from touch and his general way of life as a blind man remained with him until his death.

4. Observations Made Immediately After Discharge from Hospital

Before leaving hospital, S.B. had been out for short periods and we were not with him on these occasions. He had spent Christmas at home after the first operation (on the less successful eye) and had been out for one or two walks in Wolverhampton. He was driven to London from the hospital by Mr. Merrick Winn, with whom we stayed with S.B. and his wife at a London hotel.

S.B. was very tired when he arrived, and his eyes were painful. Mr. Winn told us that on the drive down S.B. had been almost completely unresponsive, accepting quite calmly what must have been unfamiliar visual scenes. He complained that the world seemed a drab place, though when the sun appeared he could see more clearly, and he was disappointed when it set. The one spontaneous comment S.B. made to us that evening was to describe the colours in the sky at sunset, to end sadly:

"...then we came down a hill and it all disappeared". When questioned about his general lack of interest in the journey, he said that the speed was too great for him to see very much; this was probably not the whole story, as later observation shows. He seemed dispirited, and indeed he never seemed the cheerful rather extravert man he was at the hospital when we first saw him.

Next morning, at breakfast, he sat for preference facing a very large wall mirror in which the room was reflected. This fascinated him, and mirrors continued to be chosen objects. (At his "local", a year later, his favourite place was opposite a mirror from which he could see the street through a window.)

We took him round London, and showed him several of the "sights", but he was almost uniformly bored. He found all buildings dull, of no interest. His only signs of appreciation were to moving objects, particularly the pigeons in Trafalgar Square. He took great interest in them and liked to touch them while he watched. He described how as a blind man he often felt isolated and sought sounds of activity and movement.

He found the traffic frightening, and would not attempt to cross even a comparatively small street by himself. This was in marked contrast to his former behaviour, as described to us by his wife, when he would cross any street in his own town by himself. In London, and later in his home town, he would show evident fear, even when led by a companion whom he trusted, and it was many months before he would venture alone. We heard that before the operation he would sometimes injure himself by walking briskly into a parked vehicle, or other unexpected obstruction, and he generally did not carry a white stick. As a blind man he was unusually active and aggressive. We began to see that this assurance had at least temporarily left him; he seemed to lack confidence and interest in his surroundings.

We were disappointed in his lack of interest and response to the everyday sights, and so we suggested that we take him to the Science Museum, in South Kensington, with a view to showing him things, particularly tools, which he would have heard about and wished he could have used when blind.

(1) Visit to the Science Museum, South Kensington

S.B. had a long-standing interest in tools and machinery; we were thus particularly interested to discover whether the sight of these things would serve to stimulate him, and dispel the lethargy into which he had fallen.

We took him to the large Watt's beam engine in the main ground floor gallery. This certainly interested him, especially when we arranged to have it run (by compressed air) for his special benefit. So far as could be told he understood little or nothing of its function and was disappointed.

A model windmill he at first described as: "It's a sort of cross—is it a windmill?" Upon questioning, it appeared that he had made simple windmills for children, and this enabled him to guess its identity. He made nothing of the rest of the model, only the cross-like sails.

We showed him a large stone-cutting bow-saw, which had large clearly defined teeth. At first he made nothing of it: it took perhaps 30 seconds for him to identify it as a saw.

The most interesting episode was his reaction to the fine Maudeslay screw cutting lathe which is housed in a special glass case. This is a large and fairly simple example. We chose this object because a lathe would be a tool that he must often have wished to use.

We led him to the glass case, which was closed, and asked him to tell us what was in it. He was quite unable to say anything about it, except that he thought the nearest part was a handle. (He pointed to the handle of the transverse feed.) He complained that he could not see the cutting edge, or the metal being worked, or anything else about it, and appeared rather agitated. We then asked a Museum Attendant for the case to be opened, and S.B. was allowed to touch the lathe. The result was startling; he ran his hands deftly over the machine, touching first the transverse feed handle and confidently naming it as “a handle”, and then on to the saddle, the bed and the head-stock of the lathe. He ran his hands eagerly over the lathe, with his eyes tight shut. Then he stood back a little and opened his eyes and said: “Now that I’ve felt it I can see”. He then named many of the parts correctly and explained how they would work, though he could not understand the chain of four gears driving the lead screw.

The episode with the lathe was extraordinarily interesting to watch: it is a great pity that a film record was not made.

(2) Visit to the Zoo, Regent’s Park

The officials of the Zoological Society Gardens very kindly arranged a special visit in which we were allowed to enter many of the cages normally closed to visitors.

Before he saw the animals, we asked S.B. to draw an elephant as he imagined it would look. (Fig. 15).

Fig. 15. Drawing of an Elephant.

It may be noted that this is a very poor drawing of an elephant; and yet when he saw the real thing, for the first time, later that day, he recognised it and expressed no surprise. This brings out the extreme difficulty we had trying to understand his world.

SB. had no difficulty in identifying the giraffe, elephant, monkey, lion, snakes or giant tortoises. He appeared to identify the tiger at once, though he was surprised to see that it was striped. However, after several cages of leopards, panthers, etc. there was another tiger and he did not recognise it as such. (As the first tiger was in the next cage to the lion, recognition of it may have been due to a natural association between the two.) He could not identify bears, seals, rhino, hippopotamus, crocodiles, or a gazelle. He was given a mongoose to hold, and thought that it might be a ferret, then a badger, then a stoat. He had never heard of a mongoose. He was amused by the elephants and giraffes, and particularly amused when he saw two giraffe heads looking at him from high up over the top of an adjacent cage. This was the only visual situation noted which ever made him laugh. He was allowed to throw cabbages into the mouths of the hippopotamus and his aim was good. We obtained a film record of this. When allowed to handle the animals, he did so with pleasure, and showed no fear or revulsion when snakes were hung round his neck. This also we filmed.

(3) Visual Skill—A Game of Darts

At S.B.'s request, we played a game of darts with him. He had played when he was blind by touching the board and walking backwards until he was told to stop. He would then be told the result of each throw. He now tried, for the first time, with sight. He occasionally scored accurately but was on the whole inaccurate, with a marked tendency to aim too low. He then tried with his eyes shut, and there was little difference in his performance. There was, perhaps, some evidence that with sight he tended to underestimate the distance.

We made several general observations during the two days that we were with him at this time:— He walked downstairs with complete confidence, with no hand on the rail; but on two occasions when there were three or four steps only, he stepped straight off the top one and had to be saved from falling. He would walk past objects (cages of animals in the zoo for instance) without seeing them when a normally sighted person would have reacted to them at once. On the other hand, when we asked him, outside Buckingham Palace, if he could see Big Ben, he said that he could see "that sort of tower if that was what we meant," and whenever his attention was drawn to animals in the zoo he would react at once. He said again that he did not recognise people by their faces but by their clothes—the colour—and that he was unable to understand expression on faces. He only looked at faces when spoken to and then in a rather "blind" fashion, though there was some evidence on the second day that he was beginning to look at faces with more curiosity. At a meal one would look up and find him rather tentatively studying one's face. One would have given a lot to know what he saw.

5. Observations Made Six Months After Operation

We visited S.B. at his home six months after the operation and spent a day with him in his familiar surroundings.

At his house we saw his shed, in which were hand tools for cobbling and woodwork and a new circular saw which he had recently installed and which he demonstrated with great pride. He apparently used it only for cutting up fire wood, but he operated the machine with frightening confidence.

The shed was fitted with a coke stove, and he informed us that he had installed this himself while blind, a statement confirmed by his wife, though he may of course have had some help. He was a keen gardener before his operation, growing mainly Vegetables and setting them out in rows with strings. He described how he used to try to picture the plants, and particularly liked their smell.

S.B. was clearly proud of his ability to deal with the tasks of making and mending: he was an aggressive man determined to tackle all that was possible to him with unusual perseverance and on the whole successfully. He used to go for long cycle rides, being guided by a friend's hand on his shoulder, and he took particular pride in the installation of the stove in his shed. But talking to him now he seemed dispirited, and we formed a strong impression that his sight was to him almost entirely disappointing. It enabled him to do a little more, and he had a strong desire to drive a car, but it became clear that the opportunities it afforded him were less than he had imagined. We found a still active middle-aged man of fairly high intelligence, but with a labourer's job and unable to read more than a few simple words. His income and status were obviously lower than they would have been if he had not been so handicapped, and these facts were very clear to him. He described the world as rather drab; he still to a great extent lived the life of a blind man, sometimes not bothering to put on the light at night, and he still made little of the normal visual occupations of the cinema or television. He did not get on well with his neighbours, who regarded him as "odd", and his workmates played tricks on him and teased him for being unable to read.

At his favourite "locals" he cheered up considerably, and was clearly regarded as a "character". He was able to recognise his friends at a distance of at least fifteen feet, from one bar to another, and he would now cross roads with some confidence. He certainly relied a great deal on vision, but we formed the impression that this very reliance cost him his self-respect, for he had been proud of his abilities when the handicap was obvious, but now his previous achievements seemed paltry and his present position almost foolish. He was not a man to talk freely, but was obviously depressed, and we felt that he had lost more than he had gained by recovery of sight.

In view of his depressed state, we felt it best not to undertake formal tests. We did, however, ascertain that he was able to find his way about without the use of his eyes, and that he could detect the presence of houses and doors by the echoes from his footsteps. He was still fascinated by mirrors, and he still noted improvement in his ability to see. In particular, he said that he noted more and more the blemishes in things, and would examine small irregularities and marks in paint work or wood. Quite recently he had been struck by how objects changed their shape when he walked round them. He would look at a lamp post, walk round it, stand studying it from a different aspect, and wonder why it looked different and yet the same.

6. The End of the Case

We find that a common feature of the earlier cases is a psychological crisis following the operation. There are many instances given by von Senden; two examples will serve as illustrations:–

Mesmer (1777)

> In her ill-humour she once complained to her father; 'How comes it that I now find myself less happy than before? Everything that I see causes me a disagreeable emotion. Oh, I was much more at ease in my blindness.' The father consoled his daughter with the thought that her present agitation was solely due to the sensation of strangeness in the sphere she was now moving in. The new situation she found herself plunged into by the recovery of her sight must necessarily awaken in her an uneasiness never felt before. She would, however, become as calm and contented as others, as soon as she had grown more accustomed to seeing. 'I am glad to hear it', she replied, 'for if I were always to feel such uneasiness as I do at present at the sight of new things, I would sooner return on the spot to my former blindness'." (von Senden, p. 160—61)

Beer (1783—1813)

> "Among the most remarkable psychological phenomena presented to my observation in all the patients so far operated upon, is the rapid and complete loss of that striking and wonderful serenity which is characteristic only of those who have never yet seen; for hardly are the first lively sallies of their curiosity satisfied after the operation, than already they evince this striking transformation of their attitude. Gloomy and reserved, they now shun for a time the society of others, which was so indispensable to them while they were blind that they lamented every moment that they were obliged to spend without it.
>
> Might not the reason for this sudden and striking change of temper, indeed I might say of the whole character, be partly due, perhaps, to the fact that the patients have supposed all objects, which they could only get to know by feeling when blind, to be quite different from what they subsequently see them to be; and might not also even a sort of injured pride contribute something to this transformation, in that they now suddenly find themselves so far behind other people of their age, even in the most trivial matters of knowledge? I fancy that in some at least, I have found traces of such a thing." (von Senden, p. 161).

Now it seems clear that S.B. had a similar crisis, starting at the time he left hospital, and not ending before his death.

Before the operation he was regarded by everybody as a cheerful rather dominant person, and we independently formed this opinion when we first saw him at the hospital. He seemed changed when he came to London; dispirited and bored. It seemed to all of us that he was deeply disturbed; yet too proud to admit or discuss

We give now two letters written to us by his wife, which give some insight into his mental condition at this time.

10.12.59

Dear Mr. Gregory,

Sorry to have kept you waiting for the enclosed drawings from my husband, but he is not at all well. He has been at home from work for the last six weeks with internal shingles and nerve pains, mostly in his right arm, hand and shoulder, also all underneath his arm and chest it is swollen with pain.

He has treatment continually from his doctor. It is the reaction no doubt, and he is not well enough to join you as you talked about when you were here.

He is very disappointed about everything. But when he feels better he says he will do more drawings for you when he is able. S. says Mr. Hirtenstein is very pleased with the condition of his eyes. And he wishes you a very Happy Christmas and hopes to see you again soon.

Best wishes to Miss J. Wallace and yourself.

H.B.

The second letter we do not give quite in full because she has described part as confidential. (It does not add a great deal to the picture.)

8.6.60

Dear Mr. Gregory,

I was very sorry that Mr. B. was not well enough to be at your lecture [a lecture given at the Christmas meeting of the British Psychological Society in London at which we had hoped he could be present] but he really wasn't fit to undertake the journey. He is not any better. I wish you could help him. His nerves are so bad, I can see his hands trembling, even as he ate porridge this morning, and he could not cut even sausages on his plate. He had a notice from National Health Ins, to see another Doctor, and I have been told it was a Psychiatrist. But instead of seeing him Mr. B. signed off and went back to work. I think hospital rest would do him good. If he collapses again, I shall see what his doctor says, He (Mr. B.) has been at home weeks, ill, having injections from his doctor and Codines and tablets, and has great pain in his right arm.

We shall be pleased to hear from you. I think it would be well not to mention this letter of mine. Mr. B. needs the help, which I think you can give to him, but would not agree to my asking for it. I want to get him well again, as he was a cheerful help to me and lots of people, and he had great faith and patience, which has now gone. It seems to me our world is not grand as we thought and Mr. B. did not know the way people acted—until he got his sight. I still think that the physical and mental ill-treatment, which we have both endured years ago, before we met each other, have contributed a great deal towards his ill health. Some things best forgotten, but some people can be very cruel. (There follows a paragraph about S.B. 's present state which she describes as confidential) . . . but since last Sunday, he has sat listening to the wireless, in the evenings, content with the dog which makes a great fuss of him, S., as he does not get home until 5.30 p.m. from 7.0 a.m. and I can't imagine S. will manage to keep going at that rate.

Yours sincerely,

H.M.B.

On 2nd August, 1960, S.B. died.

His story is in some ways tragic. He suffered one of the greatest handicaps, and yet he lived with energy and enthusiasm. When his handicap was apparently swept away, as by a miracle, he lost his peace and his self-respect.

We may feel disappointment at a private dream come true: S.B. found disappointment with what he took to be reality.

7. Relevance to the Theory of Perception

The fact that we have attempted to make some sort of a study of a case of recovery from early blindness does not give us the right to attempt an authoritative statement as to the importance of such cases for the theory of perception. In thinking about this single case, however, the whole problem has been much in our minds and has inevitably led us to develop some opinions.

In 1949, D. O. Hebb made a great deal of the cases assembled by von Senden in his well-known book on *The Organisation of Behaviour.* Indeed he regarded them as providing powerful evidence for the slow development of perception in infancy. "We are not used", he writes, "to thinking of a single perception as slowly and painfully learned, . . . but it has already been seen, in the discussion of the congenitally blind after operation, that it actually is". (Hebb, *opus. cit.*, pp. 77—8). In the light of our experience with S.B., this inference strikes us as distinctly questionable. Is it really certain that what applies to perception after recovery of vision in the adult applies in essentially the same way to its normal growth in infancy?

First, what are the reasons for the slow recovery of vision in the adult patient? Hebb evidently believes that the situation of such a patient is essentially that of the child, with its normal perceptual development arrested until the eyes are opened. Although he is evidently aware of the "emotional crisis" through which such patients commonly pass, he plainly does not regard reduced motivation as the principal cause of slowness in learning. Indeed he draws special attention to the fact that motivation is not disturbed in the first phase after operation, immediately upon beginning to use the eyes. He suggests, further, that the "crisis of motivation" is due directly to the difficulty in achieving pattern vision, and is thus a direct response to the disheartening slowness with which perceptual skill is acquired.

But is it? In the case of S.B., the patient made extremely rapid progress after operation and very soon found that his vision was useful, as in telling the time. It did in fact change his whole way of life within a few weeks of the first operation and some progress continued for the next two years, until his death. It is true that he did not learn to read, and for this and many other reasons found himself handicapped in the world of sighted people. It is this sense of overall inadequacy, we suggest, rather than deficiency of pattern vision *per Se*, which produced a crisis which lasted until the end.

Further, if emotional crisis is primarily a response to slowness in perceptual learning, why does it not occur in the normal child? It could of course be argued that the process is more difficult for the adult, but throughout Hebb argues that the position in the child is basically similar to that of the adult whose vision is restored at operation. Is this a tenable assumption? The adult, after all, has developed a "touch world" which has served him well for many years, and which has become accepted as the principal vehicle of his occupational and social adaptation. The child, on the other hand, is concerned to develop a "visual world" *ab initio*, and although tactile and motor activities contribute in an important way to its evolution, it is difficult to think of the two cases as in any real sense similar.

We find similar difficulties where Hebb tries to show that the perception of form is largely built upon patterns of eye movements. (Hebb, *opus cit.*, pp. 84—91). Hebb takes as evidence here the reported fact that operated patients count the corners of polygons in order to name them, moving their eyes from corner to corner as a man might move his fingers in active touch. Yet can one really infer that the patient is reproducing the normal visual behaviour of the young child? First, there is no clear evidence that, in the acquisition of form perception, children really do scan the contours of objects or figures in the manner suggested by Hebb. And secondly, it would indeed be surprising if people who had lived for years without vision did not, at least at first, tend to "touch" the salient features with their eyes though one must bear in mind that ocular scanning is often severely disturbed by nystagmus. Although further study of the role of eye movements in the growth of form discrimination is evidently needed, it would appear *prima fade* unlikely that cases of the kind described in this study can tell us anything very significant about the normal development of perception in infancy.[1]

It is of course true that in nearly (though not quite) all these cases of recovery of vision after long-standing blindness the development of perceptual skill is very slow, even when considerable sight was present before operation. But this, we suggest, is due not to the fact that visual learning, whether in the

[1] The same objections apply, *mutalis,nutandis*, to arguments from studies such as those of A. H. Riesen (see, e.g. his chapter in "Plasticity of Behaviour" in *Biological and Biochemical Bases of Behaviour*, edited by H. F. Harlow and C. N. Woolsey, Wisconsin, 1958) on bringing up animals in darkness and then studying their behaviour as adults after exposure to light. Studies of this kind are of course important in so far as they throw light on arrested development and its *sequelae* but it is doubtful whether inferences regarding normal development can properly be based upon them.

child or the adult, is *inevitably* slow but to lack of practice in making appropriate use of the available input. It would seem that the difficulty, is not so much in learning *per se* as in *changing perceptual habits and strategies from touching to seeing.* A not dissimilar phenomenon occurs in many cases with gradual loss of a sense or a limb; the patient will, at a certain stage, do better to abandon using the sense or limb altogether; to change his way of life to avoid and ignore it even if it is partly functional. In the event of some recovery of function, great difficulty may be experienced by the patient (and by those concerned with his rehabilitation) in inducing him to revert to the use of the impaired sense or limb. Indeed this may be one of the principal obstacles in the re-education of patients with any type of higher neurological disability.[1]

Another point of some interest in the present case is the relatively good intelligence and education of our patient, in which he resembles the patient reported by Latta (1904). Our patient, like Latta's, was much concerned while blind in trying to *visualise* the world and to know it as other men know it. One might even say that their attempt to see was made long before their eyes were opened to the light, and in this respect they differ not only from most other cases in the literature but also of course from infants.

The finding that S.B.'s visual space was not disturbed by the geometrical—optical illusions, and that apparent depth was not evoked by perspective drawings, show that his spatial organisation was far from normal. Since investigating the case, we have devoted considerable thought to the origin of these illusions and have arrived at the tentative view that they depend upon inappropriate scaling by the mechanism which produces size-constancy. If this should prove correct, it may be surmised that the figures failed to evoke constancy size-scaling in our patient, either through lack of early learning or maturational defect. It would seem of some importance, therefore, to devote attention to the study of these illusions in children with special reference to the development of size constancy.

Perhaps the most important outcome of our study is the evidence it provides for *transfer from early touch experience to vision many years later.* The fact that our patient was able, certainly with a minimum of training—and perhaps with none at all—to recognise by vision upper case letters which he had learned by touch, and that he was *unable* to recognise by vision lower case letters which he had *not* learned by touch, provides strong evidence for cross-modal transfer. It will be borne in mind, too, that it took him many months to learn to recognise by vision letters which he had *not* previously learned by touch. One may point out that the "control" provided by the lower-case letters is vital to the argument, since we can never wholly rule out the possibility of some residual vision (undoubtedly present in this case). The fact that S.B. could recognise the figures in the Ishihara Plates (by far the most surprising observation we made) gives evidence of transfer and, incidentally, renders it most unlikely that the *modus operandi* of transfer lies in identity of motor patterns (i.e. patterns of eye-movement corresponding with patterns of active touch). As has been said, gross observation of eye-movements, which consisted in large and apparently uncontrolled jerks resembling exaggerated saccades, made it impossible to believe that the patient could follow outlines of relatively small figures, such as the Ishihara digits, by controlled movements of the eyes.

We may conclude that this case does provide evidence of transfer of perceptual information from the tactual sphere to the visual modality.[2] This seems somewhat at variance with the evidence from studies of cross-modal transfer in animals[3] and we can only speculate as to the reasons for the discrepancy. It may be that language is the decisive factor.

In our view, these cases tell us nothing about the classical philosophical problems of the nature of perceived space (as von Senden fondly hoped that they would) and they tell us little or nothing about the importance of early visual learning for perception in the adult. We cannot sustain the view of Hebb that these cases provide windows through which we may see the perceptual system of the infant—they are not living fossils in which the past is re-enacted. We studied an adult with a unique past; what we found was the effect of this past on a normal brain. We did not find the brain or the perceptual system of an infant and we learned little or nothing about the normal development of vision. At the same time, we believe

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[1] See, e.g. K. Goldstein: Restitution in Injuries to the Brain Cortex. *Archives of Neurology and Psychiatry* (Chicago), Vol. 27, 1932, pp. 736—44.

[2] Professor D. O. Hebb has suggested to us that the surprising degree of cross-modal transfer which we ascertained in this case may have been due to the amount of vision available to the patient in early infancy. (Hebb, personal communication, 1961). [This could hardly apply to writing or telling the time.]

[3] G. Ettlinger. Cross-modal transfer of training in monkeys. *Behaviour,* 1960 **16**, 56—65. D. Burton and G. Ettlinger, Cross-modal transfer of training in monkeys, *Nature,* 1960, **186**, 1071—2.

that our case has demonstrated the impact of visual experience on a man to all intents and purposes long blind, and the gains and losses which this revelation brought in its wake. We have ascertained that vision, although it may prove genuinely useful to the man long blind, is at the same time a potential source of grievous hurt. We have further ascertained that, in such a case, direct transfer of information from patterns of touch to equivalent visual patterns is almost certainly possible.

Appendix

Correspondence on the Case

A correspondence took place between Mr. Hirtenstein, Dr. von Senden (who is still interested in the problem though he has not been active in the field for many years)[1], and ourselves. Since quite a number of points arise in the correspondence we include it here, publishing the letters in full except for small passages of a conventional nature, which would not be of general interest.

First we have a letter from Dr. von Senden to Mr. Hirtenstein, dated 14th May, 1959. This letter has several points of interest. It gives Dr. von Senden's reaction to the newspaper accounts of the case. Since Dr. von Senden quotes the relevant passages we do not give them separately here.

14th May, 1959

Dear Dr. Hirtenstein,

I still have to thank you for your kind lines of the 3rd February. Some days before Miss Schweppe had already sent to me a copy of your letter to her of the 16th January which was especially important, since you had written to her: "He had no difficulty in recognising shapes, faces and objects with which he was tactually familiar whilst blind. This he explains by saying that he had a very accurate mental picture of things he could feel."

If he used the word "picture" it is the question whether he used it like other blinds do without an idea what this word means to the seeing person, or with an at least partially influenced by visual experiences, conception of space and shape.

With regard to the hand movements which he could perceive prior to operation on the last operated eye, he will have perceived them only as a change of more or less light, without a change of "direction". But if you write that he had an accurate light projection on the first operated eye then he must have had to my opinion also a certain idea of a visual "direction", that a light can change this direction independent of his own behaviour. And if you have moved the light beyond the reach of his arm he could get conscious of the fact that visual objects cause sensations to the visual organ without touching it, that they are remote in a "space", this otherwise being unconceivable for the blind. He *can* have possessed even a certain ability to discern some colour shades, e.g. the difference of the normal eye-lid grey of a closed eye from some more yellow or brown or even red shades.

In this regard I would like to know (a) whether your patient had a nystagmus ante operation, (b) how he had pointed out before operation the different positions of the light, by following it with the whole head or by showing at it with his arm?

When the journalist of the *Daily Express* interviewed him Mr. B. told him with regard to his wife: "She was just as bonny as I thought she would be. My wife had given me a word picture of what the world was like and I found out that buses I travelled on and cars looked just as I imagined. Lorries seemed very strange." Here the word "picture" seems to have no optical component. Therefore I presume that the "mental picture" as well as the "word picture" means what I have called in my book the tactual schema. Mr. B. had no doubt compared before operation, e.g. his own rather tall figure with that of his wife by feeling. The result of this feeling act could be with regard to his wife "long and thin" or "short and roundish". I find it not so astonishing that the first visual impression which he got of his wife confirmed in his mind anyhow this gross tactual schema; especially if he has had at this moment already a certain experience in the interpretation of visual impressions, if his wife has not been among the very first "objects" presented to his new sense.

In the meantime, Mr. Merrick Winn of the *Daily Express* has published a series of articles after having spent 10 days with Mr. B., together with Mr. R. L. Gregory and Miss Jean Wallace of the University of Cambridge, two months after his first act of seeing. I have no idea how Mr. Winn has attained his very dissolving pictures which shall adequately show how your patient could really see at this period, according to the physiological status of his eyes. But if he could get indeed no sharper images from the visual things I find therein a confirmation of my standpoint that he *could* get at the first aspect of his wife no more than confirmation of his tactual schema "long and thin" or "short and round ".

In virtue of my examination of 66 cases of operated blind-born patients described in the literature I had come to the conclusion that a blindborn—by means of his tactual sensations—can neither get an idea of the deep space nor a conception of the shape of things, which one can reasonably design as such; and that he will

[1] At Dr. von Senden's request, a few minor alterations in phraseology have been made to improve his already excellent English (Editor).

get post-operation this spatial idea immediately but the comprehension of shape only after a more or less long lasting learn process. On reading the publications about your case one has the impression as if space *and* shape were (so to say) presented to him without his doing in his first act of vision, in spite of his very distracted vision. If this would be true one could only wonder why Mr. B. should show such an antipathy against any practical use of his new sense; if it comes not from an anxiety for eventual consequences for his economical life (e.g. loss of a pension).

Very significant in the report of Mr. Winn was the matter with a fork: "I'd pick up a fork, feel it and remembering how a fork felt when I was blind I could say: 'This is a fork'. Then I had to learn to remember it the next time I saw it". Without feeling the corresponding visual object before he cannot say what it is. I dare suppose that it was a similar proceeding in your tests with him: a visual aspect, a feeling act for control, say what it is and then impress the visual image upon his mind ("learn to remember it the next time".) You seem to have wondered how quickly this proceeding had a good success with Mr. B. But according to the report of Mr. Winn he must have had still infinite difficulties in this later period of his learning to see.

Mr Winn describes your patient as a cheerful, very good-natured and courteous man—which is confirmed by the picture of Mr. B. in the *Daily Express—who* likes to do any favour to his fellow-creatures if he can. Since you—and probably some other surgeons—had made all imaginable efforts with him and had to surmount so many obstacles for about 3 years he felt a deep gratitude for you and had the best will not to undeceive you. Therefore he showed during your tests full interest and full energy to support your efforts by his own efforts "to learn to remember as soon as possible the visual images, and tried to declare to you his success in his regard by his 'mental pictures'." When Mr. Winn spared no pains with him and was rather disappointed at the end Mr. B. was in the same crisis which is reported in nearly all cases and which can be surmounted only by full moral energy of the patient.

After all I have not the impression that it has been really of visual cognising of a former tactually gained "mental picture" or "word picture", but a confirmation of a tactual schema after feeling control of the respective visual object.

The first visual object he caught sight of was your face of which he could not have a "mental picture". In this regard he has told Mr. Winn "I saw a dark shape with a bump sticking out and heard a voice, so I felt my nose and guessed the bump was a nose. Then I knew if this was a nose I was seeing a face". I find this description very exact and conclusive. Above all it has been his consciousness of the situation which led him, which generally is highly developed in all blind persons. He knew your voice already before operation i when he heard it post-operational close to him the situation was quite clear for him. If you use perhaps a well-scented hairwater this would have been a further confirmation for him. The first visual impression which excited his reflection (probably as being the nearest and the lightest object) was the "bump" in the middle of a darker surface which he called "shape" as he knew this word pre-operatively from a seeing person. He knew that a nose is "in the middle of a face", asked himself whether this bump could be a nose, controlled his doubt by feeling his own nose. But even then he felt not quite sure but "guessed" that it was indeed a nose, and concluded that the whole surface (if his guessing was right) must be your face. Thus the seeing of the "bump" was not a recognising of a "mental picture" "nose" but partially a knowledge of the situation, partially a real seeing act, partially a controlling tactual proceeding and for the rest a mental conclusion.

Now Miss Schweppe and the publisher of the English translation mean that there is an essential contrast between the declaration of your patient with regard to the "mental picture" and the conclusion in my book that a man born blind cannot get any kind of a shape-conception. Therefore she has suggested to me that I should (1) ask Mr. B. himself by letter, (2) declare in the Preface of the English edition of my book for which reason the result of your investigations is such a contrast to my own conclusions.

(Ad 1) I cannot imagine that Mr. B. would be delighted to receive a letter from an unknown foreigner or could be encouraged thereby in his efforts to improve his vision. I am afraid indeed to increase by my questions his feeling of embarrassment and misery. And if he would be inclined to reply then I must doubt whether his declarations will have a greater value, since he scarcely can understand the special point of my questions. In this respect it would be a more promising way if you—having his full confidence—would try to elucidate this contrast, if you believe that this would be possible, and if you have the time for it.

(Ad 2) I have only tried to evaluate in my book the reports of those who have executed such an operation on a man born blind without having myself an occasion to occupy myself with such a blindborn, neither before nor after an operation. Therefore I feel myself not competent enough to express an opinion with regard to your case of which I know too little, and would do it only if you mean that it would be favourable to mention your case in the Preface.

Nevertheless you will understand that it is my personal interest to clear up this seeming contrast resp. to hear your opinion about it. This is the principal purpose of my letter. Therefore I beg your pardon if I have still some more questions:

(1) How long have you occupied yourself with Mr. B. before the first operation? Have you had an opportunity to examine whether he has had more than a mere knowledge about space and shape, as communicated to the blind by seeing persons?

(2) What has happened in the 3 weeks between the first and the second operation with regard to the training of his seeing? It is mentioned somewhere that your patient has visited other patients within the hospital and has walked about in the hospital garden in this period. Has he made his experiences under control or without it?

(3) In your letter to me you write that the psychological aspect following the operation (the second op.?) was investigated by Mr. R. L. Gregory of Cambridge University. In this respect I would like to know how long after the operation Mr. Gregory has seen your patient the first time. Had you given him information before the operation or was he induced only by the first notice in the *Daily Telegraph?* Was it possible in your opinion to reconstruct at that moment truly the whole development of his learning to see? I have the impression that Mr. Gregory cannot say out much more than Mr. Winn in his press articles.

I am regretting, dear Mr. Hirtenstein that this letter has become so long and that I waste your time immoderately. But I would be very obliged to you for a reply which can be so much shorter. If you want to read the conclusions of my book in English please ask Miss Schweppe to send them to you. For I believe that the contrast is only in the words but not in the real state of your case, as I have tried to explain above.

With kindest regards,

Yours sincerely,

Signed M. von Senden.

Secondly, we have Mr. Hirtenstein's reply to the letter quoted above, dated 24th November, 1959. This letter gives several details concerning both the eyes and also S.B.'s visual ability as observed by Mr. Hirtenstein.

24th Nov., 1959

Dear Dr. von Senden,

I apologise for not having written to you sooner, but your letter dated 14th May never reached me, and I have just received a copy of it from Miss Schweppe.[1]

As to your questions:—

(1) S.B. had no nystagmus before or after the operation.

(2) The light projection before the operation was tested by a pencil-light, and the patient indicated with his hand from which direction the source of light came. This was quite accurate in his case, with both eyes. Moreover, trans-scleral retinal stimulation produced a clear pattern of retinal vessels subjectively, and this was the main reason that I decided to operate on him.

(3) S.B. was referred to me by a fellow-ophthalmologist, and I knew the patient for a few weeks prior to his first operation. I had no means of testing him about space and shape of objects before the operation.

(4) As soon as the operated eye was uncovered after the first operation, the patient's ability to assimilate new visual sensations was truly remarkable. He was able to learn colours quickly and recognise simple objects with which he was familiar through tactile sensation, (chairs, tables, doors, etc.). He walked through the Hospital corridors without difficulty, and avoided objects and subjects in his path. It is interesting that his visual re-education still continues; every time I see him in my Out-patient Department he seems to be more

[1] Miss Sylvia Schweppe, of the British Museum, was instrumental in arranging for Dr. von Senden's book to be translated into English and published. The story of how she managed to find a micro-film copy of the German—the publisher's copies were destroyed by Allied bombing— and how she overcame other difficulties is quite remarkable.

confident in his walking and ability to "get around" generally. He now travels a considerable distance by train and bus to visit me at the Hospital from his home.

(5) Mr. Gregory saw the patient only after the second operation; he learnt about the case from the daily newspapers, and I invited him to examine SB. whilst still in the hospital. He spent a considerable time with the patient, and he is just about to publish his findings. I think it would be perhaps worthwhile for you to get in touch with him, as he would, I'm sure, give you all the information you require about this case.

Yours sincerely,

Signed: A. Hirtenstein.

Thirdly, we give extracts from a letter written by one of us to Dr. von Senden. We include it here because it gives an account of our general impression of S.B. at that time (November, 1959) before later events had a chance to change and perhaps dull our impressions. (This letter was written before we had read Dr. von Senden's book, though we knew of his work and had read accounts of it.)

Psychological Laboratory,
Downing Place,
Cambridge.
30th November, 1959.

Dear Professor von Senden,

We found that S.B. has a strong personality, and is not suggestible.

He had difficulty in naming some colours, in particular yellow, but could name most objects and judge distances accurately. He made very little from pictures, or large clear colour photographs projected on a screen.

We gave him a large number of perceptual tests, including reversible figures (the Necker cube for example) and we also gave him the Ishihara colour test. This produced a most interesting result, for he was able to read correctly every one of the numbers represented by the coloured dots seen by normal observers. What struck us was not so much that his colour discrimination was normal on this test, as that he was able to recognise block letters and figures tactually, and it is quite clear that this knowledge had transferred to sight without special learning being required. This was the most definite and the most striking finding of our examination.

He did not seem to get any depth from perspective drawings, or to get reversals of Necker cubes, although his visual acuity was probably adequate. (It is worth pointing out that one can get reversals of Necker cubes when the retinal image is degenerated, by viewing through highly astigmatic lenses).

The patient showed no nystagmus at any time I examined him. His eye movements were far from normal, however, for his "searching" or "scanning" movements were infrequent. He did not look round to the source of a noise anything like as often as normal, and he did not look at people's faces. He could however recognise people by the way they moved and from their clothes, or so he informed me.

As for the "psychological" reason why he became upset after the operation, my own opinion is that while blind he had managed exceptionally well. He went for bicycle rides with companions; he tended his garden and was something of a craftsman. Once he regained his sight, he felt, I think, up against the competition of sighted people. Further, he had throughout his life been treated with special consideration by his family and friends. After the operation this became modified. To his workmates he became something extraordinary and they would play small jokes on him. He must feel that by being blind for more than 50 years he has lost a great deal, not only sensory experience, but perhaps more important the chance of holding an interesting and well paid job. One must remember that he is an intelligent man with a strong personality. He would undoubtedly have risen above the social position into which he was born if he had not been handicapped, and he must realise this. I should add that this last point was not made explicitly by him; I give it as a reasonable inference from the evidence which is available to me.

With regard to his first "perception" of the surgeon: he told me that the newspaper account was wrong. His account is that he heard Mr. Hirtenstein's face and looking toward him (by Sound) "saw" a confusion of colours, and knew that this must be Mr. Hirtenstein's face. (He may, of course, have been wearing a mask). He was able, within hours, to name many objects correctly, and would get up early in the morning to watch cars passing on the street below.

He tended to misjudge the size of objects he had not been able to touch or walk along. For example, a bus looked too high but the right length.

Yours sincerely,

Signed: R. L. Gregory.

Before replying to this letter, Dr. von Senden wrote to the Editor responsible for the English translation of his book "Space and Sight" commenting on a report of our case appearing in the *Daily Express.*

Hamburg, 12th December, 1959

According to the first short report of the *Daily Express* of the 7th January, 1959, Mr. B. had told his interviewer that his wife "was just as bonny as I thought she would be. My wife had given me a word picture of what the world was like and I found out that buses I travelled on and cars looked just as I imagined" . . . "When the doctor removed the pad I could see his black hair and his face."

People who read those lines were glad that learning to see apparently was a rather simple affair. But those who knew my book were surprised, having the impression that these assertions of Mr. B. were contradictory to the conclusions which I had drawn from my studying all comparable cases reported in the literature.

The question is how the words of Mr. B. must be interpreted, whether the circumstances he tried to express with these words corresponded with the signification which seeing people adjudge to them. A person born blind learns all words of his language from seeing persons but cannot know which sensual or mental content they have for a seeing person. He uses all these words indeed, but as a seeing person cannot explain to a blind one much about things, a blind person cannot explain exactly (by means of the words of the seeing world) to a seeing person what occurs to him in his daily life. The same words have a different sense for these two categories of human creatures.

As Mr. Hirtenstein—who has executed the two operations on him—wrote to me he has "had no means of testing him about space and shape of objects before the operation". According to him the patient had a very poor vision but could indicate before the operation accurately the direction of a little pencil light with his hand! This fact indicates that Mr. B. has had already before operation a certain idea of a visual "direction"; he had been aware that a light can change this direction independent of his own behaviour, how it is when a light "moves". Thus he must (or at least could) have become conscious pre-operatively of the fact that visual objects cause sensations to the visual organ without any participation of the sense of touch, and could conclude that they are remote in a deep "space". Therefore we may say that "space" was nothing fundamentally new to him before operation. As I have shown in my book every operated blindborn has the space immediately post-operatively without any education for this purpose, but B. has had it already earlier.

When Mr. Gregory—as he wrote to me the other day—asked him later how it really has been when he used his new sight for the first time after the operation he has answered that the newspaper account was wrong! His own account is that he "heard Mr. Hirtenstein's voice, and looking toward him (by sound) 'saw' a confusion of colours, and knew that this must be Mr. Hirtenstein's face" (who may, of course, have been wearing a mask in this moment). This description is quite analogous to all other descriptions in the literature, as mentioned in my book.

This report of Mr. Gregory is very interesting indeed also in many other points. But as he intends to publish something about this case I don't want to anticipate him. But as he has accompanied Mr. Winn and Mr. B. for several days during their stay in London I like to allude to the remark in the very fine report in the *Daily Express* (two months after the operation) where Mr. Winn says: "S.B. was still basically a blind man. He could see but did not care. All this time he had been 'seeing' largely not to let us down"; and on another spot: "He never knew my face properly in all these 10 days we were together but he knew me instantly by my voice, clothes, walk, even breathing". Therefore I agree with Mr. Hirtenstein and do not wonder if he writes that B. "was able to learn colours quickly and recognise simple objects with which he was familiar through tactile sensation (chairs, tables, doors, etc.)". But I am sure that in these acts of "recognising" sight was participating only a very little. A hospital room contains only a small number of furniture objects. An intelligent blind man like Mr. B. has no difficulty in building up for his own use the tactual schema of the room within the first 24 hours. He can exactly indicate then where the different objects are, which name they have, etc. And if "he walked through the Hospital corridors without difficulty and avoided objects and subjects in his path" there is nothing extraordinary in this, especially if we remember that during the 3½ weeks between the two operations he could attain any kind of visual experiences without a scientific control, that he walked alone in the garden and had passed the Christmas days in his own home.

With regard to his assertion that his wife was "as bonny as I thought she would be" I may remark that this word "bonny" to my opinion has no component of space or shape. It merely signifies that the aspect as well as the tactile feeling causes agreeable sensations. B. himself declared to Mr. Winn: "I always felt in my own way that women were lovely, but now I can see them I think they're ugly". Also for this "lovely feeling" we have parallels in some other cases.

Concerning the bus I can imagine that he has had indeed a certain conception of it preoperatively. When he awaited (very very often in his long life) on the halting-place of his bus he could *hear* the typical rolling noise of the arriving vehicle and that this noise ceased together with the stopping of the bus; he could *see* that the diffused brightness surrounding his eyes before the arrival of the bus was darkened when it is quite near to him and that the brightness eventually reappeared when the bus had passed his place; and he could *number* how long the light was darkened by the outrolling bus. Having got these three different dates and correlating them to each other he could have got to a certain degree the idea what it means what seeing people call the "movement" of a vehicle, what seeing people call the "length" of an object, and that one can measure "breadth" and "height" on a similar way. Thus he could imagine already pre-operatively a "mental picture" of a bus. But it is quite clear that in the forming of this or other "mental pictures" the visual sense has participated a great deal.

Therefore I am sure that this case is not fundamentally different from the other known cases, and that this case does not alter the conclusions in my book.

Signed: M. von Senden.

The relevant parts of Dr. von Senden's reply were as follows :—

Hamburg-Othmarschen,
Schwindstr, 13.
14th December, 1959

Dear Mr. Gregory,

What has equally struck me as yourself is your test with the block letters and numbers. Had anybody punched out them for his personal use in wood or some other material? Block letters and numbers have indeed a very pregnant form and are easily distinguishable from each other. Also in this regard it would be very interesting to ask him anew how he has proceeded to transfer from touch to vision. Have you observed perhaps that he has made some movements with his finger-tips as if he followed out mentally (perhaps with closed eyes) the outlines of the block letters which he saw and recognised their name by controlling the well known tactual sequence of the resp. letter?

Very interesting also are his drawings. What order had he got when he made these drawings? Was he to draw for instance a table out of memory as a proof for the "word picture" which he had affirmed to possess from touch? Or was he drawing an object he could see in this moment?[1]

In any case I may assure you that I shall be very pleased to read some day your publication about this case, don't forget it please!

With kindest regards,
Yours sincerely,
Signed: M. von Senden

We have presented all the evidence available at this time, and it is now unlikely that more will ever be learned. We hope that the material has been presented in a form which makes it possible for the reader to form his own opinions as to what, if anything, this and other cases can contribute to our understanding of human perception and its development.

We feel privileged to have had the opportunity of studying this case, and feel grateful to all those—including poor S.B.—who made it possible.

[1] As described above his drawings were from memory, and some were of objects he had never seen, especially the chipping hammer.